~~Page 3~~

Page 4

R&D PROJECT REVIEWS

TIME SCALES

PROJECT	TITLE	REQ'D TASK	BY	DATE REQ'D

R&D PROJECT REVIEWS

TIME SCALES

PROJECT	TITLE	REQ'D TASK	BY	DATE REQ'D
162	Semiconductor Film Dev.	reliable & reproducible system operation	AS	8/31
		1st material from new 25Kw rf generator	HW	9/30
126	Masking Techniques	Step-and-repeat camera	SMF	12/1
		2 optical jigs operating in our service facility	"	9/30
179	Photo Diode Arrays	Establish feasibility of facsimile scanner, etc	WW	1/1/62
170	Photo Transistor Dev	FSP-5A - memo describing device for transmittal & MV-Test. comp.	EB	10/1
		XPD-1 - Batch from Special Products for evaluation	"	8/15
		XPT-2 Same as XPD-1	"	"
		Existence proofs on die & lead att.	"	11/1
		" " " encapsulation	"	11/1
		Package samples & demonstrate Mounting on edge of printed boards	"	12/1
		Complete evaluation & characterization	"	2/1/62
121	Data Storage Devices	limitation of probe material on write speed, etc - determination	KG	8/15
		Mechanical structure - experimental work to start	"	8/1
		Recorded electronics - complete	"	9/1
		system concepts - complete	"	11/1
		Conduct successful bi-directional comm. w/ flexowriter	"	12/1
161	Analytical Tech. Dev.	Portable set up for analysis available	BY	9/30
		Microprobe X-ray fluorescence Analysis set-up	"	8/31
160	Packaging Techniques	Demonstration sample of moly-manganese metallization & GEM	RTB	8/30
		Ceramic Metallization:		
		Demonstrate feasability	"	11/1
		Have service capability	"	1/1/62
		Microwave Transistor Pkg:		
		10 dev. in existence proof pkgs to OB	"	8/24
		Transfer of Micr Trans Package		1/1/62
		Design of leaders firm	DFA	10/1
		1000-sample packages	RTB	11/1
		Est. header supply for 1000/wk	RTB	10/1

R&D PROJECT REVIEWS

TIME SCALES

PROJECT	TITLE	REQ'D TASK	BY	DATE REQ'D
148	Diode Development:	Product Manual Draft	OH	8/1
	Epitaxial Diode →	" " Completed	"	8/15
	"	Dice for San Rafael solder down to S.R.	"	7/13
	"	Duplicate SR backside soldering cycle	"	End of August
	"	Results of FD-5 comparison.	"	8/1
	"	Sample of final assembled product	"	7/21
	"	Supply of samples	"	8/15
	"	Epi'al Material Spec	"	8/1
	"	Torture test results	San Rafael	8/31
	"	Correlation Problem	OB	8/7
	"	Minimal set of specs	RS	8/15
	Ultra-Hi Speed Diode	Objective Spec.	DFA	8/1
	"	Existence Proof (assembled)	"	8/1
	Microdiode	10 existence samples	LS	8/31
171	Zener Diode Dev	3-layer zener structure - 1st samples	FF	7/21
		Get structure defined		During August
		Operating life data	OB	8/4
		Transfer 1st zener to production		9/15 - 10/15
		Complete Prod. Man. on Temp. Comp. Zener		10/1
189	Field Effect Transistor	Obtain Crystals	OL	8/1
	(Chopper - FET)	Devices to D.H. for evaluation	"	9/1
		Parameter evaluation completed	DH	9/15
	"	Samples of n on p		8/31
	"	Samples of p on n		9/15

R&D PROJECT REVIEWS

TIME SCALES

PROJECT	TITLE	REQ'D TASK	BY	DATE REQ'D
142	SCT Device	Objective Spec	OB	8/21
		Optimum Structure Evaluation of Device	CTS	Meeting of 8/21
108	7000 Device	New Masks	PJ	8/15
		Contact. Scheme Disc	PJ	8/4
		Packaging Discussion	RB	
		Epitaxial Samples		7/31
		Existence Proofs ready for transfer sched.		10/1
117	Lex Lice Transistor Array	Patent disclosure	MW	7/14
		3 units soldered on boards		7/31
144	1500 Series	1st order feasibility stmt.	LC	End of July
		1710/1711 Samples	"	End of August
146	4500 Series	4700 - 100 hr. data	LC	7/14
		3501 - 1st Samples to OB	"	7/21
		Transfer best prod.	"	Month of October
		Prelim. results - no gold pops	"	7/31
145	4000 Series	Prelim. data 1-shot 3001's low beta	OB	7/14
		Failed & sectioned units examined	"	7/21
		Split run - completed		During July
143	1000 Series	Final Design Samples	DFA	9/1
		1211 - Into Production		October / November
172	Advanced μcircuit Technology	First sample - diode array	JC	End of October
152	The μlogic Family	Masks for entire family	LK	9/1 - completed
169	Multiple Diodes	1000 good power to Spec Prod (Robson)	OH	8/31
		Capacitor coupling in std. appli.	OB	8/31

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JOB NO.	JOB TITLE	DATE	PAGES
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116	Basic Alloying Studies	8/2/61	37, 38
165	Competitor Dev. Eval. **3/23/62	8/3/61 *11/17/61	39 *70 **136,137
160	Packaging Tech. Dev.	8/4/61 *1/[illegible]/62	40, 41, 42, 43 *105, *107
114	Special Diffusion Research	8/10/61	44, 45, 46
163	Pipes & Related Phenomena	8/10/61	44, 45, 46
109	Diffusion Tech. Dev	*9/27/61 8/14/61	47, 48, 55*
115	Noise Research	*1/20/62 8/21/61	*106 49
148	Diode Development	9/8/61	50, 51
110	Glass and Ceramic Development	*11/8/61 9/20/61	53, *65
-	Project Realignment	9/22/61	54
-	Step-and-Repeat Camera	10/4/61	56
-	FT-4400	10/5/61	58
109	Diffusion Tech. Dev.	10/9/61	59, 55
-	Project layout - out-diffusion data	11/6/61	63
-	Meeting with Diode People	11/8/61	64
-	XPT-3 (Photo Diode)	11/13/61	66, 67
-	Resistors	11/20/61	71, 72, 73
-	Fareman Discussion	11/21/61	74
-	Microcircuit Layout	11/27/61	75, 79
-	Facsimilie Discussion	12/6/61	76
108	7000 Development (Power Trans.)	12/8/61	80, 81
171	Zener Diode Dev.	1/29/62* 12/14/61	*111, 112 82, 83
-	Large Geometry Meeting	11/17/61	84

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TABLE OF CONTENTS - Miscellaneous Type Meetings
(Other than Project Reviews)

See "R & D Project Review" Table of Contents for Miscellaneous Meetings prior to January 5.

107 - 7500
143 - 1000
144 - 1500
145 - 4000
148 - Diode
169 - Multi diode
166 - Contact Tech
113 - New Materials
133 - Electrochem.
141 μ-wave planar
105 - Ox studies
116 - Basic alloying
119 Surface Research
120 Si Material Res.
161 Analytical Tech
165 Competitive Devices
167 - Special FCC Dev
176 - Proposals
177 - Thin film tunnel

Project Review Schedule, week of Feb. 5 - 10

106	Controlled Rectifiers ✓
170	Photo-devices ✓
( )	Anodic oxidation ✓
126	Masking Tech Dev. ✓
160	Packaging tech Dev.
110	Glass & Ceramic Tech.
121	Data Storage Devices
179	Explor. Phototransistor Dev
190	Experimental Hardware Dev.

Gordon Moore

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July 6, 1961

Project 142 — S.C.T. device Project review

Q. — Is "it" ready for production?

Present program

1. Fabrication: A. Try to get g_m high — have gotten 15,000 $\mu\Omega^{-1}$
r_{oe} low — " gotten <10K

$\mu = g_m r_{oe}$

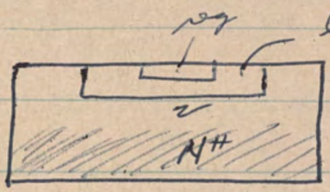
lowering Q (C_0) on base increases g_m, decreases r_{oe}

B. Oxide — presently highest in thick oxide
— low in thin oxide
Oxide yield is ~30-60% in 0.5μ oxide (original (1000μsi)
is ~ 5% if reoxidized to 0.15 μ
Problem is pinholes from photo resist.

There is a possible technique to get rid of the pinhole problem by ~~set~~ double KPR with different pattern and double removal.

Q: How thin must the oxide be to be useful?

Epitaxial is being tried
"Optimum" structure



4. New masks desirable β - should try wider grid for high gm

No data yet on reproducibility.

5. These devices are slow cooled rather than metal gettered.
This is done by pulling out from 1040°C to 600°C in 3 hrs.
(Only in the last operation)

6. New geometry using smaller emitter being tried

Eq. structure: 

Q: When should DA get involved to develop a product
Objective spec — or date for objective spec

Point of max control should be slightly + voltage

Fab. problems

1. Reproducibility
2. Yield
3. Low Co base
   a) low Q
   b) out diffused
4. Slow cond process

not yet assigned

Evaluation

1. Reliability & stability
2. Characteristics vs T
3. Bias problem
4. Objective spec.

Theory & understanding

1. Optimum structure
2. Surface diffusion
3. Impurity segregation into oxide
4. Surface states & recombination center distribution
5. Hysteresis

July

Aug

Sept.

15 — 5 runs for reproducibility
DFA (with D.T.)
Gm at ≥ 4000 $\mu\Omega^{-1}$
at $V_g = 0$
$I_c = 10$ ma

20 — Define developmental program (or send back)
a) opt. structure (CB
b) obj spec (DFA #2 chain)
c Report on Rel. & stab. Characteristics vs T Bias problem } O.B.

Projects 108 (7000 development); 136 (X-2000); 144 (.1500 dev)

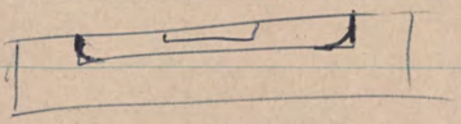
July 7, 1961

Project review, Project # 108 - 7000 Development.

Allison
Norman
Baker
D. James

Big problem - pipes & yield in single-sided structure.
No other problems on double-sided structures.

Planar, d.d.



Epitaxial version of above

Diffused from both sides — Not promising

Mesa'd 7000

Epitaxial N+P with N diffused.

By mesaing the planar ones we get a greatly improved yield.

Project restriction:

Concentrate on double-diffused planar device to try to get to ≥ 10% yield consistently to high spec.

Contacting technique is of two types, gedanken & capillary ballbonds

Standard Tests for X 7000 Agreed To by
& P. James 3/27/61

LV_{CER} @ 10Ω 100 MA	85		33	
BV_{CEO} @ 100 μA	50	110	23	
BV_{CBO} @ 100 μA also @ 1 M.A.	110	160- 200	70-90	
I_B or h_{FE} @ 150 MA + 5V also @ 1 amp + 5V	Ranged 55 - 180 Ranged 44 - 105			
Resistivity Range	1.8- 2.0 Ω cm	6.0- 8.0	0.6 - 0.8 Ω cm	
V_{CE} (sat) @ I_c = 1 amp β = 10	0.27	1.6	0.4	
			2.5V	@ 5 amp β = 10
V_{BE} @ I_c = 1 amp β = 10	0.83	1.0		
C_{ob} @ 10V	180 pf			
I_{CBO} @ 30V	Ranged to all extremes			
h_{fe} @ 20 Mc I_c = 500 MA V_{CE} = 10V	Ranged 2.5 - 3.5 ~~continue [illegible]~~			

Mesaed Emitter (Similar to RCA devices but

Run #	Resistivity	B. W.	Geometry (size	β@10V w/50MA=I_c	BV_{CEO} (Punch thru) @100MA
3	16-17Ω-cm		6000	20	110v

3 V_{CE} sat @ 500MA β=10 1.2V but with overlap diode subtracted out it becomes .2V and V_{BE} very uniformly .68

Run #	Resistivity	B. W.	Geometry (size	β@10V w/50MA=I_c	BV_{CEO} (Punch thru) @100MA
6	16-17	14.5μ	6000	19	29v
8	11-12Ω-cm	9.5μ	6000	38	77v
9	11-12	10.3μ	7000	20	30v
10	1.5-1.8	7.25μ	6000	18	66v
11	1.5-1.8Ω-cm	6.8μ	7000	e-c shorts	-----

Oxide Masked Emitter

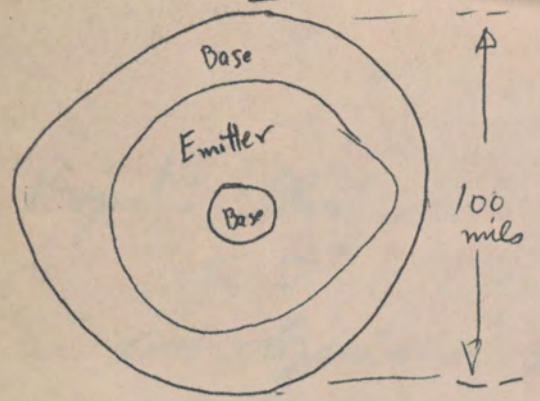
Run #	Resistivity	B. W.	Geometry (size	β@10V w/50MA=I_c	BV_{CEO} (Punch thru) @100MA
4	11-12 Ω-cm	9.5μ	6000	32	41v

Epitaxial P-N (collector) Junction Mesaed

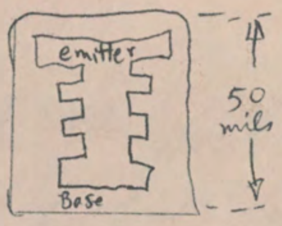
Run #	Resistivity of Film	Thickness of Film	B. W.	β@10V	Punch Thru Voltage
1	3.1 Ω-cm	51 fr.	43 fr	75	40v
6	3.0	37 fr	24 fr	75	32v
7	1.7	29	21	70	45
8	1.0	30	13	72	55
9	1.7	28	26	22	55

P. James
R. Parker 6/27/61

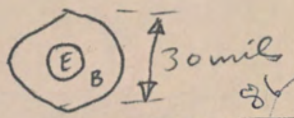
X7000

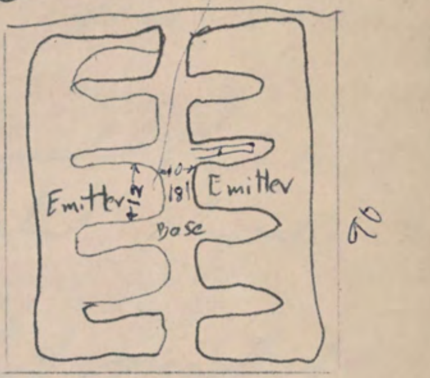


FT6200



FT4200





Proposed New Geom
for X7000

X7000 has 3.6 times area of FT6200
but only 20% more emitter periphery
X7000 has 11 times area of FT 4200
New Geometry with same Area would double
emitter periphery!!

25 units tested for NPNP switching

	½ amp	1 amp	5 amp
25°C	none		none
100°C	none		none
150°C	none	none	two at 3 amps out of 25
175°C	none	none	

Project: Must work out the following:

1. $\geq$ 10% yield of dice to high specs to an objective spec. supplied for
   - a) A non-epitaxial experimental device
   - b) An " objective device

   must be obtained regularly.

2. A practical contacting method must be developed and demonstrated. Good to 10 amp.

3. Interim package in TI thing for the evaluation of high current characteristics.

4. Check Al metallizing that can be used. If ρ this is $\leq$ 0.01 $\Omega/\square$ after alloying, make new masks.

Objective specs:

BV_{CBO} (1ma) $\geq$ 100   ρ 2-4 Ω-cm

h_{FE} at 5amps, 2v $\geq$ 30

$V_{CE}(sat)$ 5amp, 500ma $\leq$ 0.5 v

Milestones:

New masks by [redacted] Aug 15.

Alternative contacting scheme discussion (P.J. presentation) and packaging by R. Brown. Aug 4.

Epitaxial samples, ~~[illegible]~~ [illegible] geometry, power packages by July 31.

All epitaxial profs ready for transfer schedule by Oct 1.

Suggested supporting ~~inf~~ research.
1. Pinholes

Need development
Package

Project Review, X-2000 - Project 136 | July 7, 1961

~~Definition~~

Review:

Preform bonding: during last 3 weeks has given ~41% (out of 300 start) thru 1st encapsulation. This has made the preform less critical.

Opens are reduced considerably by using a soft initial encapsulation. This, however, creates problems later.

Objective: good dice thru encapsulation ≥ 60% by July 31
≥ 70% by Aug 31
≥ 75 by Sept 30
≥ 80 Oct 31
≥ 85 Nov 30
≥ 90 Dec 31

Objective: ~~Expap~~ Extrapolated prime costs (confirmed by S.E. in Mtn View) at ≤ 0.08¢

Re-encapsulation

2 Projects <u>108</u> (7000 development); <u>136</u> (X-2000); <u>144</u> (1500 dev)

July 8, 1961

Project 144 — <u>1500 Series devices</u>

Review:

1740 — All in Mtn View. Len is following life test program. Runs being made from 0.2 to 50 Ω cm material to make plot of LV_{CEO}, h_{FE} vs ρ.

1741 — Shotgun approach to get ρ of film. Study effects of film thickness, but looks ~ 10-12 μ. Normal (or better) yields and diode hardness

Storage time on 1741's are lousy!

1741 is useful only if it approaches the switching performance ~~(storage tim~~ of the 2N695.

Au in 1740 is being re-checked
Calculation of effects of substrate impurity diffusion being ground out.

Make some 1710's and 1711's.

(See last 2 pages opposite)

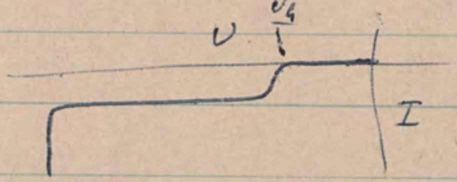
Projects 146 (4500 series); 144 (1500, con't) 7/6/61

Project 146 – 4500 series

4700's using 1740 diffusion (~1000 good ones to meet Autonetics spec except for BV_{CBO}) are being made in Mtn View. (See memo of 6/16/61) — Aim at out by Aug 11.

There is a run oriented problem with 1740's wherein the devices become soft on power aging. Needs investigation!

The O.B. match test has some (a very few) that don't change.



The "hook" characteristic where V_h can be shifted up and down by the O.B. match test has not yet been explained.

4701 — a few will be thru about next week
3501 — first run ready for emitter diffusion.

Channel extent limitation samples showed no low breakdown.

Summary of jobs

1741 aim at 2N695 specs
1710-1711 samples to make & evaluate
Optimum recombination doping study
3501 design & feasibility
4700 1000 samples
4700 direct 4500 replacement development inc.
channel eliminating studies
Completely unguarded units for β degradation.

Results in order of need.

A A planar 4500 replacement
A A device to compete with Ge PNP's
B A high current PNP without β degradation.
C A high voltage PNP, ~~[illegible]~~ a h_{FE} useful at I_c 100μa

Suggests β degradation study on PNP SCT.

Program: Project 146 - 4500 series

Objective optimum PNP planar in production.

Task 1. Study Ga furnace and/or limitation of channel area to learn to make 4700's meeting ~~$BV_{CBO} > 50$ volts~~. 4500 spec.
Life test of limited channel devices 100 hrs by July 14.

Task 2. Make and evaluate 3501's. Determine if yield looks practical, switching times and β degradation. First ~~set~~ ~~[illegible]~~ samples to O.B. by ~ July 21.

Task 3. Prepare to transfer best product (LV 4700, 4700, 4701, LV3501 or 3501 in order of increasing desirability) during the month of Oct .

Project 144: (1500 series)

Objective: A PNP silicon to compete in the ~~same market as 2N501, 2N~~ high speed Ge market.

Task 1. Try Au to kill storage in thin base PNP. 1st order feasibility statement by end of July.

Task 2. Some feasibility samples of 1710 & 1711's. These can be one-shot deals for order of magnitude evaluation. First samples by end of Aug.

Task 3. Do calculations on effects of substrate impurity diffusion on 1741's and other epitaxial PNP's. From these make 1741's with optimum epitaxial thickness. Evaluate these for storage times and correlation with LV_{CEO} or C_{OB}.

Task 4. Measure epitaxial profile by capacitance on grown test junction and diffused junction. Consult with VHG on techniques. ~~Jon~~ C.C. will make samples, O.B. will measure them.

Suggested research: Other ~~lifetime~~ deathnium that segregates preferentially into P-type material.

Comment: The personnel working on the pnp project, 144 & 146 will be increased during July by ~~transfer~~ re-assignment of responsibility of existing personnel and by looking for a technician.

Project Review, July 10, 1961 Project 145 - 4000 series

This is picking up the 3001, 4201, etc and some studies on high BV_{CBO}, etc.

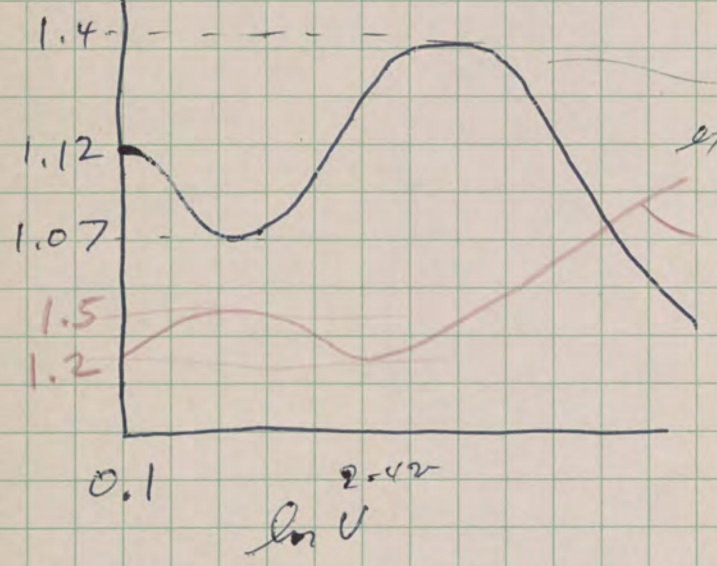
Review:

On H.W. epitaxial some wafer of 3001 are very good, but The 3001's show an abnormal fall off of low current β. This is an EB channel problem that is not so bad if the a Ga treatment is given but it shows all the problems one would expect (ie, collector channel).

This is the principal 3001 problem.

R — These all have the regular epitaxial switching problem. THIS SHOULD BE UNDERSTOOD.

O.B. says that there is a screwy capacitance problem on SOME OF the epitaxial units. For example on an epitaxial diode



This bump may be associated with excess leakage.

Qualitative behavior of shunt resistance. (Notice that this corresponds to a pretty lousy diode by shunt resistance)

In the forward direction it falls from 0 volts.

Left to do on 3001

T R.C. 1. Clean up low current β.
T O.B. 2. Measure temperature effects on the low power.
T O.B. 3. There is a new failure mode in these devices ~~that~~ must
T R.C. be analyzed. Until then a conservative $I_C(max)$ spec should be included.
4. Present package is defined as TO-5 flat Kovar.

145, cont'd

R – On 4300's β goes down on Au diffusion, it goes up on 1340's. A run was made of 4300's with exactly 1340 diffusion (and with a control?). The β's still dropped on the 4300's. An area effect? We will do a split run to confirm this screwy effect – R.C.

(R) The anomalous microphonic effect in planars w/ mesas is being checked by Lon Reiss. This must be confirmed and understood or not confirmed. ~~UHG & DFA will get together with P.F. & R.C. to~~

(R) T We should have the data on how to make 4200's meet the old 4000 spec. Should aim at all D.C. specs, but just miss loosing on V_{CE} and/or 150° I_{CBO}. Say aim at ~~10~~ 5-10 μamp I_{CBO} with no yield loss to 50 mμa. Phil Flint have taken some preliminary data. UHG & DFA will get together with P.F. & R.C. to get ~~this~~ this done as efficiently as possible.

Work on increasing BV_{CBO}'s on 4205. ~~Ga diffusion~~

4205	– 100	volts
4205+Ga	– 150	"
Mesa	– 190	"

By removing oxide, etching lightly and ~~at~~ then re-oxidation

R: Some 300-400 volt units were made ~~out of units previously having <200 v.~~ on a piece of material that previously gave <200.

This whole area has many witchcrafts in it!!

R Slow cooling vs Ni gettering is best done outside of this effort.

T Major problem: low temperature β. Not being solved at Mtn View accord to UHG. Have a meeting with Mtn View to examine. A definitive program will result.

(GEN) Cancel #191, assign charges to 145. – Done 7/10

Project 148 - Diodes July 10, 1961

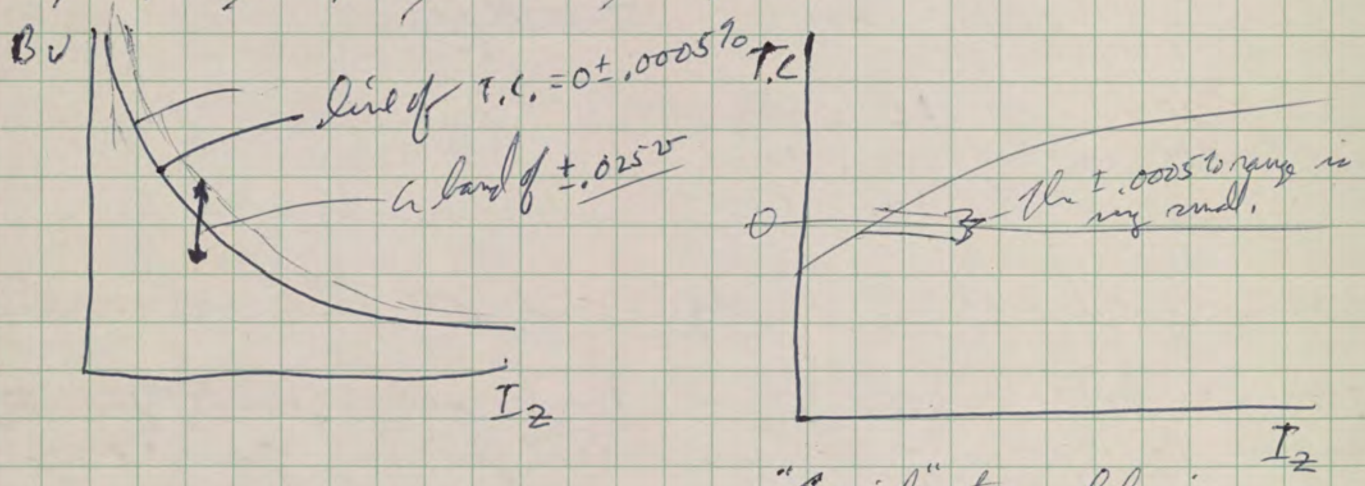
Zeners: - New #

Temp compensated unit:

Competitor units ±.001% @ 1ma (60 dynamic at 1ma), 10.5-11.3.
Hoffman

±.0005 %/°C @ 7.5 ma (25Ω max)8-8.8v.

We have made measurements on
FT -1340
1341
1240
1243 from emitter to collector
at 100μa, 250μa, 500μa, 750μa, 1ma.



"Typical" type behavior

Out of 35 diodes

I_z	10 ≤ ±.0005%	±.001 ~~[illegible]~~	±.0025 ± ~~[illegible]~~
100μa	5%	15%	80%

T. Determine roughly the distribution of T.C. for some of these units — say for a random sample of ~~100~~ 49 units. This is included in next task.

T. Distribution of V_z at some useful current of a good random sample of FT-1340. Take ~200 units of representative FT-1340's. FF will work with Lloyd Walsh to collect the sample. He can also check regarding the data logging (card punch) to punch out the BV_{ECO} at I_c = 100 μa, 500 μa, 1 ma.
Take a representative sample from these for T.C. measurement. This should be ~50 units. July 31

Work on new 3-layer Zener structure to continue. First samples then by end of next week. — July 21

T F.F. will publish his curve of BV vs I_Z ~~with~~ for ~~with T.C. < ±.0005~~ with T.C. as a parameter.

T Try to make 7.5 ma unit of T.C. = 0 ± 0.0005. This requires the 1210 diffusion. Expect to get to this as a defined structure during Aug.

Work on the straight, single junction temp. compensated Zener is discontinued for now.

Personnel involved: Franco Forlani

Franko is planning on returning the end of this month. This is somewhat up in the air.

T We need some precise operating life data. Start with ~20 of the 35. Get more data on the ~50 1340 samples. O.B. will see that this gets done. ~~Some~~ 100 hr data on the original 20 units will be available by ~~July 31~~ Aug 4.

T Transfer 1st T.C. = 0 Zener to production during Sept 15 – Oct 15. This implies final design by ~ Sept 1.

T Completed product manual by Oct 1

148, cont

FD-5 ~ O.H. with Broze

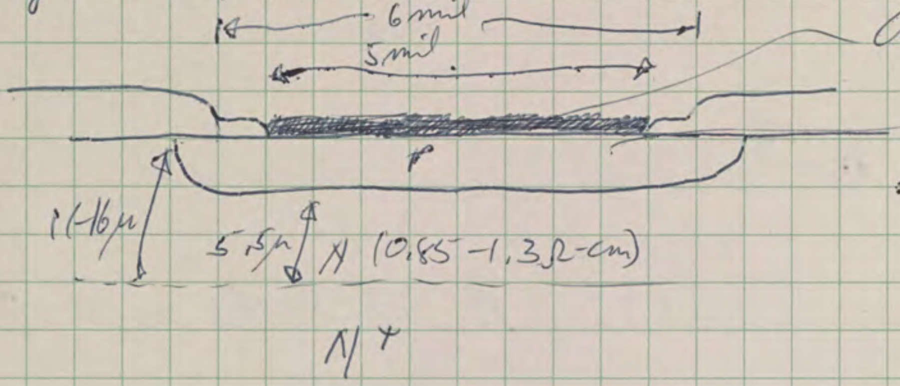
T Product Manual – Draft form by Aug 1; Complete by Aug 15. O.H.

Project review:

Problem: There is an apparent increase in leakage on power life.

A decent Al alloy has given shorting problems.

Best guess of FD-5 structure



Al alloyed well (3 min @ 580°)

Emitter-type surface concentration.

We are using 6 mil Au balls on these.

No final devices have been cranked out yet.

There is a lot of waxing & waning on exact size.

T Duplicate S.R. soldering cycle — by end of Aug.

T Compare methods of solder dam.
1. S.R.
2. Our version of S.R.
3. External, hand job.

Units (dice) to S.R. on 7/13, complete by Aug 10

T Aim at 1 run of 3 wafers /day starting no later than 7/12. Assemble ~ 20 units /run to evaluate.

T 7 mil material spec by Aug 1. Material will be Amco grown.

T O.H. will present the back-side solder case on Thursday.

T ~~Life tests~~ ~~Over-stress~~ Torture tests of these diodes: ~~O.B.~~ 100 representative units by July 28. ~~Rating~~ Results by Aug 31. Environmental at San Raphael. ~~[illegible]~~

O.H. has supplied some 8pf, 60v ~~[illegible]~~ BV diodes with > 1amp at 1v.

T We will be in a position to measure recovery times this week. There is a potential correlation problem with San Raphael. We will try to con application out of their Tunition scope to alleviate this problem. Correlation to be obtained by Aug 7 (O.B.)

Diode arrays: Larry Ragle - New H

Review: Made ~125, ~ half shelf.

Yield data:

On wafer before dice good arrays (7 out for diodes) ~90%
Good out of dicing compared with good in -30-50% at best
(This is just a mechanical dicing problem)
Assembly yield (no reason to expect it to be bad) ~70%

It looks like 0.9 is about the probability that a given structure is good.

T ~~Take~~ Try some epitaxial material in both direction of polarity?

T Decision on how this device transfer to production by July 15. (G.M.)

T Does the capacitative coupling bother in std applications?
O.B. - Answer by Aug 31.

Ultra high speed: - O.H.

No work recently. Fastest to date ~1.2 ns. Some very strange results are in existence. No existence proof.

T A rough objective spec - DFA to issue Aug 1

T An existence proof to objective spec. - Aug 31

μ-diode, VSI form factor Len Sedlick

T 10 Existence sample by Aug 31.

Other packaging will be picked up under packaging.

Project Review - Projects 152, 153 July 11, 1961

The micrologic family:

Transfer schedule to Mtn View:

Aug 1 — Mtn View in operation with in process inventory of F.F. and/or gate.

Complete family of 6 elements being made in Mtn View by Oct 1.
~~All masks~~
First go-around of masks for family completed by Sept 1.

Transfer implies the ability to make a yes or no decision.

T RHN will assume that the testing can be done.

Where do we go from here?

1. Larger arrays using the same technology.
2. Analog circuits
3. Other digital

Full shift register stage (25 elements) — L.K. right after 1st family.

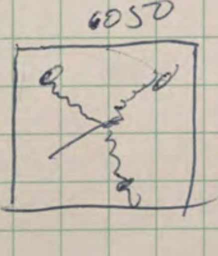
Circuits with ≤ 8 Xstrs and resistors ≤ 1K that can stand capacitance, etc, will be made directly in Mtn View.

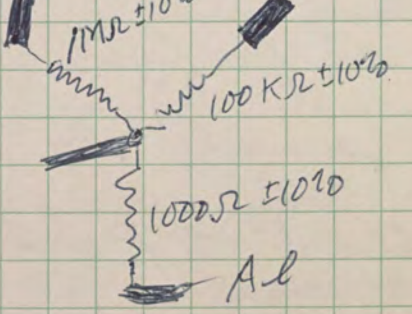
D. Need S&R field of ~.200"

T. Mask-making technology to Mtn View by Jan. 1, 1962.

New technology: — J.C.

Resistors: Aim at this array





on an oxidized Si substrate.

On these resistors aim at 0.01%/°C. JN & JC will lay out a reasonable time scale and intermediate objectives.

Capacitors: — R.M.

We must see what MOS and junction have as far as C/unit area and temperature coefficient.

An objective of new technology might be ~ 0.01 μF in .050 square.

Special gadgets: — Needs a lot of discussion.

Project Review - 1000 Project #143 July 11, 1961.

In the mill -

The 1310 is gone

Working on 1311 -

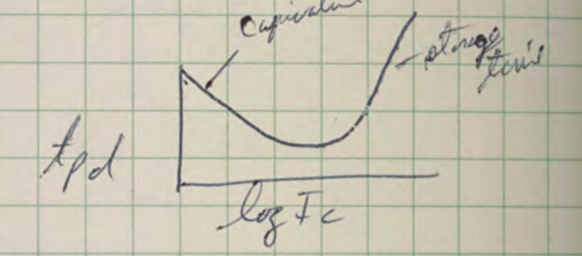
Problem - Question

1. 1311 not as fast as 1310 unless β of layer → 1310 β.
2. There is a material supply problem.

We now use propagation delay as our measure of speed

O.B. has written a report showing that

$$t_{pd} \sim A\frac{1}{I_c} + B t_c I_c^2 \quad , \therefore$$



The good 1311's and 1310's give ~ 3 ns at ~ 5 ma
1340's " ~ 8 ns at ~ 10 ma

T. Define 1311 - double base stripe by definition.
$LV_{CEO} \geq 8V$
Speed ≥ that of 1310
$V_{CE(SAT)} \leq$ 1340, it would be nice to get 0.5 v @ 50 ma.

Aim at final design samples by Sept 1.

Transfer during Sept. This requires a new stepping.

T. DFA will follow the Mtn View work on a very low current ~~Ba~~ device.
We would like to have a 1210 sized device that has good low current β. Say ≥ 20 at I_c = 100 ma

~~1210~~

FT - 1220

Make a few runs ~~[illegible]~~ (square pattern) to try to get good low current β. Priority below 1311 work.

T: Device 1200: Aim at 1ns propagation delay as next generation device f_{max} 4KMC.
This is a big packaging problem.

For evaluation it might be useful to take a piece of ceramic that can take, say 10 units. This could be made by silk screen. This will be integrated as part of packaging.

Agg. device
Blow-out procedure ok
Device yield ok
Bar bar procedure seems to be working, but resolution is poor. We are using Al on Al, but there still seem to be some contact problem.

T

This project is concentrating on solving the bar bar problem.

1211 Must be defined. It is 3 stripe geometry. It is designed as a power oscillator (power out at 500 mc). $P_{1211} < P_{1311}$.
It will go to production during Oct or Nov.

Plot P.O. @ ~~[illegible]~~ 1000 mc vs. β and thereon. $BV_{CBO} >$ ~~30~~ 50 ~~30~~

Project Review - Field Effect #189 July 12, 1961

Review: (~~Otto~~ Leistiko)

Out diffusion

Aimed toward the chopper configuration (See Hilbiber Memo)
$r < 100\Omega$ at $V_g = 0$
Need not be completely pinched off
BV ≥ 5 v.

Getting special Xtal - geometry angle grinding ~~there~~

got 272 ± 41 Ω for channel resistance over 1 run (13 units) in one run (wafer)
BV avg 32 v
$I_{~~\phi~~gd}$ (15v) 68 μμa } No metal, just wet O_2 and slow pull
25v 100 μμa }
Using metal one gets ~ the same thing.

There we can't pinch off - probably ~ 60 v V_{PO}.

C ~ 24 pf at 0 v ~~dep~~

V_{offset}: < 10 μv at 100°C, << 1 μvolt at room temp.

It looks like this is a fantastic device as an isolated instance.
Questions now are
1. Is it reproducible
2. Is it testable - yes
3. How do we handle?

This has all been Al-P. Just recently we got some Ga-P material. The initial Ga results look v. good.

Xtals to OL by Aug 1
Devices to DH by Sept 1

T It is necessary to take best guess process and determine reproducibility. Say start with 5 Xtals aimed at identical specs of Ga-P material. Try to make reproducible devices from various places in the Xtals and evaluate for R_{ch}, I_{S60}, offset at 100°C by D. H.
Get this out by ~~Aug 31~~ ~~[illegible]~~

T Make some epitaxial ones. It would be very interesting to make them in the other polarity too. Samples of n on p by Aug 31, p on n by Sept 15?

Check Xtal to Xtal
One part of an xtal to another
Run to run.

Pentode:

Requirements: Must pinch off at $V < 10v$
< 10 pf, pref 1 or 2
$BV \geq 40v$
$I_{SDO}^{(sat)} = 200\mu a$ to $600\mu a$

This implies ~$5K\Omega$ for channel resistance (different Xtal than "Probably")

This used the double-striped 1210 geometry, but the final device need not have two devices. Some of these look good.

definition $V_{P.O.} = V_g$ for $I_{SD} = 0$
I_{SDO} (sat) = saturation current S-D with gate open.

Contact areas must be deep

Eventually this device will need new masks

T. Measure noise figures on some of these Dave Hilbiber - by Aug 1.

T. Make some of these to check on ability to hit objectives such as I_{SDO}. This comes after the chopper version in priority, but some should be made by Aug 31 to check this.

Priority:
1. Make chopper by best technology
2. Compare technologies
3. Make pentode & other structures.

Bigger Pentode - larger version of ~~above~~ C.L. pentode - no one making any for now.

Switch: Like the pentode, but better on impedance and higher off would be nice.

Metal over top ~~[illegible]~~ field effect: — 4th priority for now.
Possible advantages:
1. Normally off switch
2. Double gating for lower pinch-off voltage.
3. ∞ input resistance.

Field Effect, cont

VHG notes that the out-diffused type devices are incompatible with integration with std. gadgets. & 189

Project Review: #162 July 14, 1961 – Film Growth

Arjun Saxena:

Bell jar did ~6 wafers/run, but good ones. Very poor doping control.

~~####~~ Tube-type resistance furnace: Boat material is a problem as is mounting

Some wild approaches to the boat are in the mill – eg, pyrolytic graphite

± 5% on film thickness except at center. – Deposit at ~3μ/min.

On doping system the gaseous dilution technique is potentially very flexible.

The boat problem has arisen with new graphite supply.

Hank Wigton:
No metal in the system
Liquid phase feed

Recent problem has been that substrate have contributed most of the doping.

Using only high ρ P-type wafers and growing n, one gets as good uniformity as can be measured.
1Ω-cm goes to 0.1 un backed
0.9 " " 0.4 oxidized
0.9 " " 0.6 wafer backed.

Work is progressing toward solving the uniformity problem.
When wafer backed, there is Si transport from backing wafer to top wafer.
This is worth checking further.
By making bigger envelope the ±20% dropped to ±10%.

H.W. thinks that ~95% yield to 1341 spec is reasonable.

Flexibility is the problem. Personnel to evaluate is also a problem.

4 Segments

1. Get a system for production
2. Service
3. Understanding and extension.
4. New systems & materials.

II. Service area:

A three-headed monster like Prod. would do the service job. This would tie up a r.f. generator completely. It seems that our r.f. requirements for r.f. are as follows:

Service system
Xtal growing
Experimental epi.
} 25 KW at 450 KC

(Pedestal growing) — 10 kw at 450 KC and 10 kw at 4 MC.

Aim at a service system set up on time scale consistent with space available
6 weeks for generator
1 month to build system ∴ Sept 30 for first materials

Q: Can the 10 KW machine do the research epitaxial job?

III. Advancing technology and understanding with respect to Si:

1. Process response & control. Aim at control and prediction of resistivity and thickness. Say ± 20% on ρ, ± ? on thickness

2. Growing junctions both at interface and in film. These should behave as expected with respect to capacitance, leakage, etc.

3. Unique structures including multiple layers of various dopings, masked structures and structures combined with ~~masking~~ our old technology of diffusion and photo-resist masking.

IV. Research direction

1. Large areas on something if an idea is available

2. GaAs on GaAs and GaAs on Si or Ge

I. Shear Gage

A. Theoretical considerations

Determine relationship between geometry and "transducer gain" (9/1)

$$G_{TV} = \frac{\Delta V}{F_i \Delta \epsilon} \quad + 1MO \qquad G_{TP} = \frac{\Delta F_o}{F_i \Delta \epsilon}$$

B. Technology investigation and development

1. Minimum repeatable X_j — check theory. (9/1)
2. Geometrical accuracy (output terminal offset) — (9/1)
3. Surface conditioning (for 2. and higher strain)

C. Product development (11/1)

1. 1:1 ST replacement — std. strain element
2. 1:1 STB replacement — 30Ω strain element
   a. Mask design
   b. Product evaluation

D. Silicon sensor base — Donut with a ~~tonge~~ of Si — Feas.Date (10/1)

1. Technology development
   a. Etching techniques
   b. Masking and aligning techniques (sensor)
   c. Base mounting
2. Theoretical considerations
   a. Optimum geometry
   b. Strength of material

II. Transducer Development

A. Accelerometer ← Being xferred to L.A. now, complete by (9/1) (They are having some trouble being ready to market it)

1. Damping studies
2. O.T.T.L.A. Orderly xfer to L.A.

B. Second generation transducers (after 11/1)

To follow shear gage development

1. 0% pressure transducer — Complete re-do w/ s.o.a. tech. — July, 1962
2. Low range accelerometers
3. Consumer products — Phonograph pickup?
4. Small accelerometer — Probably before 2 — Early 1962

-1-

Kobell
Kuind
Regan
Kofley
Kuck
Moore(LAU)

III. Special Gage Elements

A. STB for LA--on demand + 1MO ~~[illegible]~~ 15

4 more evaluation runs--masks ready-to product spec. ~~(1 month)~~

B. Bondable gages — If we want to go for BLH.

Feasibility investigation of fabrication and bonding

C. Oddball sensors

1. STR--3200 square

2. STV--with transistor

D. Phenomenological investigation of other strain effects (10% one man)

IV. Standard gage evaluation

A. Characterize ST elements 98% complete

B - Scribe dice evaluation.

1. eval. 4 beam. backside scribe
2. eval. 100 beams 10^6 cycles

strain gauges July 17, 1961

19

Kobell
Grinich
Pearson
Lofberg
Wick
Moore(LAU)

Std Gauge evaluation:
Seibel dice or U.S. dice vs. std
Rept in preparation on T.C., sensitivity, etc. (N. Pearson)

resistance change ~~Ptl.~~ 15-17%/100°C at emitter doping of boron
~26-27%/100°C near ~~base~~ doping of boron

mesium 23-27%/100°C at base doping
" ~18-23%/100°C at emitter doping

Essentially independent of orientation

Au didn't help much because it ruins junction first.

$$E_y = j_x T_{yx} \Pi_{1212}$$

It is necessary to confirm the eqn above by making and measuring structures

The optimization desired is Vg optimum consistent with output impedance.

Film, cont.
Argon system
Boat problem

July 19

--

Boat must be impregnated with Si by coating and melting. Perhaps coating without melting is ok. There is a real graphite problem — it worked once, but we dont what "it" is.

Materials problem must be solved. this should be by either

1. Coating without melting or
2. Better graphite.

This looks like it could become a real merry-go-around.
T(?) It looks like not melting-in is a first thing to try.

New manifold is ready too - a couple of weeks to set up.

Follow up to get results and check — work until production is going in one system or another.

T. Some surface barrier capacitance measurements to map resistivity and correlate with other techniques would be useful. A.S. will do, CTS will consult.

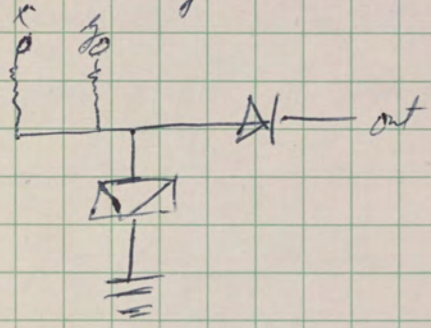
We will get together in ~1 Mo or so to see where we go from here.

July 19 — Tunnel diodes

Project 150

For Si; CTS suggests reverse diodes

IBM tunnel diode memory



Also on GaAs work — nothing specific for now.

Masking technology: July 20, 1961 Project 126.

Mask making

KPR

Mask making (photo)
Problem
1. Capacity of service masks
2. Max resolution over 80 mil circle
3. Present µL type resolution over 120 - 140 mil if pattern ≤ 6
 If > 6, then

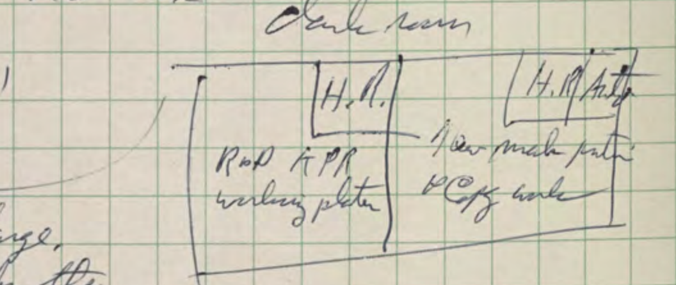
This is limited by the coordinagraph field.

It is established that for any pattern of which we can conceive that an absolute scale factor as ± 2.5 %. ~~If this is not true, then~~ The only

attn. GM Porter James has screwed up the system by straining the sizes.
This must be cleaned up!!!!

attn. GM 4700 is also asking for a 0 tolerance mask

Bottleneck and Problems



1. Scratches on plates (copy camera)
2. Step & Repeat (capacity)
3. Printing Space and equipment.
 The working plates job is getting v. large.
 Part of this is that people order masks they don't need. For example XFD 5 has ordered 100 masks they don't need.
4. Gross lack of experimental facilities.
5. Waxing of plates (off and on) one girl can do 50/day max.

On the copy camera

Set up – 2-4 hrs

From now on we will reject a box as soon we find a scratch.

On this basis it should only take about 10 minutes to shoot a good plate.

∴ Two patterns per <u>day</u> seem reasonable here if (necessary)

Presently the same one person does the coordinagraph and copy job – and keeps up!

~~I Copy camera needs three point suspension for the pattern~~

S&R.

Set up – 2 hr /pattern – Most of this is getting rotation & exposure correct.

Stepping is ~4 hrs,

∴ 2 pattern/week capacity.

From here thru working plate this must be done:

1. Print sub masters ~~co~~ – an exposure pattern – 2 hr/submaster-pattern

∴ We turn out ~6 sets of submasters in 20 hrs for a 10 pattern mask.

2. Print working plates in 20 hrs

∴ Balanced line is 2 sets/week.

To be continued sometime!

Project Review – July 21, 1961 – Photo

1. Solar Cells – no more work is contemplated at ~~present~~ moment
It looks like we can make 10% n+ on p's for @ 90% yield.

Project 170:

2. (see slides) Send a memo to Bob Graham describing how to make and test FSP-5A and forget it. Aug 1.

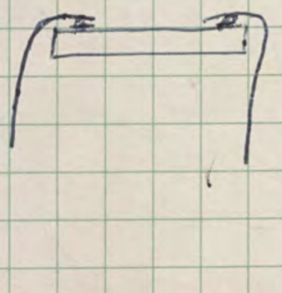
3. XPD-1 photodiode needs a mask of a 0.006" dot on 4200 spacing. Its advantage is that it is the fastest photodiode available.
It has advantages of
a) speed
b) linearity

4. Special product – darlington. To be made by special products

5. – The real impt. R&D job
This aims at a cheap photoxstor of 50×50 mil die size.
Main missing pieces:

T. Get moisture proofs

1. Solderable metallizing for



tape assembly

2. Clear plastic encapsulation

3. Life & reliability

Needs new molds.

PROJECT 117--SOLAR CELLS

Objective:

1. Determine suitability of technology for solar cell production.

   Answer: technology suitable.

2. Determine economics of production.

   Answer: Probably not economical.

Recommendation: If answer to 2 is negative determination should be made to drop project or to conduct a ~~marginal~~ MATERIAL investigation.

PROJECT 170--PHOTOTRANSISTOR DEVELOPMENT

Elmer will see that:

1. FSP-5 — (4205, hi β @ 1μa I_B with ~~[illegible]~~ a lens)

   A. Military specification

   B. Frequency response characteristic

   C. Spectral response characteristic

   Main problem: Measurements under control.

   Recommendation: Complete items above by Sept. 1, 1961.

2. FSP-5A--High Sensitivity (no base ring)

   write memo to S.P.

   A. Repro runs

   B. Characterize

   low priority for us. Roberson can make them.

   Recommendation: Have testing done by Device Evaluation. Complete by Oct. 1, 1961.

3. XPD-1--Photodiode — just 4200 base diffusion

   A. Complete characterization

   Eval)

   B. 5 repro runs

   Recommendation: Complete by Aug. 1, 1961. Introduce product at WESCON.

4. XPT-2--Darlington Phototransistor

   A. Complete characterization

   Evaluate lot — Aug 15.

   B. 5 Repro runs

   Recommendation: Complete by Aug. 1, 1961. Introduce product at WESCON.

PROJECT 170--PHOTOTRANSISTOR DEVELOPMENT (Continued)

5. XP-3 Family of economy devices

   A. XPT-3 phototransistor

      1) Objective: Photodevice for data reader at low cost with universal mounting for card and tape reading.

      2) Cost: 10 cents prime cost maximum.

      3) Dice Design:

         a. Preliminary mask--completed.
         First run--completed.
         Evaluation--in process.

         b. 2-mil emitter evaluation to be completed by Aug. 15.

      4) Package--complete by Dec. 1, 1961.

         a. Die and lead attach methods complete by Nov. 1, 1961

         b. Preform--complete by Nov. 1, 1961.

         c. Encapsulation

            1. Plastic

            2. Glass

         d. Mounting--printed circuit board with connection.

      5) Evaluation and characterization complete by Feb. 1, 1962.

Recommendation:

A. Make major push on this product.

B. Prepare Application Notes, etc.

C. Complete per schedule above.

D. Introduce product at IRE, 1962.

PROJECT 170--PHOTOTRANSISTOR DEVELOPMENT (Continued)

6. Lateral Photodevice (XPL-X)

Objective: Lateral photodevice, single dimension at this time.

Work required:

A. Mask design--1 week.

B. Packaging--0.008 week.

C. Contact design--1 week.

D. Evaluation and characterize--1 month.

Recommendation: Develop product-work should be completed two months after approval.

7. Photochopper

A. Characterize in terms of β and light sensitivity (1-2 weeks)

B. Design chopper and build (1 month)

C. Characterize and Application Note (1 month)

Recommendation: Complete project as manpower permits.

8. Special Photocell--Scanner Photodiode

Recommendation: Complete as manpower permits. — 3 months due

PROJECT 179--EXPLORATORY PHOTOSENSITIVE DEVICE

R

1. Photodiode Arrays

   A. Low voltage array for Graphics (>10v)

   B. High voltage array for miscellaneous applications (Got to get to 600v or so on planar diode. (with shallow junction))

      1) Objective--product array of uniform photosensitivity, breakdown voltages and leakage.

      2) Status:

         a. Investigating effects of starting material, surface preparation and post diffusion treatment.

         b. Low voltage arrays to Graphics for evaluation.

   Warren Wheeler is doing this as his main job.

   C. Work to be done--other facets

      1) Contacts for high voltage printing bar--vapor deposit copper or other material.

      2) Complete contact assembly for FAX scanner

   D. Recommendations: Make major effort to complete project as soon as possible. Feasibility should be completed by Jan. 1, 1962.

2. High sensitivity photodiode

   A. Objective: Investigate linear avalanche phenomenon for applicability to solid state photomultiplier.

   B. Investigations: Large geometry photodiode on high resistivity material.

   C. Recommendations: Should be high priority project; results of photodiode ARRAY development should be applicable to this project.

3. Measurement Standardization

   A. Objective: To obtain a standard method of measurement for photoelectric devices.

   B. Tests to be standardized:

      1) Light intensity (illumination)
      2) Spectral response
      3) Frequency response
      4) Transient response
      5) Noise performance

   C. Recommendations: This project should be carried on as fast as possible. Work performed should be changed to project number (if approved) for photodevice applications.

PROJECT 188--LIGHT EMMISSION

1. FLP-1 light pulser

   Characterize

   - FT-6000 dice
     - Light output
     - Speed response
   - FT-6200 dice
     - Light output
     - Speed response

   Note: Characterization of FTD 6000 dice completed. Characterization of FT-6200 dice to be performed as time permits. Low priority item.

2. R&D investigations
   - A. Matrix arrays for memory
   - B. Investigation ham. volcano effect

Recommendations: Project should be continued but no major effort should be expended at this time.

NEW PROJECT--PHOTO~~DIODE~~ DEVICE APPLICATION

1. Conduct investigation into applications for the following photodevices:

    A. Phototransistor
    B. Photodiode
    C. Lateral photoelectric device
    D. Light sources
    E. New photodevices

    Some of the applications that should be investigated are:

    A. Photochoppers
    B. Nuclear detectors
    C. Tape readers
    D. Light communications

2. Conduct with aid and assistance of other groups in R&D

    A. Life tests
    B. Environmental tests
    C. Electrical tests

    of photodevices manufactured by FSC and other manufacturers

Recommendations: The minimum effort that should be applied to this project is one engineer and one electronic technician.

6. Lateral Photodiode

Make some planar ones to see how they work

Consider as product only if we can think of a use in a transducer or something.

7. - A special product that we should play with when we get XP-3 dice,

- Just sort of a boondoggle for now.

~~8.~~ (Write up principal works and collect the remainder)

8. Special photocell for Sam Levine

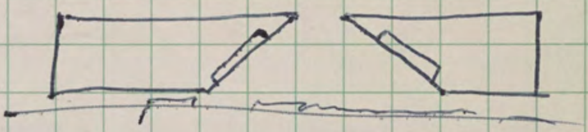


Photo diode arrays 179

Project 119 - Surface Research - July 24, 1961

Review: $Si-SiO_2$ interface & oxide itself to understand effects of charge in oxide
Study of impurities introduced by:
1. diffuse in Au evap film
Ga from spread film
H_2 gas

And study electrical properties.

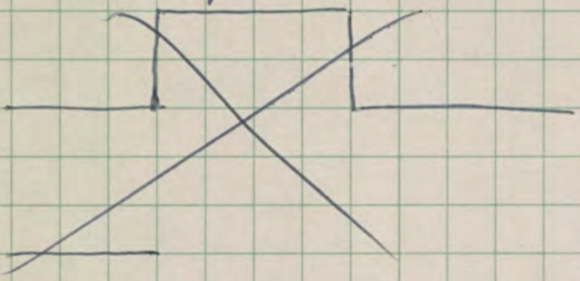
Also aqueous phase introduction of ions(?) by high field

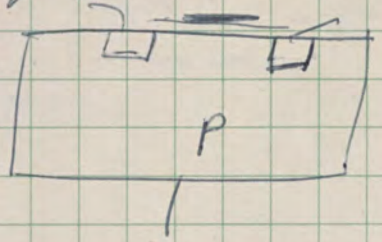
Measure surface conductance, field effect, density & energy of ~~states~~. - Reported tech.

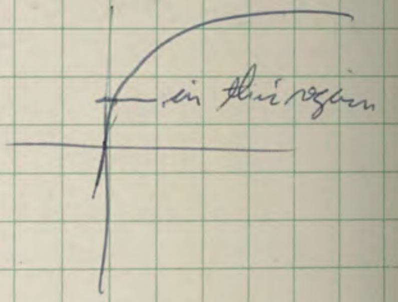
Pulse and relaxation. Some look exponential (1 time constant), some don't.

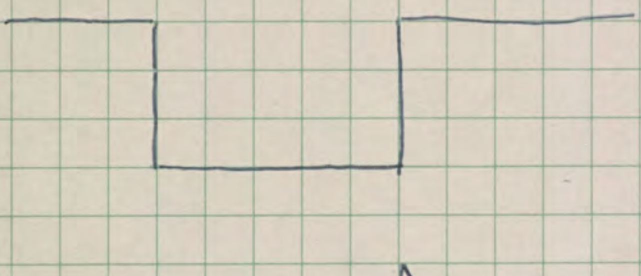
We get a relaxation time ~ 5 μsec with a slight temp. dependen

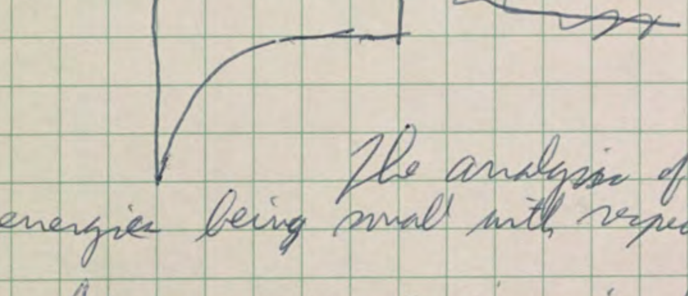
~~From these measurements~~
a typical set: (Pulse S-g, sense S-d)











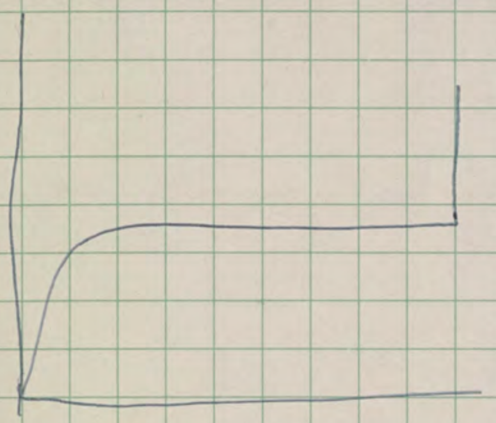
Measure slopes and/or fit exponential

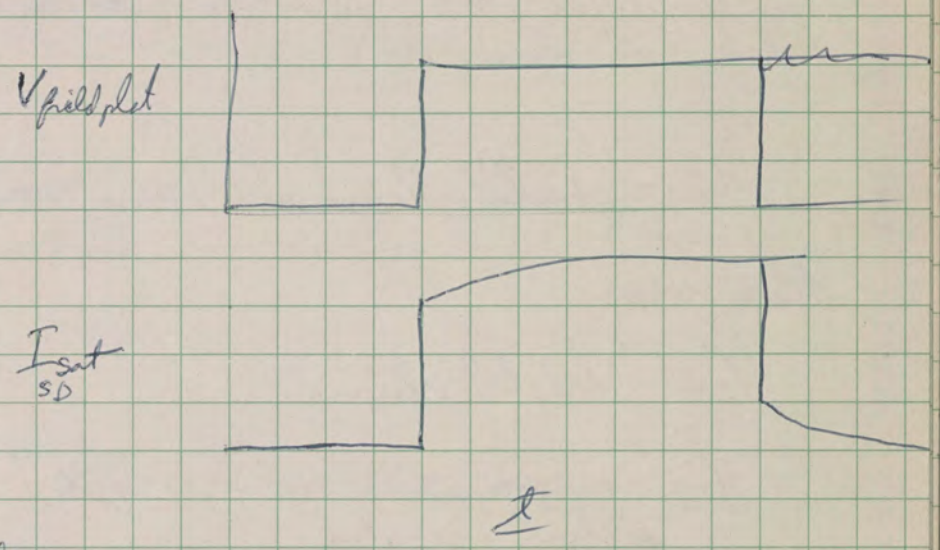
The analysis of the data (as usual) depends upon ~~the~~ energies being small with respect to kT, or large.

Au gives no inversion layer at all (1Ω-cm P-type)
Even at high field electrode voltage no scope observable inversion, but by a pinch-off direction, the BV changes down as a low breakdown.

Q What is being planned?

The results with the Au doped units is screwy.
Time dependent changes are still observed.





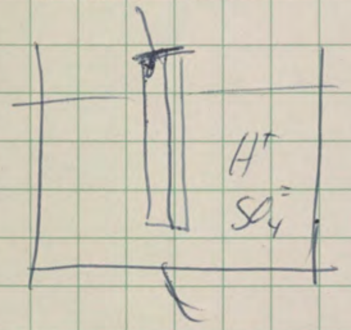
thin

1. Study to see if the long term change is ions or electron tunneling. This can be done by study of thickness and field dependence.

CTS has done some of this and is doing more. He will clear up the question.

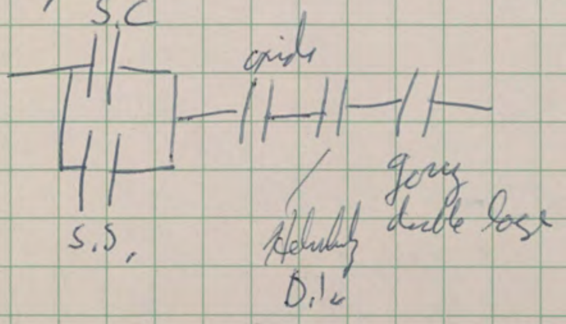
We still need surface state location study — how do we hold

Lets look at the electrolytic study:



Put field across oxide.
Measure capacitance

Object: to drive ions thru oxide.



119, cont.

~~Other possibilities~~

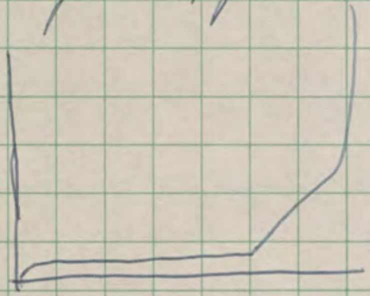
(It seems to me that the best fundamental measurements that could be knocked out is the diffusion of H_2 thru the oxide on a particular device – should be able to decide ion, atom, etc.)

Ne We will have a new meeting to lay out project in 1 week or so.

More review:

Ga treated device

Ga 10 min at 10^{-2}, 10^{-3}, 10^{-4} mm Hg vapor press at saturated gallium pressure



— Typical characteristic

On hyperbolic get τ ~~[illegible]~~ constant to factor of 3 from 200° to R.T.
Measured a trap energy level – find tau, ΔE (from cond. band)
Don't know what this means, because no undoped one to try.

No H_2O.
No thermal cycling.

New meeting in week or so to see where we go from here.

Project 121, Data storage device July 25, 1961

This aims at making a tape punch + tape reader with high bit density and relatively high punching frequencies.

Prove feasibility of 10 mil center bits.

Computer this should accept.

1. It must be able to accept the memory contents of a computer and put them back in later.

Assuming feasibility, then what?

Define a family of machines that make this useful:

1. Key punch writer
2. Reader

Then this can plug into all existing machines by appropriate connection.

We will get Sam Levine + our office machine mgr. in on this as soon as we have probe feasibility.

See sheets over.

Potentially a
real problem — Need
1Khr life or 0.1Khr
with easy change.

#121 DATA STORAGE DEVICES

A. Data recording
  1. Probe structure
    a- Material (tungsten)
      Determine limitation of probe material on write speed - erosion, cooling, etc. (in process) complete by 15 Aug.
    b- Mechanical structure
      Etched circuit
      Built-up
      (Now in study phase, experimental work to start 1 Aug.)
  2. Recorder electronics
    a- Thyratron drive circuit- 80% complete
    b- Trigger circuits- 0% complete
    (Complete by Sept. 1.)

B. Recording Medium
  1. Investigate dielectric base properties.
    a. Mylar - various grades and surface finishes.
    b. Papers.
      coating adhesion, dimensional stabilty, optical transmission, durability.
  2. Conductive surface
    Al. Al. Cu. Ni. Co. and Cr. by both evaporation and plating.
    a. Durability
    b. Recording properties.---- conductivity, melting and evaporation energy, mechanical strength. etc.
    Will investigate both vendor supplied mediums, and prop. coatings.

C. Data Reader
  1. Design sensor
    a. Structure design
    b. Procure masks
    c. Fabricate. (Complete one month after recorder structure is finalized).
  2. Optical system (Complete two weeks after recorder structure finalized).
  3. Read electronics (1 month to design and fabricate)
    a. Amplifiers
    b. Threshold circuits
    c. Strobe circuit

D. System concepts (complete Nov. 1)

1. Microtape

   a. Modify audio tape transport

      Use 1/4" tape

      Bit density--125/inch

      7.5 K characters/sec.

      9 tracks (8 data + 1 strobe)

   b. By Dec. 1 conduct successful bi-directional communication with Flexowriter.

2. Micropage

   Develop concepts for unit record machines and media.

Project Review – Project 161 – Analytical Techniques July 25,

Review:

Qualitative analysis by ring-oven technique – possibly semiquant. This is useful for many metal ions.

Three areas by B. Y.
1. New techniques
2. Services
3. Safety + waste disposal, industrial hygiene.
4. e-microscope
5. Servicing work
6. Metallographic repairing
7. Metallurgical research
8. Solvents and supply.

Pick up some day to define,

Thinking of polarographic technique.

X-ray is being built up. Short preamp, etc. With luck we will be on the air in Aug.

Inert gas analysis is needed. for H_2O ~~we have ordered Beckmann meter~~ With this and de-oxo we can do O_2 also (even if we bleed in H_2 in N_2)

T. We should be able to monitor H_2O, O_2 and dust count in any line at any time. End of Sept.

Water sampling is set up (for conductivity and particles)

Work we are doing that don't get charged to plant.
Sb in preform
Sn-Pb solder bath

(Are we paying for acids?)

Oxide etch, etc should be covered.

Electron microscope + diffraction still needs man

Betty Thomas on

a) Orientation studies
b) Phase studies (purple plague, etc) } #½

Which should be studied?

We will need the Ni/Fe ratio for magnetic field.

Make sure that Mtn View plating can do their own control.

126

Masking technology (cont from pp 22,23) July 27, 1961

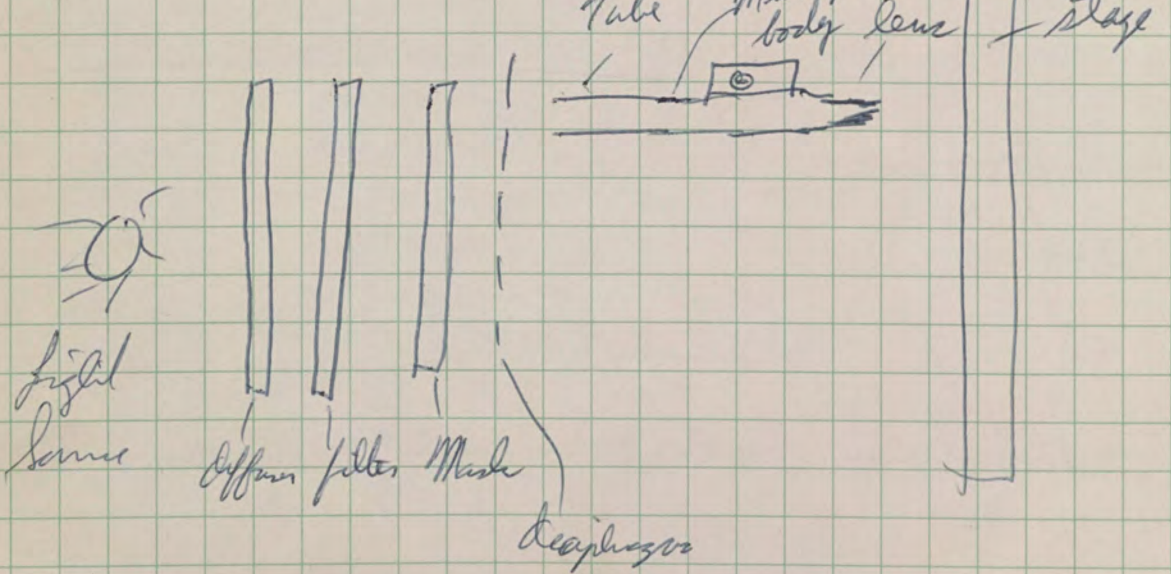
Agenda:
1. Our S+R camera * ✓
2. Setting up Mtn View —
3. KPR service
4. Optical jigs ✓
5. Other KPR technology
6. Metal etching
7. Mask alignment
8. Mask making technology - growing & shrinking

1. Our S+R camera

Present status:
Basic over-all design complete
Granite slab
Horizontal light path
X - horizontal — 360 lbs
Y - vertical 90 lbs
Stage granite + WC

Principal problems with existing are.	Method to get around
1. Pivoting of stage - need 1" of arc	Kinematic design on granite
2. Focusing	Micrometer (dial) on reference surface on each lens.

3. It will use an hydraulic drive



Time scale:

1. 5 Weeks delivery on stage. Stage to be ordered by ~~Aug 15~~
2. Hydraulic drive (~4K$) from Farrand - quote next week

The only thing holding up having this ready by Nov 1 is lack of design time (Don Elam). It could take 2 months full time to get to a reasonable point.

We want to build R&D + Prod in parallel (50K$ gamble)

Need an autocollimator. (2K-3K) to check out.

We will be on the air by Dec 1.

Optical jigs: Split field has been checked out
We have two, but we have lent them to Mtn View
Mtn View has two
One is being made for San Rafael.

~~Get Quote by Sept 30 and have as part of our service~~

II We will have these two optical jigs operating in our service (not experimental) by Sept 30.

I Order stage - bed by end of Aug.
Design complete by end of Sept.
On the air by Dec 1 making pattern

3 We must have personnel and facilities ready for dev. dev. HPR activity and independent service by new bldg time.

4 Mask alignment → We have been doing some for Mtn View + San Rafael. Masks take ~ 4 hrs / mask to align (using arbitrary pattern).

T On HPR service Monitor, record & report avg delay / operation for

a) special 3 wafer runs
b) general runs.

This should be on working hrs available and should be in the progress rept.

T Consider a notification scheme for informing people of completed runs in box.

T Order 4 mercury arc systems (two for split field jigs, two to replace C's)

5) Plans for new technology:

1. Check out AMER
2. " " KPL
3.

Will keep abreast of W.W. etch rate study.
Art is studying pin-holing, coating uniformity, resolution.

General Objective: 0.1 mil lines and 0.1 mil spaces in oxide and metal.

(T) It would be nice to be able to grow & shrink circles by a large fraction of a mil. ~~Determine what we can do now~~ – without changing c/c spacing.

6) Metal masks:

No new work is contemplated. We will only sustain the existing technology.

Projects 141, 118, 125
μ-wave plasma, parametric amp, app. μ-wave devices

~~July~~ Aug 1, 1961

The charges to 125 have primarily been the high frequency measurements on Xstors.

Eliminate 118 and 125 – Charge 141 for all work on μ wave devices instigated by [illegible] Soltz requirements.

Review: Martelli – Ho

Palo has used FD-6's [illegible] in glass pkg 2,5 & 8 pf up to the 2 kmc range.

He is happy with these. He has gotten 2.8 loss in a quadrupler to 220Mc

Main improvement needed is a decent ceramic package!! It should come today

Once he has this he wants to go to 6KMC

Irwin Ho is looking at optimization of C vs V, etc. We can try to do anything that looks better.

Planar may offer lower surface loss.

The MOS epitaxial should be a high frequency device.—

Perhaps the **MOSOM** on double epitaxial.

A more non-linear resistance than an ordinary diode could be useful (if possible).

Read diode might be do-able ~~at~~ by epitaxial (if it works in principle)

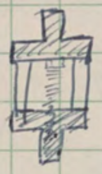
The 3rd quadrant ~~[illegible]~~ alpha Xstor – say epitaxial 1210 – could be interesting.
Need to get to < 10Ω to see this.

Some μ-wave packaging problems:

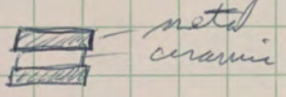
1. The co-ax cable connector is rude because it takes too long. A cheap pkg would be nice.

Brownie has a co-ax package he is working on that has the possibility of diode and Xstor job. This is basic, but will, at best, be a 5-7 Kmc pkg.

We also need a ~~wg~~ wave guide pkg
Palo is doing a double stud deal



μ wave Assoc has a 1/8" pill



Projects 166, 116 Contact tech dev.
Basic Alloying Studies.

~~July~~ Aug 2, 1961

Review: We still use Al on Si with Au or Al

1. A solderable metallized contact.
   a) A new metal
   b) A plating over the Al - Can we do this?

W.W. is working on putting Cu over the Al for Peter Ullmann.

Needed for: 1. Photo-diode
2. Power xstor
3. Variation on μ circuits.

2. A contact system that can be processed at high temperature, certainly over 800°C, probably over 1000 C°.

Harold Weinin?

Needed for: 1. Experimental
2. Glass potting

3. It would be nice to have bond-metal system that does not suffer from a visible intermetallic phase like purple plague. This is need for
   a) A defensive measure when our competition have ~~conf~~ convinced our customers that purple plague is bad
   b) Small devices

Mark?

We have tried Pt-Al, Pd-Al, Ag-Al, Al-Al, Au-Al, Au-Au
Most of these were over the oxide. We saw Cu-Al + Al-Al ultrasonic.

On Pt-Al, the Al pulled off the oxide
On Ag-Al, doesn't bond well

+ Dick Craig will summarize his results

Alloying cont.

4. Should we do anything on the problem seen in the past of deterioration of EB junction having Au over the oxide over a junction.

1. What is failure rate vs parameter?
2. What is the associated phenomenology?
3. What is the metallurgical mechanism?

This looks like an interesting problem, but we don't see who to do it at the present.

5. The Al - Nichrome contact @ 300°C is unstable - it drifts

6. The forward drift problem in the diode is an important and interesting problem. We must either decide to go the Al route or to really study this problem soon — say by Aug 15 - GEM.

Project 165, Competitor Evaluation Aug 3, 1961

Collection - mainly by sales
Loyd Walsh makes measurements
W.W. sectioning and layout
Data goes to Loyd for final report.

We run ~ a couple a month.

We are looking at for

Any device competing $1310 Si or Ge
$1341 Si
3001 Si

Any PNP diffuse Si

Any diode that gives us trouble.

Any micro circuit.

Any "planar" device.

I'll write a letter to the district sales office.
2 where ever possible

Flow:
To Loyd Walsh to log in
To R.S. will decide in general how complete an evaluation will be done
L.W. will see that the device travels to the right places for evaluation ~~including to Betty Thomas for crosssection (or autopsy)~~
L.W. will see that the complete report is issued
The device from L.W. and copies of all data will come to DFA.
DFA will do any additional evaluation needed and will order from Betty Thomas any sectioning or ~~evaluation~~ other metallographic or chemical analysis.

On diodes we want S.R. data (rough copies) and samples to DFA for crosssection. DFA will set this up

Project 160 Packaging Tech. Development Aug ~~3~~ 4, 1961

We need the fast turn-around technology to do all experiment packaging in house.

The packaging development and the device development must mesh.

Packaging problems:

1. μ wave diode
2. μ wave Xstor
3. Power Xstor
4. Cheap photo diode
5. μ diode
6. New micrologic pkg
7. Gadget for short delay meas
8. Diode array
9. Rex Rice pkg
10. "Std" header supply
11. Small two lead photodevice pkg (<TO18)
12. Printing array contacts
13. Facsimile array (~2000 leads)
14. A microelectronic to hand craftsman adapter.

Technology needed.

1. Ceramic metalization, pattern and solderability.
2. Ceramic - metal seals
3. Glass - " "
4. Glass potting
5. Plastic potting.
6. Ceramic supply
7. Metal punched parts.

PACKAGE STATUS

7/13/61

I. Packages on which we are active.

A) Power Package for FT-7000.
  1. Gum-drop package.
  2. Vacuum tight package.
  3. Modified FT-6200 package.

B) High Frequency Package.
  1. Ceramic diode package for Paulo Mastalli.
  2. Coaxial transistor package.

C) Packages for Diode.
  1. 30 watt Gum-drop stud.

D) Packages in the Sealing Industry.
  1. Copper cored Kovar lead TO-5.
  2. Copper flange BeO TO-9.
  3. Stacked ceramic package.
  4. Copper TO-9 package.

E) Package Parts for Low-cost Photo-Device.

F) Miscellaneous

II.

A) 1. Gum-drop Package - This is a package designed for maximum heat transfer to a metalic heat sink. The The package is .520" in diameter by 3/4" long. There is a 3/4" hex-nut brazed near the top, and a tungsten, or moly slug brazed into the bottom. Both brazing operations are made simultaniously.

This package is used by soldering down the die, attaching the leads, coating device and leads with a flexible medium and potting with an epoxy resin.

A) 2. Vacuum Tight Package - This package is almost identical with the Gum-drop package. The major difference being that the upright copper part for containing the epoxy is rolled over onto the hex-nut so that the cap may be cold welded in place.

There are three practical internal configurations for die and lead attachment.

1. The moly, or tungsten slug as in the Gum-drop.
2. BeO insulator heat-sink with Al_2O_3 lead attach to base.
3. BeO covering total inside bottom with isolated lead braze areas, as well as isolated solder-down area.

This latter configuration should handle any device which can be stepped .

A) NOTE - Both of the above packages have a dri-seal pipe thread for maximum heat transfer; but this may be easily modified to a 1/4-28 stud if the industry is not interested in efficient heat transfer.

A) 3. Modified 6200 Package. - This package is the 6200 with a .180" disc set off-center and, in most other respects, the same as the power stud package.,

B) 1. Ceramic Diode Package. - This is basically a ceramic tube about .210" long by about .210" in diameter. The ends of the tube are metalized and a copper stud brazed into one end. The die is soldered on the other end stud and soft solder is used to seal it into the ceramic sleeve. This gives us a chance to dissipate the maximum amount of heat. Only if it becomes necessary, will we use a buffer metal slug. (We can get by with this because of the small die size.)

B) 2. Coaxial Transistor Package. - This package is made of two identical pieces of ceramic. Both will have a cold-weld flange brazed in place. One end has a tube to accommodate the base (or emitter) lead, the other end has a solid rod connected and a disc to solder the device to. The metalized layer can be used as a shield between input and output.

C) 1. 30 watt Diode Package (Gum-drop) - This package is meerly a 6200 stud with flange machined off and a nut brazed on at same time that the buffer disc is brazed in.

D) 1. Copper Cored Kovar Lead TO-5 - There are two configurations involved.

a) One is the standard TO-5 with copper core Kovar lead substituted for the Kovar leads of the standard package.

b) ~~This~~ SECOND is the solid Kovar head with copper core Kovar substituted for Kovar.

D) 2. Copper Flange BeO TO-9 - This is the Frenchtown porcelain header, but we have substituted a copper flange for the nickel flange which they now use.

D) 3. Stacked Ceramic Package. - This is the stacked ceramic package .150" diameter by about .060" high with radial leads. The ceramic rings are Al_2O_3 or BeO. The metal parts are of HC (Copper) or silver.

D) 4. This is the TO-9 (by Litton) made with a Housekeeper seal.

E) Low-cost Photo Device Package. This is a very small punched part to which the device is soft soldered and gunked with silicone and potted in epoxy or poly-easter resin.

III. STATUS:

A) 1. Gum-drop Package - Samples have been made. At present, there are no devices to waste on testing this package.

A) 2. Vacuum Tight Power Pipe - Harlan has been asked for quotes on the metal piece parts. We have our metalizing working well. We must get a larger transformer to increase the temperature and thus speed of the operation.

A) 3. Modified FT-6200 Package - We have 100 of these modified packages on order from Litton Lab. We also have 200 each of the standard 6200 packages, except with BeO disc on order.

B) 1. Ceramic Diode Package - We obtained ceramic tubing which has been cut to length. This is ready to metalize. The copper parts are ready. It is only necessary to metalize and obtain jigs for brazing.

B) 2. Coaxial Transistor Package - We have ceramic parts ready to metalize. We have the metal forming dies. We just need to make these dies work and then jig and braze.

C) 30 watt Diode Package - Six of these were sent to J. H. Wardell at Diode, S.R.

D) 1. Copper Cored Kovar TO-5 - 1000 each of the two types are on order. Myra is checking delivery dates.

D) 2. Copper Flange BeO TO-9 - 100 each of these are on order with Frenchtown.

D) 3. Stacked Ceramic Package - 100 each are on order with American Lava. We have a quote from Frenchtown which isn't too bad. This package may solve the $V_{ce(sat)}$ problem.

D) 4. Copper TO-9 Package - We have about 200 with 4200 devices soldered on. We are polishing the weld dies now.

E) Parts for Low-cost Photo-Device. - This has taken an inordinate amount of time. Much talk and time; little do.

F) Miscellaneous

We have brazed a number of parts for H. Roos' group.

7/13/61

We must be able to make ceramic parts in small quantity.

T Bob Brown will investigate obtaining a supply of precise, high quality ceramic pieces in many sizes, shapes & descriptions.

T We must have a supply of machinable, unfired ceramics and the ability to machine fired stuff.

T Investigate getting a small firing furnace.

Ceramic metallization:

T 1. We will get so we can do an adequate, reproducible job of Moly-Manganese metallization on a service basis on high purity alumina. Demonstration samples by Aug 30 delivered to me.

T 2. Establish that we can braze (or solder) & get >90% helium leak tight seals.

T 3. Be able to make patterns as fine as 10 mil stripes on 20 mil centers. We will be able to do art work, get the masks made on the outside. Objective — to be able to supply metallized part from request in 1 week.

It would be useful to be able to make etched patterns in many other materials, Mo, Ni, Stainless Steel, Sn, Be-Cu.

Ceramic - metal seals.

We can braze to metallized ceramic. Al_2O_3 matches the Mo, W, Kovar type metals. Non-matched seals, to quite heavy Cu, for example, say 0.020", seem to be ok.
T That this makes good seals shall be checked.

Glass - Metal seals

No special work planned here

(Packaging, cont)

Glass potting - Marvin is working on this in conjunction with work by Neusenstein & Wrigan

Plastic potting - Cheap photo-diode Sid Jennie & Peter Allen
μ diode - Les Subibi.
Gumdrop pkg for 7000 - primarily for evaluation for now.

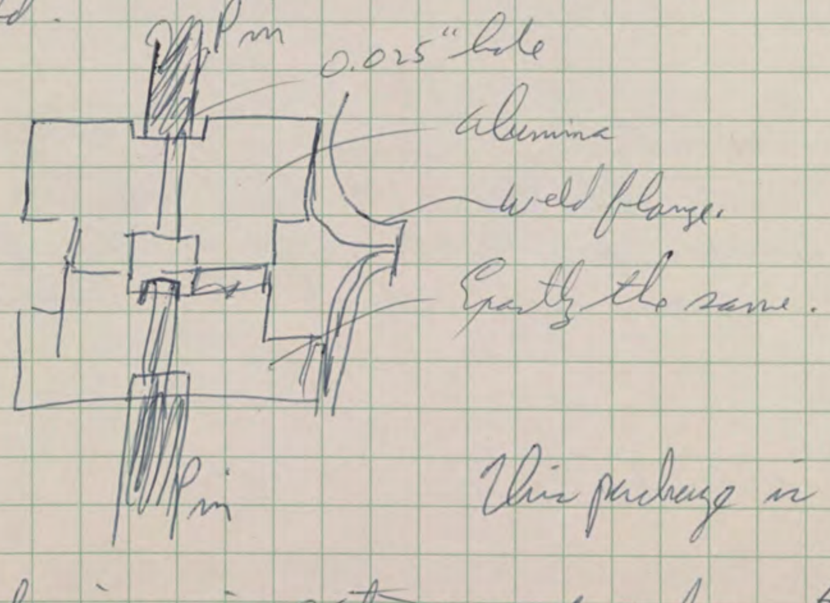
Specific packages:

1. μ wave diode. The double stud is in the mill. The outside is defined, but not the inside.
The μ-wave associates "pill" type package looks useful. I.S. will define what he would like.
This project is package limited and therefore deserves a high priority in this area.
The double stud ones made now are held together by epoxy.

It is very possible that we could want to sell some of these through special products - say 50/week. We would have to supply plugs.

T We will have some of these assembled before Pete leaves in 2 weeks.

2. μ wave Xstr.
Modified type N connector is dead - O.B. says it is a waste of time.
We have designed a co-axial package which we are trying to build.



This package is not without its problems

T. Have 10 devices in customer proof packages to O.B. This will take two weeks work after new dies. New dies by Aug 10.

3. Power Xstrs

The present objective transfer schedule for the FX-7000 to Mtn View is ~ Jan 1.

We need header design firm by Oct 1
We need header supply established for 1000/wk capability – Dec 1
We need 1000 packages in house by Nov 1.

Package does not have insulated collector.
Stud should be a Std machine thread. It will come with correct hardware for mounting.

On this one we plan on making our own header in production.

4. – By the device projects
12. – " " " "
13 – " " " "
9. – By Weisenstein.
5. – Les Hobbs is doing
7. – Hold for now.
11 – Requirements will be determined. This will then be defined to R Brown.
6+8 – Specs to be supplied to Brown before work is done.

Copper-cored Kovar for 3001 type devices. Suppliers are incapable of supplying this header. R Brown & DFA will transfer the info and problem to Hank Boss via a detailed Memo.

T

Project 114,163 - Aug 10, Pipes & Special Diffusion

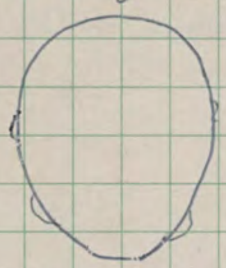
Various projects:

1. Pipes - still far from really solved
   a) bulk pipes
   Random Statistical distribution & related to oxidization

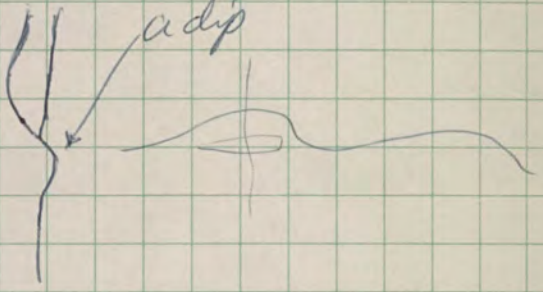
   b) edge pipes on planars - at least mostly cleanliness.
   there is still some pinhole problem that is not understood

Lay out pinhole work.

In addition to cleanliness there is still a relationship to the bulk ~~[illegible]~~ doping.



or on a large scale



This "dip" is the place that lights up.

We are now doing some work at La Jolla on electron beam & analyzer to determine the characteristics of pipes.

2. Oxidization studies
   a. rates vs T, ambient. We agree within FSC and for O_2 with Atalla. He is a factor of 3 higher in steam than we are.
   b. We must summarize our oxide growth rate.
   P.F. will collect, edit & issue report. This should be compared with the literature. Sept 15

Need to [illegible] ox

   b. ~~Set~~ Bomb in in 1 week. Experimental size of 316 Stainless. good to 3600 lbs (~\$500). Work will be done to evaluate the effects of low temperature oxidizations as well as rates.

   c. Study the effects of impurities ~~&~~ during oxide growth to accelerate oxide growth - Has been done by Motorola. By putting ~5% PbO in the oxide the oxide grows much faster. P.F. feels that Motorola is using this on completed device (300-600°C) (Relative low purity

3. Diffusion in a reducing atmosphere — It has been reported to give no pipes. This looks interesting, but needs an idea to be useful.

4. Cryostatic studies — ~~we now~~ can
Objectives:
a) Determine doping levels in compensated Xtals
b) Study of certain odd-ball solute type metals — Au, done! Ni, Fe?

Other items:
1. Surface diffusion coeff — Needs work
2. Impurity distribution into oxide & out diffusion — see 8.
3. Metal precipitation in emitter. — Needs work

5. Au diffusion & solubility in Si
Development of Planar 4000 is main motivation. This suggests that we should do a lot ~~of~~ more work to understand our processing.
Phil is quenching and claims he retains more Au

T This is another area that should be wrapped up and put to bed company wide in a Technical Report. By Jan 1.

T Phil is working with CTS ~~to~~ to get the experimental verification of Joni's paper. We consider neutron activation for this.

6. Gettering
Can't confirm that glassy layers getter
Cooling in steam at 900°C after emitter diffusion & grow with the original oxide left on. The oxide can be stripped and regrown at fair yield, but gettering is not as good.

T Ottob. along with Trevene & Hatcher have done slow cooling to make very low I_{CO}. NPN's work this way and PNP's don't. Should summarize & report. Suggest joint tech report. — Date ~ Oct 1.

7. The channel problem — Ga quick fix. Philco is ~~not at~~ ~~really~~ trying to read B.R out of this completely. Straighten this out!
ME —

8. Diffusion understanding – e.g., understand O'Keefe curves
Phil would like to understand the profile. He has not been able to demonstrate that we get boron out-diffusion from compensated material, but O'Keefe data show a considerable amount in steam.

	O_2	Steam	No O_2 & Cl	
V/I after predep		25	25	or something
V/I after diffusion		50	25	

Phil is trying to do a detailed profile by controlled etching. V/I.

9. Ga corner to publish as technical report. Oct 31

10. It is possible to do the oxide, impurity segregation could be done by an epitaxial layer and then oxide in chemical etch to plot V/I,

11. Steve Sandor is setting up a Cl_2 furnace — for general use.

Project 109 - Diffusion studies   Aug 14.

Steve's stuff:

1. Siloxane — 250 Å/min (at 760°)

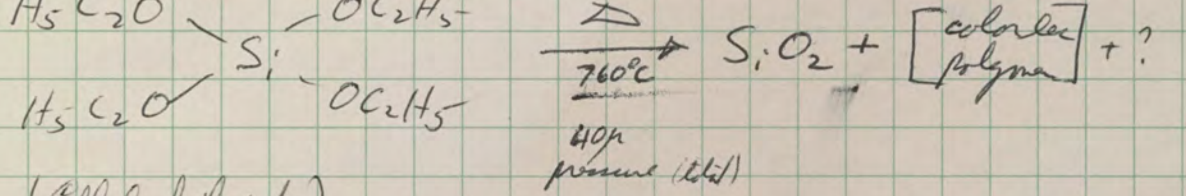
Program: to check out the SiO_2 on 1340 and 4200 processes.

We have gotten some "very hard" V_{CBO}'s. On some we have had channel problems. Steve thinks this is a cleanliness problem.

Steve says it etches faster than thermal
It seems to stick to oxide ok.

Evaluate with respect to
a) junction characteristics underneath
b) pin-holes - compare our various oxides
c) MOS capacitor

Rx in straight pyrolysis



(Ethyl silicate)
It seems not to ~~set~~ deposit on the tube walls

Get some strain cracking at ~20,000 Å (2μ), which can be annealed out. Can go to 6μ.

We should try to etch ~~[illegible]~~ holes by KPR thin thick oxide

2. Cl_2 etching is set up

3. Out diffusion
Has measured oxidation rates of Al-P doped.
Is setting up a 4 pt. probe.

MOS capacitor measurements may be useful. Or surface barrier diodes?

4. DFA needs the technology for very shallow PNP's for 1710's. Problems are
a) Boron pitting
b) Oxide solubility problem on Boron-doped oxide.

Project 109, cont.

5. Study of the differential oxide growth rate. This is potentially very useful.

6. Boron ~~dep~~ pitting is still a problem. There seem to be two kinds of pits
   a) halogen pits, which show up at predep (occasionally)
   b) boron pits that always show up ~~at~~ after diffusion — at least at high conc.

7. Technique of stand-up predep. for the isolation diffusion (where both sides need be done) with BCl_3 or BBr_3.

8. Devices going to production will use the appropriate BCl_3 or BBr_3 depending upon what is used in the appropriate production plant. We must either make BCl_3 an adjustable process or maintain BBr_3 service for this area.

Project 115 - Noise research 8/21/61

Sah
Sanitan
Jones
Noyce
Grinich
Moore

Equipment set ups for general use and particularly to measure SCT & SCD devices.

20~ to 50 kc noise meter

We usually give 1 kc narrow band noise figure

Measure on 2N1711 and 2N2049 (a 1711 with specified noise figure)

Have gotten one below 1 db. It is still very low down to 100 cycles on most of these.

First task: Attempt to correlate on a few low noise devices with the theory by making all the parameter measurements.

Task: Take some "noisy" 1613's to see if they are understandable

The smaller devices than 4200's all seem to have ~~bad~~ noise worse than 4200's. We don't know why.

The SCT device has the ability to vary surface potential and β without changing the resistances around.

Sept 8 – Project 148 – diodes – Mtng with

Hatcher
Ferguson
Baker
Grinich
Moore

FD-6 Review

The drift problem seems to be greatly improved, but it is still a problem
~~the drift before alloying~~
On unmetalized devices there is some drift before metallizing, but a lot worse after.

Differences from 1341:
0. Material is 11-17μ, 1Ω-cm instead of
1. Oxide at 920°C instead of 1200°C
2. Q ~ 3×10^{16}/cm^2 which is much larger than 1341 ($V/I = 0.8$)
3. Original etch is somewhat different
4. Dif in dry oxygen all the way thru – we steam at end of 1341

Owen Hatcher will prescribe a Q.C. check ~~at dicing~~ in the area of alloying to dicing to accept or reject a ~~batch~~ run on the basis of creep. Also a final test spec will be put in until this problem disappears.

Zener:
We will try to transfer a few points in the range of devices and the curves to interpolate
First units to be diffused in Mtn View and assembled in San Rafael.

Ultrafast – try to jazz up 1310 CB diode

u diode – we will make cost estimate of the PSI-type one

Multiple – we will continue to supply Robeson.

Don't forget the photo diode.

T. H. Bay

J. F. Ready

New diode products.

11 September 1961

D. Beadling
R. Brown
V. Grinich
G. Moore
D. Rogers

On 12 September, a meeting will be held in Gordon Moore's office to discuss new products for the diode facility. I intend to bring up for consideration the following:

Zeners
High Voltage Rectifier Stacks NO PLANS
High Speed Epitaxial Unit Needs epitaxial
Microdiodes PSI? [illegible]
Varicaps
Tantalum Capacitors
Multiple Diodes
Combined FD2 - FD3
PNPN

It is my intention, after this meeting to write a market report of sorts on those items that appear feasible.

Photodiode By middle of next year.

John F. Ready

JFR/mt

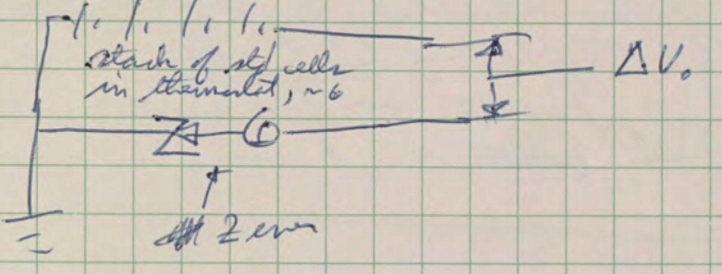
B Discussion re. diode products w Beadling Fargen
Ready Stimich

Zener:

We will supply application literature with first production showing advantages of our diode.

Ready says we need a good stability test setup.

Suggestion



Time scale — Made in San Rafael this year.

Sept 19, 1961 FET rehash
#189

Sah Grinich
Davé Lauritzen
Hilbiber Leistiko
Kabell Lemon
Ferguson Moore

Review of last Project Review 7/17/61

Chopper FET – Task 1 – 5 Xtals for reproducibility – Got low breakdown in high yield – blamed on KPR.

The channel resistance doubled for ~15% Ckts

The spread was 165 ± 10% (avg deviation) Ω.

The Xtals missed ρ seed end by x2. — bad master melt problem.

The new material looks good – it hit them on the nose.

Question:

Is our chopper better than Crystalonics and/or T.I. or the FSC differential amplifier? Answer – not much

Task: The new run will be thru about the end of this month.

Get distribution curves

Channel conductance distribut on metalized wafer
Compare pairs

These can easily be done by two point probe.

Task Mount ~200 for Hilbiber evaluation. If it looks like a useful device, the rest can be mounted and sampled thru special products. These will be the four-lead device.

Epitaxial ones – still look soft – some hardened up. No pairs in yet.

Pentode:

Task By Oct 15th we will have evaluated ~~pentode~~ pentode. We will either guarantee KPR + Material capacity or clean slate.

Noise:

F/u
11/9

INTER-DEPARTMENTAL CORRESPONDENCE

FAIRCHILD
SEMICONDUCTOR CORPORATION

TO: Gordon Moore
Vic Grinich
Phil Ferguson
Bill Fitch

CC:

DATE: 10/31/61

SUBJECT:

RE: 4400

FROM: Tom Sah

On November 9th, at 9:30 A.M., there will be a meeting in the Conference Room at R&D on the subject project.

CTS

Put on calendar

FORM S120

DEVICE: FT-4400

DATE STARTED:

			BETA 1.				BETA 2			
			600 A	600 B	600 C	600 D	609 A	609 B	610 A	610 B
ρ_c	RESISTIVITY - C - Ωcm.		1.8/2.0	→	→	→	1.6/1.8	→	→	→
N_D.	DONAR Conc. $\times 10^{15}$		2.7	→	→	→	3.1	→	→	→
X_o	OXIDE THICK. nf.		5	5	5	5	5	5	5	5
	BASE DOPANT:		CL_3	→	→	→	CL_3	→	→	→
V/I	" PREDEP: V/I, Ω		23.06	→	→	→	21.76	21.76	21.87	21.87
		R	2.1	→	→	→	2.5	2.5	1.9	1.9
	BASE Diffusion °C		1215°C	→	→	→	1215	→	→	→
	TIME min		1 hr	2 hr	1 hr	2 hr	2.5h	2.5h	3 hr	3 hr
	Steam min		20	20	20	20	30	30	30	30
	Dry min.		15	15	15	15	15	15	15	15
V/I	BASE Diffused V/I	$\bar{x}$	26.31	21.77	26.31	21.77	22.44	22.44	23.22	23.22
		R	1.99	1.63	1.99	1.63	0.97	0.97	1.34	1.34
x_{jB}	nf:	$\bar{x}$	11.5	16.5	11.5	16.5	24.0	24.0	23.6	23.6
		R								
	μ:	$\bar{x}$	3.10	4.40	3.10	4.40	6.50	6.50	6.30	6.30
		R								
	$[(V/I) \times x_{jB}]^{-1} \times 10^{-2}$ Ωcm.		1.22	1.04	1.22	1.04	1.45	1.45	1.46	1.46
Diodes	BVcbo (A)	$\bar{x}$	87.3	105.3	87.3	105.3	106.4	106.4	110.0	110.0
		R	5.5	6.5	5.5	6.5	12.2	12.2	8.0	8.0
	BVcbo (10μa)	$\bar{x}$	82.7	81.2	82.7	81.2	106.4	106.4	102.6	102.6
		R	21.25	53.5	21.25	53.5	12.5	12.5	35.2	35.2
	HARFAC: %	$\bar{x}$	94.7	77.1	94.7	77.1	100	100	96	96
		R	21.2	53.5	21.2	53.5				
	Emitter Dopant:		P_2O_5	→	→	→	P_2O_5	→	→	→
	TEMP °C		974	974	950	950	974	950	974	950
	TIME min		10	10	10	10	10	10	10	10
	Coaxial: Source °C		230	230	259	259	230	259	230	259
	AGE min.		30	30	30	30	30	30	30	30
V/I	Emit Pre V/I Ω.	$\bar{x}$	2.88	2.88	5.46	5.46	2.56	3.13	2.56	3.13
		R	0.51	0.51	0.34	0.34	0.23	0.46	0.23	0.46
	WASH time sec.		0	0	0	0	0	0	0	0
	Emit Diffusion °C		1200	→	→	→	1200	→	→	→
	Time min		14	23	15	30	47	42	49	46
	H_2O °C		85	85	85	85	85	85	85	85
V/I	Emit Diffused V/I	$\bar{x}$					0.78	0.62	0.77	0.57
		R min. T.W.	(15)	(25)	(20)	(32)	0.12	0.11	0.11	0.02
W_B	BASE Width nf.	$\bar{x}$	(9) ↕	(10) ↕	(8) ↕	(10) ↕	(11.5)	(13.5)		
		R								
W_E	Emit Depth nf.	$\bar{x}$	(5)	(9)	(6)	(10)	(13)	(7)		
		R								

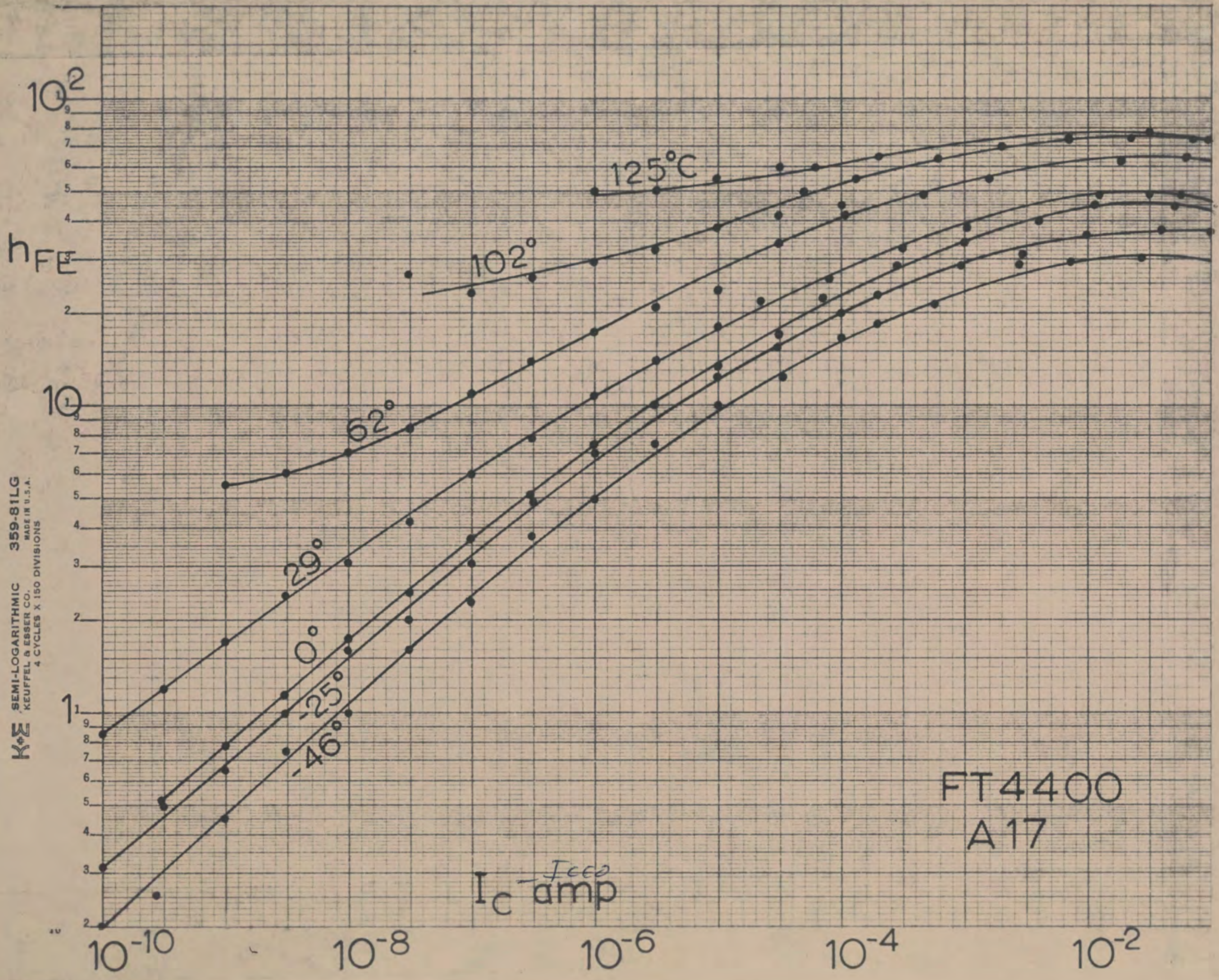
( ) = on test wafer

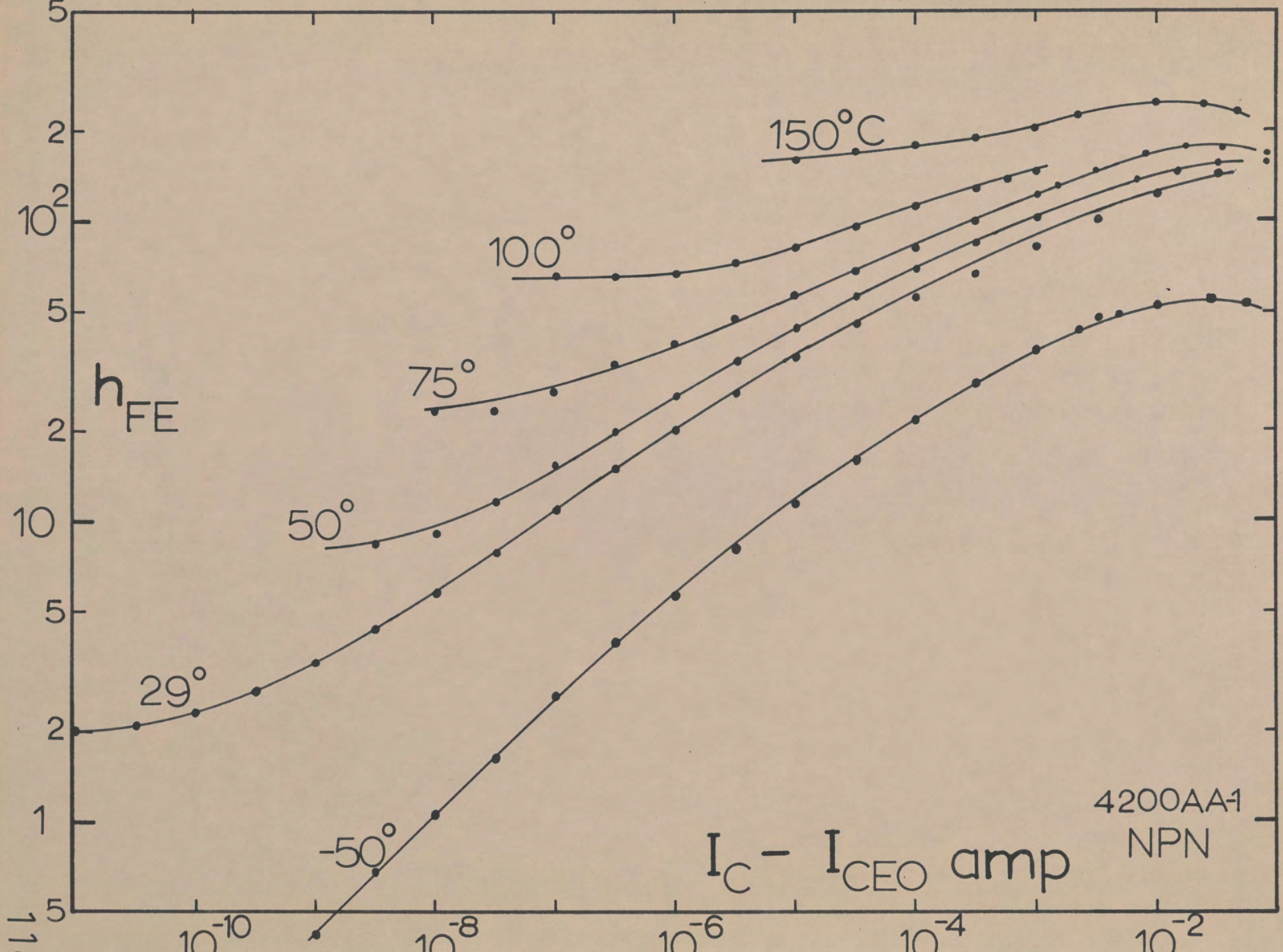
9/61
W.T.F.

DEVICE: Ft-4400 BETA 3. FB - groups.

	DATE STARTED:		8/9	→	→	→	→	→	→	→	8/15	→	→	→
			$\boxed{100}$	$\boxed{101}$	(102)	(103)	$\boxed{104}$	$\boxed{105}$	(106)	(107)	108	109	110	111
P_c	RESISTIVITY - C - Ω cm.		← 18/2.0 →								← 1.6/1.8 →			
N_D.	DONAR Conc. $\times 10^{15}$		← 2.75 →								← 3.05 →			
X_o	OXIDE THICK. nf.		← 5 →											
	BASE DOPANT:		← BCl_3 →											
V/I	" PREDEP: V/I, Ω		31.4	31.4	15.7	15.7	31.4	31.4	15.7	15.7	25.5	25.5	25.5	25.5
		R	15.2	15.2	6.2	6.2	15.2	15.2	6.2	6.2	6.3	6.3	6.3	6.3
	BASE Diffusion °C		← 1215°C →											
	TIME. hr		3	3	3	3	6	6	6	6	3	3	6	6
	Steam min		← 30 →											
	Dry min.		← 30 →											
V/I	BASE Diffused V/I	$\bar{x}$	27.4	27.4	(FLAT PRE)		22.8	22.8	(FLAT PRE)		24.6	24.6	21.3	21.3
		R	4.3	4.3			9.2	9.2			3.9	3.9	2.7	2.7
x_{jB}	nf:	$\bar{x}$	19.6	19.6	23.8	23.8	26.6	26.6	24.0	24.0	22.0	22.0	30.4	30.4
		R	3	3	2	2	4	4	2	2	2	2	1	1
	μ:	$\bar{x}$	5.35	5.35	6.50	6.50	7.26	7.26	6.55	6.55	6.00	6.00	8.29	8.29
		R	0.82	0.82	0.55	0.55	1.09	1.09	0.55	0.55	0.55	0.55	0.27	0.27
	$[(V/I) \times x_{jB}]^{-1} \times 10^{-2}$		1.46	1.46	~~1.54~~	~~1.54~~	~~1.93~~ 1.66	~~1.93~~ 1.66	~~1.57~~	~~1.57~~	~~1.32~~ 1.48	~~1.32~~ 1.48	~~2.52~~ 1.76	~~2.52~~ 1.76
Diode	BVcbo (A)	$\bar{x}$	118.1	131.8	122.5	113.4	139.2	138.0	144.4	147.0	106.2	106.1	154.8	131.2
		R	10	33	16	15	8	15	27	18	6.5	8.0	30	11
	BVcbo (10μa)	$\bar{x}$	57.6	119.8	82.9	91.0	95.4	81.4	82.4	84.7	102.6	100.1	99.2	75.3
		R	41.5	66	40.5	63.5	61.0	68.0	54.0	64.5	23.0	38.0	107.0	91.5
	HARFAC: %		48.7	90.6	68.0	80.3	68.4	58.8	57.0	57.6	96.6	94.4	63.0	57.3
	Emitter Dopant:		← P_2O_5 →											
	TEMP °C		880	880	880	880	880	880	880	880	880	880	880	880
	TIME min		75	20	75	20	75	20	75	20	75	20	75	20
	Source °C		240	240	240	240	240	240	240	240	240	240	240	240
	AGE min.		25	25	25	25	25	25	25	25	25	25	25	25
V/I	Emit Pre V/I Ω.	$\bar{x}$	4.99	8.09	5.43	7.88	4.17	8.38	4.53	8.67	3.31	6.27	4.40	7.93
		R	0.90	1.90	1.30	1.20	0.60	2.60	1.20	1.50	0.6	1.20	1.20	1.40
H_2O 10:1 HF	WASH time sec.		5	5	5	5	5	5	5	5	5	5	5	5
	Emit Diffusion °C		1200	1200	1215	1215	1215	1215	1215	1215	1200	1200	1215	1215
	Time min		55	58	70	65	75	80	85	90	50	63	70	80
	H_2O °C		55	55	55	55	55	55	55	55	55	55	55	55
V/I	Emit Diffused V/I	$\bar{x}$									0.54	0.61		
		R									0.04	0.02		
W_B	BASE Width nf.	$\bar{x}$	?	8.0 x							8.6 x	11.9 x		
		R		2							6	6		
W_E	Emit Depth nf.	$\bar{x}$	?	17.6 x							15.6 x	14.2 x		
		R		4							3	6		

x = NICKELED WAFER.


10²
10
1
hFE
125°C
102°
62°
29°
0°
-25°
-46°
FT4400
A17
I_C — amp
Iceo
10⁻¹⁰
10⁻⁸
10⁻⁶
10⁻⁴
10⁻²
K&E SEMI-LOGARITHMIC 359-81LG
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 150 DIVISIONS



5
2
10^2
5
2
10
5
2
1
5
h_FE
150°C
100°
75°
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29°
-50°
10^-10
10^-8
10^-6
10^-4
10^-2
I_C - I_CEO amp
4200AA-1
NPN

11a

FT-4400 EVALUATION.

N=50												FB →												← FB →			
	I_c	°C		600 A	600 B	600 C	600 D	609 A	609 B	610 A	610 B	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
h_{FE} (5V) *	10ma	+25°C	x̄	43.58	35.28	58.30	65.84	91.02	46.70	88.58	46.20		OVER DIFFUSED — h_{FE} (5V/10ma/+25°C) > 300							187.28	86.80						
	1ma	+25	x̄	34.08	27.70	47.74	51.46	70.98	36.70	66.86	38.46									124.34 [illegible]	55.24						
	100μa	+25	x̄	24.00	19.58	34.88	36.02	48.90	26.08	43.82	27.28									70.50	32.36						
	150ma	+25	x̄	43.65	33.00	60.60	66.45	83.46 ~~30.42~~	47.02	83.84	46.16									179.30	86.26						
*	10ma	-55	x̄	23.82	21.52	33.60	40.52	52.42	28.42	49.12	28.66									114.84 ~~284.10~~	53.32						
	1ma	-55	x̄	18.14	16.62	26.58	30.86	39.60	22.06	36.40	22.58									74.74	34.22						
	100μa	-55	x̄	11.44	10.80	17.98	20.08	24.82	14.60	22.20	15.16									38.86	17.50						
*	10ma	+125	x̄	70.98	53.66	96.92	105.28	141.82	70.36	132.30	72.20									284.10	135.28						
	1ma	+125	x̄	61.72	46.86	88.70	93.20	125.46	62.10	112.98	63.76									–	–						
	100μa	+125	x̄	52.28	39.82	82.54	82.94	115.54	55.02	96.50	58.02									–	–						
▲ Ratio's.	10ma	+125/-55	x̄	2.987	2.504	2.891	2.592	2.705	2.475	2.693	2.521									2.470	2.530						
	1ma	+125/-55	x̄	3.416	2.818	3.330	3.020	3.168	2.815	3.103	2.820									–	–						
	100μa	+125/-55	x̄	4.601	3.690	4.590	4.130	4.655	3.768	4.346	3.820									–	–						
	10ma/1ma	+25	x̄	1.27	1.27	1.22	1.27	1.28	1.27	1.32	1.20									1.50	1.67						
	10ma/100μa	+25	x̄	1.83	1.80	1.67	1.82	1.86	1.79	2.02	1.69									2.65	2.68						
	1ma/100μa	+25	x̄	1.42	1.41	1.36	1.42	1.45	1.40	1.52	1.40									1.76	1.70						
	10ma/1ma	-55	x̄	1.31	1.29	1.26	1.31	1.32	1.28	1.34	1.26									1.53	1.55						
	10ma/100μ	-55	x̄	2.08	1.99	1.86	2.01	2.11	1.94	2.21	1.89									2.95	3.04						
	1ma/100μa	-55	x̄	1.58	1.53	1.47	1.53	1.59	1.51	1.63	1.48									1.92	1.95						
	10m/1m	+125	x̄	1.15	1.14	1.09	1.12	1.13	1.13	1.17	1.13									–	–						
	10m/100μ	+125	x̄	1.35	1.34	1.17	1.26	1.22	1.27	1.37	1.24									–	–						
	1ma/100μ	+125	x̄	1.18	1.17	1.07	1.12	1.08	1.12	1.17	1.09									–	–						

W.T.F

FT-4400 EVALUATION

N=50												← FB. →												← FB →			
	I_c	°C		600 A	600 B	600 C	600 D	609 A	609 B	610 A	610 B	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
h_{FE} (5v)	150ma	+25°C	$\bar{x}$	43.65	33.00	60.50	66.45	83.06	47.02	83.84	46.16									179.30	86.26						
h_{FE} 20mc	10v/50ma	+25		5.40	3.29	5.48	4.13	3.389	2.884	3.208	2.378									3.705	3.285						
h_{FE}, 1Kc	5v/1ma	+25		38.21	31.15	51.84	57.11	84.88	42.94	80.60	45.84																
BV_{CBO}	AVAL	+25		93.15	103.96	90.50	100.35	114.6	110.0	110.8	113.7									92.12	89.42						
BV_{CBO}	10μa	+25		92.05	88.80	85.15	81.70	106.9	105.9	106.1	108.7									81.97	74.74						
BV_{CES}	10μa	+25		89.30	85.65	69.70	68.05	106.9	105.9	106.1	108.7									79.14	74.74						
BV_{EBO}	10μa	+25		8.56	8.68	8.37	9.11	11.87	8.47	12.18	9.58									12.28	11.26						
LV_{CEO}	5ma	+25		48.05	48.70	42.65	41.75	41.50	44.60	40.60	45.60									38.10	40.10						
RATIOS	150ma/10ma	+25	$\bar{x}$	1.00	0.93	1.03	1.00	0.91	1.00	0.94	0.99									0.95	0.99						
	1Kc/20mc	+25		7.07	9.46	9.45	13.82	25.04	15.99	25.12	19.27																
	1Kc/1ma	+25		1.12	1.12	1.08	1.10	1.19	1.17	1.20	1.19																
	1Kc/100μa	+25		1.59	1.59	1.48	1.58	1.73	1.64	1.84	1.68																
	1ma	+25/-55		1.87	1.66	1.79	1.66	1.79	1.66	1.83	1.70									1.66	1.61						
	100μa	+25/-55		2.09	1.81	1.93	1.79	1.97	1.78	1.97	1.79									1.81	1.84						
	1ma(+25)/100μ(-55)			2.97	2.56	2.65	2.56	2.85	2.51	3.01	2.53									3.19	3.15						
	10ma	+25/-55		1.82	1.63	1.73	1.62	1.73	1.64	1.80	1.61									1.63	1.62						

W. T. F.

CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS
PRINTED IN U.S.A.
NO. 41,310. DATA SHEET, GENERAL PURPOSE.

Sept 20, 1961 — Glasses & Ceramics
#110

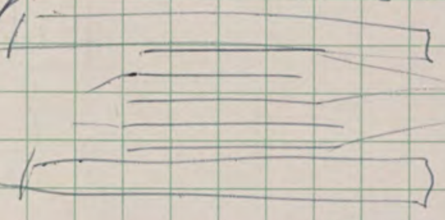
Waring
Dunnick
Campbell
Moore

Review:

Mostly on encapsulation of ~~packaging~~ devices

Glass packages

1. Preform and seal in a bubble - Corning approach
2. Glass powder —— Transition does this with pyroceram.
3. Pre-cut "flat" stock - Corning glass capacitor, for example
4. Dipping - BTL on As-S glasses



M.D. is concerned that #3 looks like low cost. Can seal glass @ ~575°C, but that is just above the Al-Si eutectic

The glass being used (#8871) has an expansion 3X that of Si

Three things are needed:

1. A metal system to take the temperature of encapsulation
2. Does the glass stick (seal) to the SiO_2
3. Kinetics of oxide penetration at encapsulation temperature

Try to incorporate PbO (or CdO or Bi_2O_3) into the SiO_2 in order to
- a) reduce tendency of SiO_2 to crystallize (reduce pipes?)
- b) grow thicker layer of oxide by having matched expansion

Must test the ability of the PbO glaze not to bother the electrical characteristics of the underlying junction.

Pyroceram powder Q&D to see a) does it hurt devices
b) does it seal

Semiconducting glasses — What is the aim? — (Pete look at stuff)

Maxine Dunnick points out that PdO is a fairly high conductivity material that can be made by oxidation of Pb — Useful for Campbell.

Sept 22, 1961 – Project Realignment –

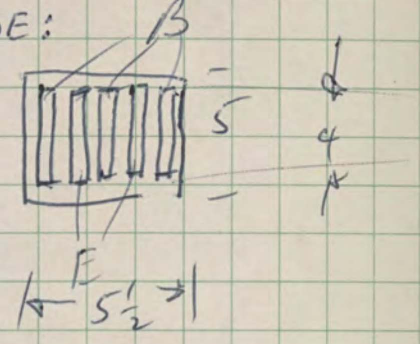
Schultz
Ferguson
Walsh
Moore

Knudsen

Q? What geometry planar devices should we consider to
a) obsolete our products
b) to bury competition

	l_E	A_E	A_C
1210	2	1	7.5
1340	13	13	78
4200	50	180	710
3001	50	150	225
1210DB	4	1	10.5
X-1210 DE	16	4	27.5

X-1210DE:



Conclusion:

1. Try 3-stripe 1211, 1311. Adjust resistivities to ~~two~~ single stripe meet 1210 & 1310 specs

We should do some life tests on single base lead vs double base lead connection

Try tetrode on 1210 three stripe.

2. Replace the 1340 family with S of A device, probably X-1210DE above.
Aim at this family by 4/1/62 to production.

Make a mask that brings out emitters separately for T^2L

P.F. will get ≅10 units to Schultz (1310DB) to measure to 2N744 spec.

Sept 27, 1961 — Proj 109 and (New #)

Steve Sanders
Phil Flint
CTS

G Moore
Grinich

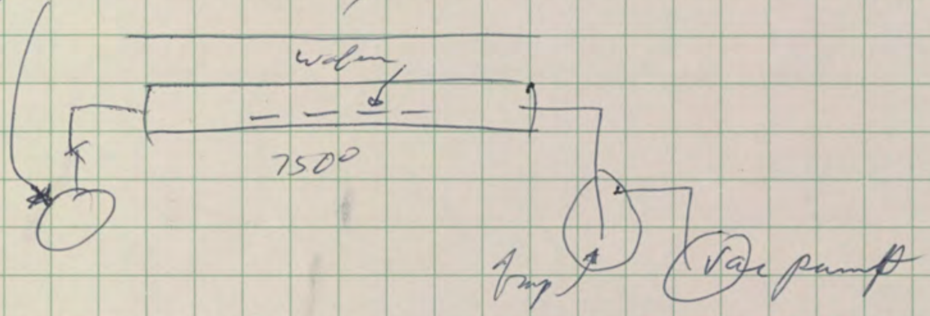
Redefine:

109 – Diffusion Technology
114 – Special Diff Research
163 – Paper
New # – Oxidization Studies

Review of Siloxane pyrolysis

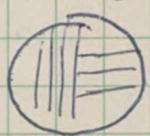
Can make quite pinhole free films, if the room is clean.

Ethyl Silicate in 40µ vacuum @ 750°C. Get 2.5 Å/min



Activation energy ≃ 84 KCAL

Works well up to 1.5µ thick films. Above this, after the O_2 furnace we see etched in the substrate

, etc. This looks like lines in the oxide.

Could not get good films with carrier gas
O_2 makes "snow" type oxide. Must flush out ethyl silicate before letting in air.

Try
1. Thick film to cut contact C
2. SCT grid oxide
3. Check surface state
4. Try for PNP channels

~~Sept~~ Oct 4, 1961 Step and Repeat Camera

Hall
Grinich
Elam
Folz ??

Summary: Since the last meeting the granite system now looks like a development program. Jim recommends that we scrap it. The granite costs are going up and the companies will not guarantee.

Stage cost have gone from $4500 to $8200 in granite, but no guarantee that it will work.

New stage is 29,500

Oct 4, 1961 - SCT

Summary:

Threw out $BV_{CBO} \leq 80v$
The β's spread all over map.

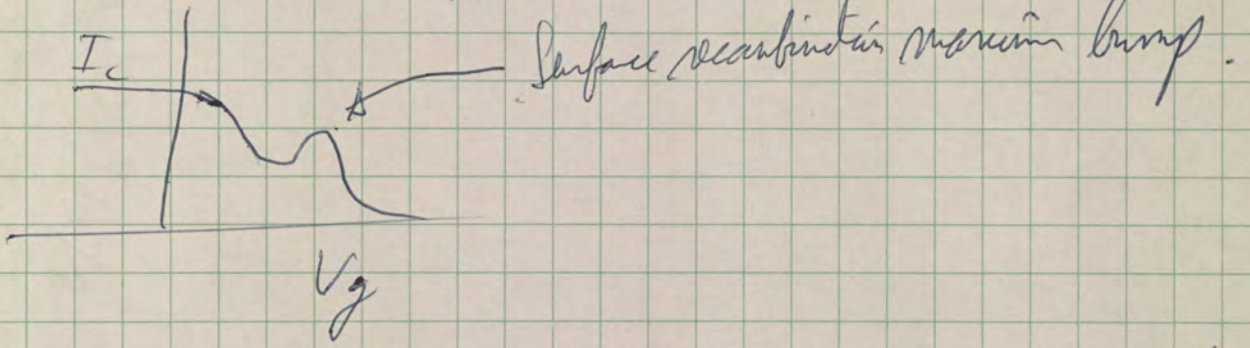
Ordinarily we get 20pf oxide on 3
12pf on 1.
On gm C2 add 6f

The following was measured:

Cg - Capacitance gate to almost anything

I_C h_{FE} - adjust to 20 ma I_C @ $V_g = -50v$, fix I_B and measure I_C at +50v.

All of these runs showed a shape like



Also measured gm and V(gm = max)

	10%	90%	Voltage for V_g = max
gm	350	1550	8
	200	770 ← this one was the thick oxide one.	11
	90	1400	6.5
	37	610	7.5

There is a hell of a lot we don't understand about the device we have made.

Conclusion:

Dev. Div. starts with new masks and best guess structure of slotted-emitter type to develop

CTS to continue to understand physics
This is a big job.

Program Plan (P.F.) by Oct 17th

Oct 5, 1961 – FT-4400

O'Keefe
Fitch
Ferguson
Sah

Summary:

CTS has run some detailed h_{FE} vs $(I_C - I_{CEO})$ as $f(T)$ on some of the old units. From −55 to +125° at $I_C = 10$ ma the 4200 ran about 4. The 4400 ran ~ 2.5. The ~2.5 is the best we've done yet.

The variable that has really not yet been checked is the V/I after diffusion of the emitter. We've tried, but something always leads to V/I 0.5-0.6. This must be tried – attempt to make some samples of ~ .02 Ω V/I.
T

T Measure some of the "typical" 4400's ~~used in~~ at 150 ma + 500 ma to see if the curves really are crossing

Oct 9, 1961 – Project 109, cont – see p. 55

Steve Sanders
Tom Sah

Review, cont – Some new data

Siloxane – have grown 4.5μ without cracking by slight steam oxide (1μ) followed by growth.

Owen Hatcher used ~2.8μ stuff to make diodes – after deposition.

Steve thinks this is ready to turn over to Dan McCall.

Steve would like to try a carrier gas system for ~10 days. In this way ~~the~~ ~~co~~ doping during growth can be tried. Problems here are that it must be completely free of O_2 and H_2O. The vacuum growth is more uniform.

action: Let's get Dan McCall going with the system on a service basis by end of October. Use Steve's furnace

Shirley Brown will do service runs until we develop steady customers. Then we will set it up under McCall ~~[illegible]~~, in the diffusion area.

So much for Siloxane – CTS will watch for transfer to McCall.

Phil Flint has gotten some *very* interesting electron probe results on Si. This is an important idea to continue.

~~Diffusion~~ Cl_2 Etch:

Steve is trying to make hole for "holy diode". Cl_2 is a selective etch for Xtal faces.

Diffusion:

What do we need:

Proj 109 1. Boron above ~40Ω V/I is not reproducible. – Reduced pressure help?
2. Boron pitting is a problem
3. Adjacent devices aren't as well matched as one might think.
CTS says some useful info can be obtained concerning the problems.
114 4. Lateral surface diffusion
Proj 114 5. Out diffusion – bull dozer effects, etc.

Suggest experiments for Phosphorus bulldozer.

Oct 16 - Project Epitaxial growth

Sprule Peterson Sah Wigtas

These papers summarize the results of the meeting: Mtng 10/6/61

For Peterson

~~Mo mandated~~

1. Production of
   nn^+ for 1341
   3001
   diode
   pp^+ 1741

2. Production of nn^+ for 1311

3. Study of substrate-to-layer doping transfer.

4. Learn to completely eliminate the need for test wafers of opposite type.

5. Study surface preparation and storage effects on the quality of the growth.

6. Compare different sources of trichlorosilane

For us.

1. Supply memo to Peterson for specs on diode, 1741, etc.

2. Learn to grow hard junction

3. Study introduction of dislocations (find out when they are introduced and eliminate)

4. Study horizontal system for ~~later~~ possible tighter thickness control

5. Learn to grow high ρ on low ρ.

6. Study of ~~growth~~ growth kinetics and imperfection

7. Growth of multiple junction and complex structures.

8. Other materials, etc.

Norman Peterson
G. E. Moore
C. T. Sah
P. Ferguson
4 October 1961

EPITAXIAL FILM
RESISTIVITY CONTROL

H. Wigton

We have made a number of runs using undoped silane and have confirmed that maximum film resistivities are a function of substrate resistivity in the present type vertical reactor.

As an example, 12 runs were made (360 wafers with 72 samples) using substrates identified as 0.01 to 0.05 Ω cm n+; the minimum film resistivity observed was 1.5 Ω cm (120 v diode); maximum 4.8 Ω cm (280 v diode); and average 2.7 Ω cm (185 v diode). Assuming the average substrate resistivity to be 0.025 Ω cm, it is seen that:

$$\rho_{\text{Substrate}} = \rho_{\text{film}} \times 0.009$$

Six similar tests were made using 0.01 to 0.02 n+ substrates and the following relationship holds:

$$\rho_{\text{Substrate}} = \rho_{\text{film}} \times 0.007$$

For p-type, in the range of 1741 specification:

$$\rho_{\text{Substrate}} = \rho_{\text{film}} \times 0.0036$$

These figures are not precise inasmuch as the substrates were not sorted precisely, however, they are as accurate as necessary for guidance now.

In summary, for production resistivity specifications:

1340 use substrates 0.007 to 0.009 Ω cm As doped
3001 use substrates 0.012 to 0.015 Ω cm As doped
1741 use substrates 0.006 to 0.008 Ω cm B doped

No doping need be added to the silane, but some silicon coating must be behind the wafers before the run or the film resistivities may drop. We find it most convenient to coat the mandrel for 15 minutes after two wafer runs. Wafers of opposite type need not and should not be included.

Our requirements for substrates will be adjusted accordingly in a separate letter.

H. Wigton

HW/ea

Oct 30 – Project 153 – Where do we want to be over next year?

~~1. Special projects product capability for Mtn View.~~
~~Machine Mask making~~

Nall Grinich
Norman Ferguson
Moore Farina

1. Custom microelectronic capability employing micrologic technology to Mtn View is one objective

2. It would be nice to make faster blocks that are plug-in replacements for μL family – say 5 Mc ckts. (0-55°C) Feasibility not established (or suspected).

T. Can we make a 5 Mc direct plug-in replacement for μL a) using only established techniques or
b) considering the possibility of using a n-p-epitaxial substrate and evaporated resistors.

Report (~~Norman~~, Farina) — by Nov 15.

3. A product manual should be written on μL to include – JPF – Prime
a) A discussion of the structure and structure-related parasitics D.F.
b) Fabrication problems, especially masking limitations – J.P.F
c) 8X10 photos of the elements. – RHN
d) Parameter distributions and fan out. – RHN

4. Assume that ~~1310, 1320 &~~ 1310 – 1320 type Xstrs are available and that evaporated ±10% resistors can be made. Lay out the program necessary to get to 20 Mc integrated building blocks.
Report on feasibility, ~~and~~ approach and timescale.

Division tasks
Evaporated resistors: Like kit chips (also for special products) of values 100 200 500 1K 2K 5K

T. – Jim Nall – A Tech. Memo will be written on the available evaporated resistor technology – inc contact reliability.

Existing evaporation masks: 25-200 Ω/□, 12, 27, 54 sq and multiples thereof.

5. Analogue ckts – Hearing aid amplifier as example – for Zenith will be the test vehicle.
Others will be done with kit first and will be used to prove out the kit.

6. Shot at the decade counter as an example of something large.
This is useful only as an attempt to do it in ~~an~~ high-density array.
Layout in modular form except for the final metallization interconnection. - RHN Examine layout to fit in. Dec 15.

7. **Packaging** - We need a μL pkg with flat ribbon leads, flat pkg.
Let us match the TI form factor pkg for μL. A possibility is a Pyroceram-potted ~~pkg~~ - can use Au T.C. bonds.

Let us try to get a contract to put μL in a μ-module pkg. Do only with the contract. RHN will feel out the situation.

Nov 6, 1961 –

Sah
Sanders

Project layout for outdiffusion data is ~ 3½ months.

This takes ~ 1000 KS in lab time at Hazleton, $150 to materials. It seems that only the high temp oxidation is worth doing, but both H_2O and O_2 are worth looking at. For example, let's look at

high - temp – low temp
steam – dry
thick – thin
high Pconc – low Pconc
} Variables

What else should be working on?

No diffusion technology seems necessary now. Steve will watch for diffusion duplication.

GaAs diffusion:

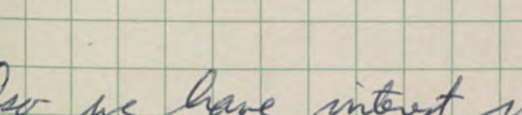
Prime Objective: Make high performance, planar Xstor (at least a planar collector junction). T.I. in their lab make ~~a~~ a Xstr. using Mn base doping and Au-Sn alloyed emitter.

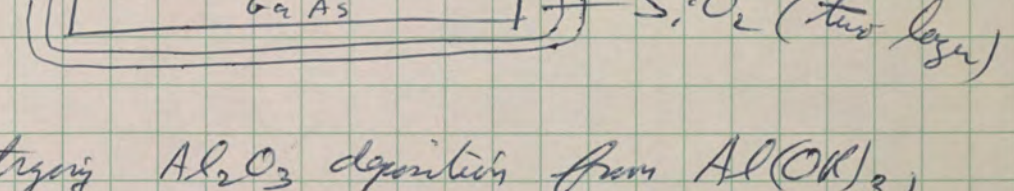
Secondary Objective: A planar diode

Tertiary Objective a°: a) Any kind diode
b) Demonstrate oxide masking against diffusion.

On the pyrolytic ethyl silicate there is evidence of doping.

Proposed GaAs diffusion in complete enclosure of SiO_2, ie,





Also we have interest in trying Al_2O_3 deposition from $Al(OR)_3$, TiO_2, etc by pyrolysis.

The GaAs work will be charged to the GaAs Exp Devel #.

Nov 8, 1961 – Meeting with diode people

Brown
Weir
Pinte

FD6: A very large percentage of the units on 200°C storage life have shown a leakage increase of ~30% or so. This is a new effect. There are units that have higher leakages than theoretical values by a fair amount.

The units we stored at 300° were stable as a rock.

Owen is convinced (as a result of 1 split run) that the "excess" leakage is the effect of poor surface cleaning of wafers before they were put in the furnace.

The diodes on the wafers are soft. If wafers are baked, they can be hardened. It is not known, but Ray will determine, if the units after life are soft type characteristics.

A set of experiments has been laid out to check out some of these effects. All in all our nose is dirty on several counts:

1. Inadequate life testing done (or planned)
2. Comparison with transistor not straightforward
3. Lack of single-variable split runs to check results.

Zeners:

The 100 μa, temp. comp. Zener is still not a well defined device. No numbers on yield, or anything.

We will supply other basic structures

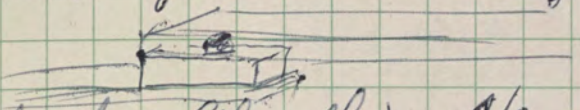
San Rafael needs to know about equipment – needs equipment.

We will cram together a complete transfer document by Dec 1.

Nov 8, 1961 Glasses & Ceramics #110 Waring
[illegible]

Review:

A new porcelain binder that eliminates the reduction to Pb. This was used for a diode (Ag contacts)



But M.S. is not strong on just potting a structure like this. He would rather do a preform tech. With ~5¢ in glass parts alone. That is done in range ~440°C up depending upon the glass. For example with 8871 (softening 525°C) would take ~575-600°C for 10-15 min. The metal is a bit of a problem. He is trying Pt, Dumet, Titanium.

Conducting glasses:

Looking at GeAsSe (400-450°C softening - can be evaporated) This is the one that was used for Aryani's tunnel device. A.S. is continuing.

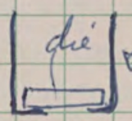
AsSeTe $\rho > 10^8\ \Omega\,cm \rightarrow 10^{-2}\ \Omega$-cm on recrystallization. There is the possibility of local recrystallization

PdO - Evaporating 80% Pd, 20% Si, It is strongly adherent after oxidation. Has gotten ~5K/□ on a nice clean film.

Task for me: Outline the packaging effort

Nov 13, 1961 XPT-3 (Cheap ~~plated diode~~ 3-layer plated diode) Kabell Ferguson Grinich

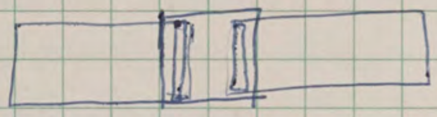
Review: Masks now available
Electrical samples in TO-18 in mill – these soon.
Assembly
1. Tinned and sweated preforms



Metallization is Al + Cu and seems to work well (as far as tinning is concerned).

Problems:
a) getting die positioned
b) removing positioning jig

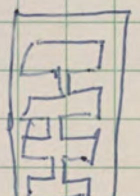
2. Use T.C. bonded ribbon plug



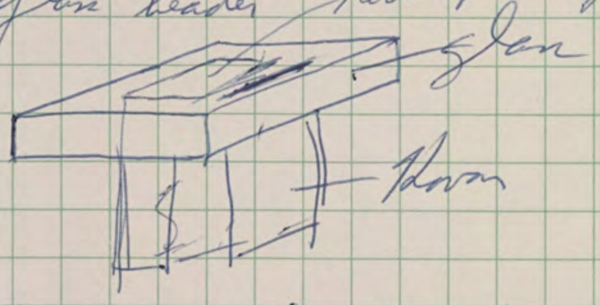
a) use pure Au ribbon
b) use Au clad Cu

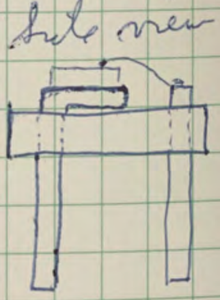
Problem:
c) Encapsulation – presently uses a drop of epoxy into a mold.

2½. Sid Levine preform



3. Au glass header





Encapsulation by Epoxy drop on top.

On the basis of this discussion it looks like we should define the work as aiming toward

1. Preform assembly using #1 or #2½ – Try to use a high temperature braze instead of Sn

2. Potting will be by single cavity (or multiple cavity) mold.

Potting existence proof by simple, straightforward process – Dec 15 for the O-order answer –

Preform assembly existence by Dec 15.

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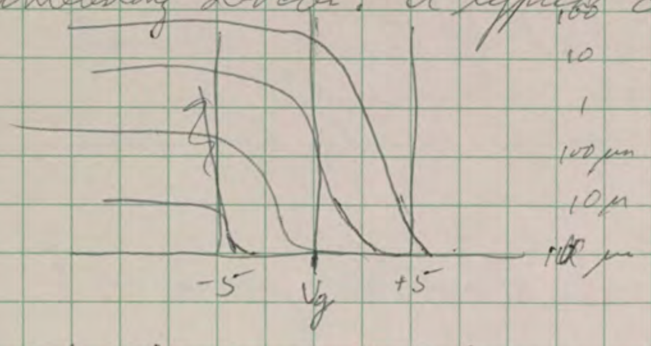
68 Nov 15, 1961 — SCT Meeting

Bogart Ferguson Lamond Tremme Grinich Moore

Review: Data on the first shorted emitter units is through. These are very interesting devices. A typical characteristic is



The metal has not been heat-treated. We don't know if the metal can be heat treated. This will be tried.

These look like ~ 60 mc f_T.

The oxide in the center of the shorting ring only is grown in an H_2O, argon atmosphere.

It is better if the device is "speced" at constant I_c.

The way to spec this thing is a real sweat. Let us make some recommendations.

We need some info on the temperature dependence of these.

We need life test data — both temp & operating.

We must make enough dice for ~ 2000 good units to be assembled in Mtn View for sampling. Before we do this we must have stability assurance ~~drift~~ and test criteria. Aim at getting those dice to Mtn View by Jan 1.

Prine is looking at the 4-layer possibilities.

High frequency geometry?

My grid structure should be patented too.

We will grind out the big one solving "all" the problems, 1st priority.

We will do highest frequency as 2nd priority.

FAIRCHILD SEMICONDUCTOR CORPORATION

DEVICE EVALUATION DATA SHEET

FT - SCT — Shorted emitter
1 mil spacing
16 mil emitter

Identification No. HB 1BT

Log Book Ref: ____________

Remarks:

hfe @ 20Mc ~3
BVEBO

Date: 11-14-61

Data Taken By: Donna Watland

Supervisor: ____________

Engineer: Howard Bogert

Xistor No.	Ic = 10μa BVCBO	Vcc = 5V ICBO	Ic = 5ma LVCEO	Ic = 10ma Vcc = 5V VG = varied MAX.GA	VG	0V CGT	Vcb = 10V COB	Vbe = 0.5V Cte					
	V	NA	V	Vo in volts	V								
20.	65.0	.26	36.0	.13	1.15	17.9	22.0	52.0					
21.	30.5	.138	39.0	.16	2.90	16.8	22.5	52.0					
22	68.0	.072	42.0	.15	1.2	16.3	22.6	48.0					
23.	110.0	.28	53.5	.14	-1.4	16.7	22.1	50.0					
24.	67.0	.125	41.5	.14	-3.0	16.4	22.5	48.0					
25.	60.0	.058	39.5	.10	-.58	16.2	23.0	48.0					
26	84.0	21.5	53.0	.11	-1.2	15.5	21.2	51.0					
27	32.0	.15	40.0	.145	-2.8	17.0	22.5	50.0		extremes,			
28.	79.0	.18	40.5	.16	2.3	17.4	22.1	49.0					
29	21.0	.067	41.5	.15	-1.6	16.3	22.8	49.0					
30.	90.0	.22	51.0	.14	-2.5	17.5	22.5	49.0					
31	73.0	.16	48.0	.115	-3.1	16.2	21.8	49.0					
32.	61.0	.12	41.0	.15	-.41	15.3	22.2	48.0					
33.	116.0	.46	45.0	.145	-.37	16.1	21.9	49.0					
34.	47.0	.395	53.0	.13	-2.5	16.4	20.8	48.0					
35.	51.0	.077	44.0	.14	-4.0	16.9	22.3	48.0					
36.	75.0	.091	41.0	.15	-.80	16.4	22.4	48.0					
37.	68.0	.0155	38.0	.14	-3.6	16.7	23.3	48.0					
38.	73.0	.101	43.0	.15	-1.3	15.9	22.1	48.0					
39	82.0	.052	44.0	.14	-2.15	16.2	22.1	48.0					
40.	117.0	.345	65.0	.12	-7.5	16.9	21.8	51.0					
41.	65.0	.080	45.0	.14	-4.1	16.1	22.0	48.0					
42.	66.0	6.8	41.0	.15	-1.5	16.5	22.5	48.0					
43.	75.0	.092	45.0	.13	-5.7	16.9	22.6	49.0					
44.	81.0	1.0	47.0	.12	-8.0	17.0	22.1	49.0					
45.	80.0	.065	44.0	.16	1.4	15.6	21.9	48.0					

FAIRCHILD SEMICONDUCTOR CORPORATION

DEVICE EVALUATION DATA SHEET

FT - SCT
Date: 11-14-61
Identification No. HB 1BT
Data Taken By: D.W.
Log Book Ref:
Supervisor:
Remarks:
Engineer: HOWARD BOGERT

Xistor No.	Ic = 10µa BVCBO	Vcc : 5V ICBO	Ic = 5ma LVCEO	Ic = 10ma Vcc = 5V VG = VARIED MAX GAIN	VG	0V CgT	Vcb = 10V COB	Vbe = .5V Cte					
46.	110.0	.33	43.0	.058	-1.2	16.8	22.1	48.0					
47.	87.0	28.0	40.0	.17	-.36	17.4	22.9	49.0					
48	96.0	100.0	66.0	.135	-1.65	16.9	21.5	53.0					

Packaging Program, ~~July~~ Nov 17, 1961

Brown
Grinich

Ferguson
Moore

Review:

7000 power package. - The TI package is presumably available. Phil will see that we get at least 5K on order.

VHG points out we may need 5W, 500 mc package (or possibly 25W, 100 mc).

JPF points out the agg device problem

The TI solid circuit package is not well defined for yet. We will go ~~[illegible]~~ a little larger.

We need the following bits and pieces.

1. Seal top (attach Kovar to metallized ceramic)
2. Seal leads into the ceramic
3. Attach the die
4. Low profile lead bonds
5. Get piece parts

We can now do the ceramic metallization

Resistors, ~~July~~ Nov 20, 1961

Martini
Campbell
Wall
Farina

Dennil
Ferguson
Pault
Moore

Review:

Diffused resistors: ~~100~~ 115 Ω/□, 1 mil stripes,
have made 250K with 2 mil stripes
will make 1 meg in 1/2" X 32 mils (2 mil stripe X 2 mil space) — but this was at 800 Ω/□.
On std resistor by base diffusion $dR/dT = 0.2\ \%/°C$ and pretty linear between 0 & 175 °C.
Look ohmic to 20 volts (by memory) in usual case
dR/dt is about same over v/I and conductivity type (0.15 – 0.22 %/°)

Nichrome evaporated resistors:

Sheet resistance range of >25 Ω/□ limited by amount of metal available on a filament
<300 Ω/□ beyond data to date — can possibly go to 1000 acc'd to Varo data.

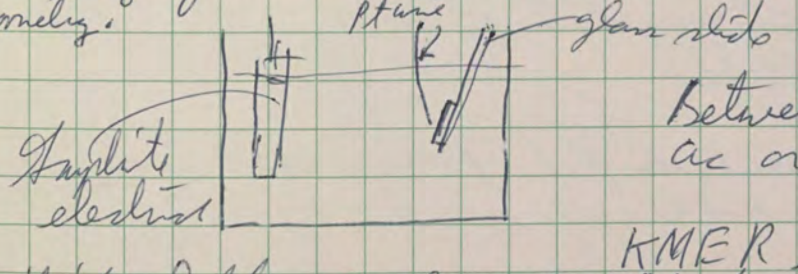
Temperature coeff in range 85-300 (generally ~200) ppm/°C
(Bulk nichrome is ~ 100 ppm — Varo claims 50 ppm)

Uniformity better than 10% over a run — can hope for reproducibility better than that.

All units to date have had Al wires wedge bonded
At 300°C we had 9 out of 133 go >5% at 5000 hours
Other batches gave similar % at much smaller hours.

In order to make resistors for special products we will need a mask that allows Au to be used.

Etching of Nichrome is in std Kovar bright dip and a reverse geometry:



Between the graphite and Pt — either ac or dc.

KMER was used because the KPR didn't hold up then. Bob Martini thinks that with a more dilute electrolyte we could get away with KPR — maybe. This seems to pay no penalty in resolution, at least by old KPR technology. The film sticks through scrubbing and does not scratch easily.

Resistors, cont.

Nichrome films, cont.

We will need 1% resistors someday. We had better look at
1) Controlled evaporation to get ±1% uniformity

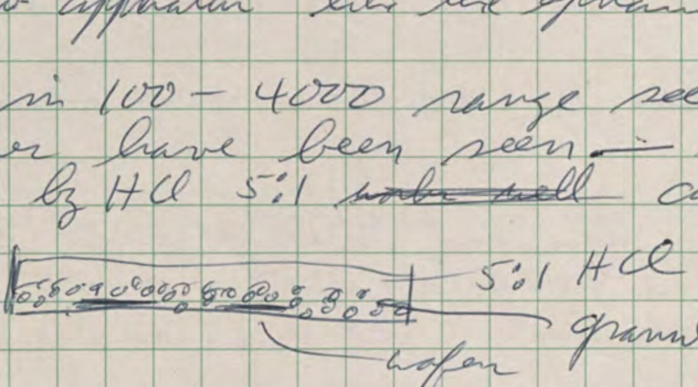
We must make a mask with 6 mil circular pads removed from the nichrome strip for Mtn View. These pads should be distant from the Nichrome. Make one geometry with the capabilities of 1000 – 10,000 Ω with the 10:1 Ω/□ available.
Phil suggests a 500 – 5000 and a 5000 – 50K geometries.

Bob Graham will see that operating and other life tests on these resistors will be started ASAP.

<u>High resistors:</u>

SnO_2: Original was a furnace deposition with very little control over what happens. Order of magnitude variation ~~was~~ in σ were found from run to runs and large variation over boat occurred.
A new apparatus like the epitaxial type ~~as~~ ~~tried~~ is being built.

σ's in 100 – 4000 range seems most likely, but higher values have been seen — up too 100K/□
Etching by HCl 5:1 ~~water well~~ and zinc in a dish.



<u>Al does not make good contacts</u>

For devices there are several problems. One of them is that any reducing atmosphere clobbers the film — Otherwise they are stable.

We are a long way from a useful process here. <u>Intalux</u> in LA is doing much better than we are.

The temp coeff here is low (20-50ppm), but is variable and can sometimes be adjusted to + or even slightly –.

Resistors, cont.

PdO – PdO$_2$

Evaporate Pd and oxidize at 300-400°C. It is adherent when incompletely oxidized.

Are comparable to pyrolytic carbon in stability, noise, T.C. etc.

Should have 100Ω – 10k/□

Using Pd and Si alloy evaporation we get good adherent film in 5-10k/□ (and up to 100 MΩ/□)

~~Maurice~~ Dr. Maurice feels that the pure Pd system is perhaps the best we have to work on.

Maurice & Jim will work closely together to conclude what way we should go on the high Ω resistors. This must be decided in a ~~[illegible]~~ month.

Foreman discussion 11/21/61

Nall
Ferguson
Grinich
Moore

It looks like the following is the way to fly:

Pilot line

Parker (or other) – gen foreman

Mask tech
Dif tech → to line and train for pilot line.

For the technology area

Dif special service } McCall + techs to train.
Mask " " }

∴ For next change

McCall + 2 techs study KPR under Engwall
2 techs study diffusion under McCall (and Flint, etc.)

Chet can go to pilot swing in new bldg.

11/27/61 — Microcircuit Layout

Moore
Grinich
Ferguson

Jobs to be done:

Priority:

0 R-element
1 a Rest of T²L family
1 b T² with high $\rho/\square$ evap resistors
2b Memory
2a Kit II
3 PNPN decade
4 ABC Amp (2 with Hearing Aid)
5 Diff Amp.

The people we have(?) available.

Farina
Gault
Craig Jan 62
Ruegg Feb 62

Judd Jan 62
Talbert

Facsimile discussion – 12/6/61

VHG
J K

Present ones print on wet paper by ion then by electrolysis
~~But~~ also have a capability of Tele-Deltos paper (multi layer) sparks to punch hole through top to expose black layer.

The use over a conventional phone and line looks ok if we go to FM type modulation.

Herb Olsen & Les McDonald – the whole department – will be here tomorrow

We have the idea of using ordinary phones to adapt.

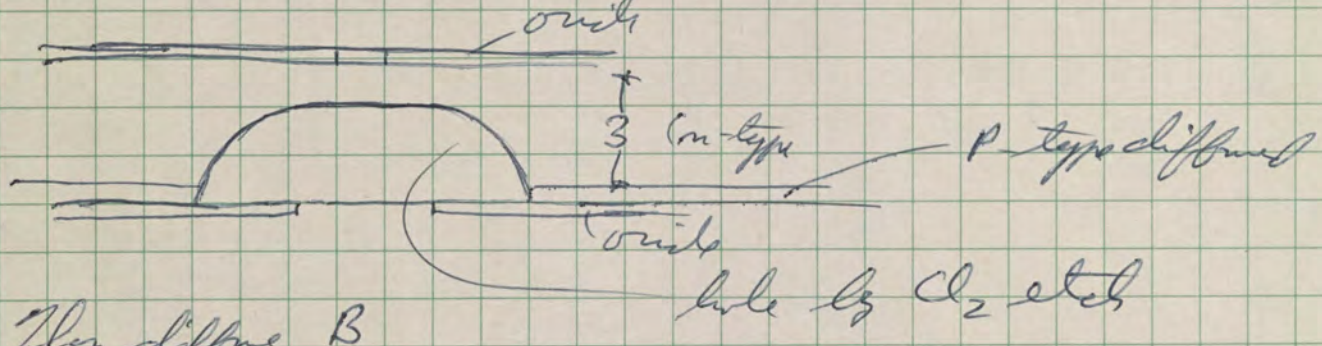
For ~~the~~ printing problem we could go the diode array route and do some development on development and ~~printing~~ fixing.

In any case, we will need the electrostatic printing.

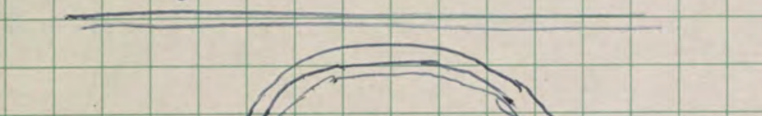
Xerox
Burroughs
Rico
} Are working now.

We would have to hire a new guy and start from scratch.
Lets get such a guy — a combination physicist-organic chemist.

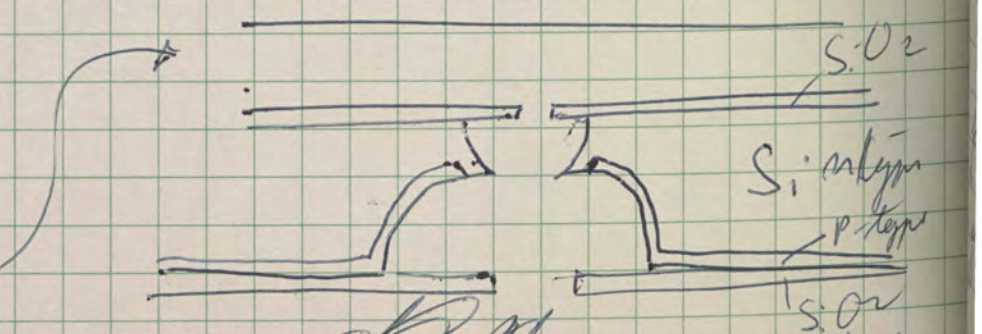
A way to do the "holey diode" that I suggested during the meeting



Then diffuse B



KPR & Cl_2 etch again
Then P diffuse to get



G Moore 12/5/61

Project 146 4500 Series development

JPF
VHG
L.G
G.M

12/6/61

Review:

The 3501 has relatively bad low current beta compared to 3500's. These are not split runs, since the epitaxial material is too variable. If a split run is made the V/I after base predeposition is fine on the 3500, but is higher on the epitaxial (usually) and as variable as all get out. The C_{TE} suggests that this is less P doping.

* It is obvious that there is a real epitaxial problem. We should confirm that we can grow an essentially perfect 1Ω cm layer on 1Ω cm material.

By an intermediate β check and custom emitter diffusion Phil Sheim has good results in adjusting individual wafers.

At present the best material is being supplied by Hank. Merck is more variable than Wigton and delivery is slow. A pretty good correlation between Hanks breakdown on diodes and series Xstors. Correlation with thickness is still not as good as one would like.

The layer thickness needed is as follows:

collector junction	5μ
collector diffusion	5μ
IR correction	3μ
Space charge	2μ
	15μ

While this material problem is annoying, to say the least, it is possible to live with it for now.

Comparative switching times:

	td	tr	ts	tf
4500	20	81	540	140
3500	15	30	400	100
3501	15	30	250	50
4700	30	100	500	160

This is probably the light base doping effect — ie, lower C_{TE}

As far as Len is concerned no good life test data exists on 3501's. (ie, no good units previously).

Len will assemble the available life data on planar PNP's from all sources and will summarize on one sheet of paper.

146, cont.

There is some feeling (no data) that a problem exists with respect to the Al not sticking adequately to the oxide.

The trend toward 1 mil base stripe, I view with a jaundiced edge — it allows 0 indexing error and increases spreading resistance.

Summary of tests to see effect of Au on these devices under power

Control – with gold solder on leads
Test – no gold – all Al lead attach.

Group I – 48 hrs @ 25°C
II – 48 hrs @ 300°C

Then they were placed upon power 300 mw (probably 30 ma @ 10 v)

Group I: (% change in h_{FE}) Group II

	0-48 hrs 25°	48 – 513 hrs power	0-48 (300°C)	48 – 513 (power)	
Control					
$I_c = 0.1$	N.C	no change	↑ (12-500%)	↕ (↑40% – ↓24%)	(from 48)
$I_c = 1.0$	N.C.	↑ (0-30%)	↑ (13-300)	↕ (↑14 – ↓15%)	
$I_c = 10.$	N.C	↑20 – ↓2	↑ (12-400)	↕ (↑40 – ↓24)	
Test					
$I_c = 0.1$	N.C.	no change except 1 unit +20%	↑ (20-500%)	↕ (↑30 – ↓20%)	
$I_c = 1.0$	N.C.	↑ (0 – 4%)	↑ (12-300%)	↕ (↑15 – ↓21%)	
$I_c = 10.$	N.C.	↓ (3 – 12)	↑ (20 – 50%)	↕ (↑30 – ↓20)	

Early experiment with Boron surface looks suggestive that it is better than Ga, but data is preliminary.

Meeting to be held on life data

Microcircuitry
ref (pp 75)

D. Talbert — Don Farina
P-F — VHG
Ned Gault — GM

Review:

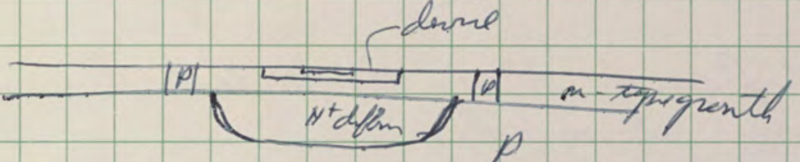
R&D should be completely through with μL family by Dec 15, except
1. If yield on C's is horrible for some reason
2. We are checking out the new mask ideas on the 5-element on a minimum square unless a rectangle is more convenient.

R-elements - New masks being drawn. This is an experimental structure to establish the capability to make something this big.

Kit I - Must be done on present camera - can't wait. - This thing is still horribly bogged down in flexibility.

Don Farina will run in a T^2 Xstor in also. He wants to check the effects of the isolation.

Ned Gault points out that by diffusing N^+ ~~before~~ into P before epitaxial growth gets around the V_{CE}(sat) problem.



This is important - it looks excellent to try fast.

Project 108 – 7000 Development 12/8/61

P. Samuel
P. Fegan
H. Bogert
P. Jones

Moore

Problem of LVCEO is primarily material.

Material:

Merck : Typical 25 %
Min 15 %
Best 45 % at die sort (hand junction)

FSC : ~~Typical~~ One group of three – 2 wafers completely shorted
1 gave 30% yield

A second group – all three E-C shorts

A third group – 1 wafer gave 7%, 2 gave complete shorts

Six wafers are being stuck in from Peterson's material.

Check of material by diffuse B + P over entire surface and check for LVCEO.

Hanks material also gives channels. It is thought that this is a function of the doping from the substrate, which is variable.

ME: Get the epitaxial program going!

Std material is still a little better – say 30% average.

Solder down:

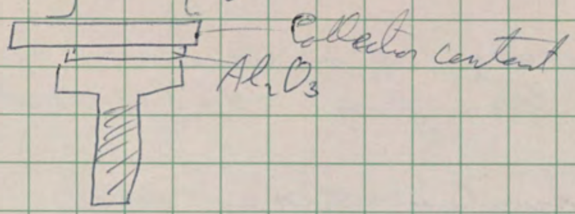
Cu-Ag alloy goes at ~780°C solderdown – ∴ can't use this with Al on top.

The best guess at the moment is Au solder down and Al to Al on top. Some of these will be put on life test ASAP. Work will be done to try to improve the solder down.

1) Wetting of back with Au by spike alloy
2) Pure Au instead of Au-Si eutectic

Pierre says that the insulation of the collector is very important.

TI now makes one like



Project 171 - Zener diode 12/14/61

Ragle
Lamond
Ferguson

Grinich
Moore

The 100 μa diode is way up in the air,
Essentially everything differs from the 1340 by now.

Here is the definition of the product:

1. It will use 1340 geometry
2. It will be diffused in Mtn View small geometry line with a slightly modified (time only) base diffusion.
3. It will be die sorted to give low temp coeff by measuring ~~BVEBO~~. BV_{ECO} (V_Z)
4. We will supply data (general curve) for
   a) adjusting V_Z to get proper T.C. at a given current to (m
   b) die sort voltage.

The self heating is ok for 25° - 150°C, but for -55 we might be sick.

~~P.L. says~~
It is imperative that we get life data.
We are short on noise measurements

Theoretical noise: Johnson ~1μV
Shot ~1μV
Measured ~100μV (probably mostly avalanche noise)

We need life data immediately. It will be the end of Jan before we have data.

Rest of the Zener family

7.5 ma - The Hilbiber looks like an advantage - but a large area top side diffusion to decrease spreading resistance must be done.

ME: Write a description of our Zener program.

Meeting Nov 17, 1961

Large geometry meeting: (Almost everybody there inc. Bay, Sporck, Grinich, Schultz, Palmer etc)

3001:
The written objective spec is $LV_{CEO} = 25$.
We should be able to do 35

The competition is
GE - 50 spec
RCA - 60 spec
Motorola — min ~60

Our problem is that 1v, 1a sat is lost at ~ 55v LV_{CEO}.

Aim at two products

① $LV_{CEO} > 35$, V_{CE} (SAT) < 1v @ 1amp

② $LV_{CEO} > 60$ v for now. Write objective for 100 v, but collect to 60 v for now.

It looks like a Feb. product announcement for both.

3101 - Some spread in V_{CE} (SAT) - 0.8 - 1.2 volts

Obj spec: $LV_{CEO} \geq 35$ v
V_{CE} (SAT) (500 ma) < 1 v
τ_s

not now to factory - they continue 4300

>11 - stripe. (4011)
Hot, but low BV_{EBO} — March — (late spring)

4400: We are doing ~1.6-1.8 on h_{FE} $\frac{150°}{-55°}$.

Lets cut the cord for a Jan 1 product. -4400 but work toward upping to 4405 (60v LV_{CEO})

6200 — We want nothing more on the Litton package.
could use 6206 in 7/16" stud for A.C. Spark application. Need 100 v LV_{CEO} for everything.

6206 - no work now.
Mtn View works on 3006
Palo Alto works on 7000

7000 -
Masks come to P.A. on Dec 18.

Chip will be on 11/16 stud.

Aim at March IRE product announcement.

2N1959 (Sylvania) is clobbering us.
Motorola Star is the toughest.

THB will notify us if a direct competitor is needed here on a crash basis.

PNP
Mtn view is making 4700 (orig 1780)

3501 - We need our life test data in order. At the moment we have egg all over our chin on this.
In order to shut the 4500 down, we must meet the 300°C life test.

Dec 13, 1961 – Semiconductor Film Growth
Project # 162

Sah
Wigton
Hale
Sanders
Moore
Flint
Yim

(WHG
J.PF)

Review of status of silicon work:

"Get even deposits on inside and fairly even on the outside" – say a spread of 20–26 fringes top to bottom on the outside.

Reproducibility at a given row is $\pm \frac{1}{2}\mu$ when the pump – check valve is working. It should be working from here on out.

Resistivity is still controlled by the resistivity substrait $\rho_{sub} \cong \rho_{film} \times 0.009$. By using this the 3001 is evidentally ok.
For PNP the relationship looks like $\rho_{sub} \simeq \rho_{film} \times 0.002$

The speculation on the doping Xfer is that the wafer backsides are being transported from high temperature to low temperature regions.
On an uncoated mandrel, the deposit Xfer is ~ 3X as much.

Hank denies that Merck can grow a ~~stiffer~~ given ρ on more highly doped substrait.
To try to minimize transfer, the best idea looks like trying SiH_4 instead of $SiCl_4$, since it is proposed that Cl is necessary for the material transport.

Runs at lower temp and low rates will be tried now that we have a good metering system.

~~The~~ When mechanically polished surfaces are used we get very high dislocation counts reflecting high substrate problems.
With chemically polished films (only P-type checked) we get a lot more dislocation in the film. Say <200 to >2000. However, just heat cycling substrates gives the same effect. It would be a good idea to do more work on dislocations. Ideally we would not introduce any more over those in the original substrate.
In one doubly heated run everything was shot on a small device

Predominant defects introduced in film growth are pyramids and dimples.
Pyramids are thought to be points of nucleation below epitaxial temperature.
Dimples are thought to be caused by dirt.
"Flow lines" are always present on grown film, but they don't hurt.

Pyramids always kill a device
Dimples don't occur very often (especially not at high temperature). Their effect is not known.

Project 162, Semiconductor Film Growth, cont

Hank feels that silicon carbide might well be the culprit on the pyramid type defect.

Phil Flint has found a defect that can be developed by slow etching with CP-6 + H_3PO_4. On the Merck material things that originally were triangles etched out to triangular moats ~~On When the~~ with Dash etch. The CP-6 + H_3PO_4, however, etches out round pits at other locations than that of the original triangles.

The dots that etch out when checked with a 1 point probe seem to be of much higher conductivity than the grown film in general.
Phil Flint will check these for correlation with electrical problems.

Electrical properties of the films:

~~Wafers~~ Films grown with backing wafers gave visibly large channel on the scope. There were ~120 - 200 V BV. It may just be a high resistivity effect, however, instead of a direct result. On the other hand, a second run (that now has thermally polished wafers) gives fewer channels. There is some indication that these are not a simple high ρ effect in that some of them cannot be cleaned up by surface treatment.

On grown junctions we have gotten pretty good ~~films~~ mesas to 50 mils on the original system of [illegible] mandrel and on the inside of the present mandrel. The regular wafers are not nearly as good. The main differences are
1. Slower growth
2. Isothermal conditions.

No improvement has been observed yet by growing junctions in the existing films

Summary of problems:

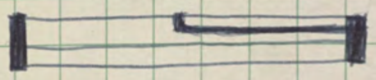
1. Electrical characteristics, especially e-c shorts
2. Resistivity control, especially to make film independent of previous history
3. The apparent quasi p-layer at the interface

162, cont.

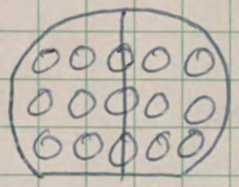
On the "good" 7000 run still was checked by a total of three test wafers, all of which were good. Still of the three wafers in the run only one was good.

Accd. to J.P.F. the Merck NN⁺ is just what Merck says it is up to ~2.5 Ω-cm.

As a test vehicle to check all the necessary electrical characteristics a wafer can be diffused with B and half with P. The structure looks as follows



and make mesas



~~GaAs films~~:

[illegible]

Project 189 Field Effect Xstors Dec 13, 1961

Flint
Lowinter
Hilbiber
Grinich
Kubell
Lamond
Sah
Ferguson
Tecetiker
Moore

Review:

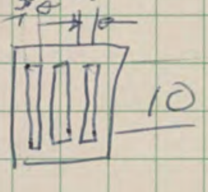
Material - uses Ga-P doped xtals mainly. Some Al-P in mill. Material is fairly predictable - it seems to follow simple normal freezing of the two components individually.

Some epitaxial has been tried. ~~for chopper versions~~

For the outdiffused plotting $X_j \propto \sqrt{Dt}$ one does not get good agreement. It deviates in the direction of getting some pile-up. The effect is not strong and can be taken into account empirically. The V/I is in the same direction. The difference, however, is larger than can be accounted for by all the P in the Si that was oxidized - this can be a factor of 100. - This last statement is not confirmed. Also if one calculates ~6 v $V_{\text{pinch-off}}$, one gets ~10-15 volts

T It would be worthwhile making good diffusion calculations on the basis of the existing data.

Chopper reproducibility run: "looked poor" - this geometry



1. Photoresist problem (>50% low breakdown)
2. R_{SDO} ≅ 200 (by adjustment of diffusion), but spread 100-500Ω
3. V_p ≅ 35 v objective, but much higher obtained, say ≅50

New xtals have higher Ga or Al to P.

By growing a Sandor oxide before out-diffusion the pile up can be greatly reduced. - Has this been tried? GM 1/15/62

We need new masks allowing for an anti channel diffusion over the channel to
1. Reduce pinch off
2. Decrease conductance.

No reliability data exists at present.

We have made some devices with diffusion over the channel by giving a light Ga diffusion of over the top of regular devices. These had extremely low noise. The gallium diffusion didn't ruin BV. The yield was low, though.

COMPANY PRIVATE

PROJECT PLAN FOR PROJECT # 189

FIELD EFFECT TRANSISTORS

O. Leistiko

A. PROJECT OBJECTIVES

Generally, it is desired to develop the optimum configuration for each of the field effect transistors discussed below. A comparison of two or possibly three approaches to developing the devices should be made. That is, one should investigate the possibility of making field effect transistors using the technology we have at hand, such as, out-diffusion, in-diffusion and epitaxially grown films.

Inherent in the development of each of the various types is the determination of whether or not the devices can be made with adequate reproducibility and stability.

Since field effect devices are potentially very useful in integrated circuitry.

The following list includes the various types of field effect devices that are of interest. An additional sheet gives a more thorough discussion of some of them.

1. Chopper

   Objective specs are $R_{SD} \overset{\sim}{<} 100$ ohms at $V_g = 0$, $BV_{SGO} \geq 5$ volts. It need not pinch off completely. Leakage currents should be very small. The devices to date have been made primarily from aluminum phosphorus compensated crystals. Initial results with gallium phosphorus material looks actually encouraging and seems to avoid some of the problems.

2. Pentode

   Requirements: Must pinch off at $V_g \overset{\sim}{<} 10$ volts, $C_{sg} < 10$ pf, preferably 1 or 2, $BV_{SGO} > 40$ volts, I_{SDO}(sat) 200μa to 600μa.. This implies approximately 5kilohms for channel resistance. While the present experimental devices use the double stripe 1210 geometry, the final device need not have the double structure. Eventually, this device will need new masks.

3. Bigger Pentode FET

Eventually we will want to make a larger version of the above pentode. No work on this is contemplated for the present.

4. Switch FET

This one is similar to the pentode, but a lower on impedance and higher off would be nice.

5. Metal Over Oxide FET

This structure offers the possible advantages of

   a. Making normally off switch
   b. Double gating for lower pinch-off voltage
   c. Infinite input resistance

6. Application and Development Program

The field effect transistor has possible usage in three major fields

   a. As a chopper modulator
   b. As a high OFF impedance switch
   c. As a high input impedance amplifier (pentrode replacement)

The first application, as a chopper, competes with mechanical choppers and transistor pair choppers. The requirements here are a low offset voltage that should be less than one microvolt, in order to be competitive with mechanical choppers. For instrumentation purposes this should hold over a temperature range from 0° to 60°C (military equipment -55°C to 125°C). The main advantage here would be the possibility of operating at quite high frequency so that the system band width could be considerably improved over mechanical chopper systems. This would require the balancing of capacity currents that also create and offset voltage. The present structure is aimed in one device. One question of design of this device revolves around the compromise between frequency response and temperature range.

The second application, as a high OFF impedance switch, requires that the device be completely pinched off and be used in place of stepping switches in large process control installations. The requirements of the OFF impedance are determined primarily by the number of switch points tied to one input. In general, to be useful these should be of the order of 10 to 100. In order to prevent cross coupling, this requires that the OFF impedance be in the order of $10^{12}\Omega$. This is a much more stringent requirement since the gate leakage current flowing in the OFF direction will add up from the OFF switches and flow through the ON device. Frequency response and temperature range are not as completely determined here. Possible more attempt to control the temperature should be made, if the performance characteristics justify this.

The final application, the pentode replacement, would be for building completely transistorized test equipment so that the input stage could be both the high input impedance and high frequency response. Present transistor circuits require use of very low currents to get the high impedance and hence frequency response suffers. In addition, the possibility of using a field effect device as a DC amplifier has not been exploited and warrants attention. The characteristics as an input stage in a piece of test instrumentation would require that the amplifier it produces be compatible with present VTVM and scope input preamplifiers; that is, in the order of 1 - 10 megohms shunted by less than 50 pf, which must be met with reasonably high gm devices.

B. PROPOSED PLAN

1. Chopper

A new set of masks has been designed which makes it possible to use the the same crystals (for the case of out-diffusion) or the same epitaxially grown films for both the chopper and pentode replacement. The following characteristics should be obtained:

$BV_{GS} \overset{\sim}{=} 40$ v, $R_{SDO} \overset{\sim}{=} 200$ ohms, $V_P < 10$ v,

$I_{GS} \overset{\sim}{=} 20$ μμa at 20 v reverse bias, $V_{OFF} = \leqq 1$ μv at 25°C

a. Make a comparison of reproducibility using out-diffusion and epitaxially grown films.

   b. Design masks and make reproducibility runs for a low noise chopper, ie isolate channels from surface using a transistor like structure.

2. Pentode Replacement ($I_{DO} = 200 - 600$ μa)

   A new set of masks has been designed but will not be available until the first part of January 1962. The new configuration isolates the channel from the surface. This was done to reduce noise figure (see attached drawing).

   a. Check effect of isolated channel on noise figure.
   b. If noise figure is sufficiently reduced over the range using the above masks make reproducibility runs using both outdiffused and epitaxial material.

3. Switch FET

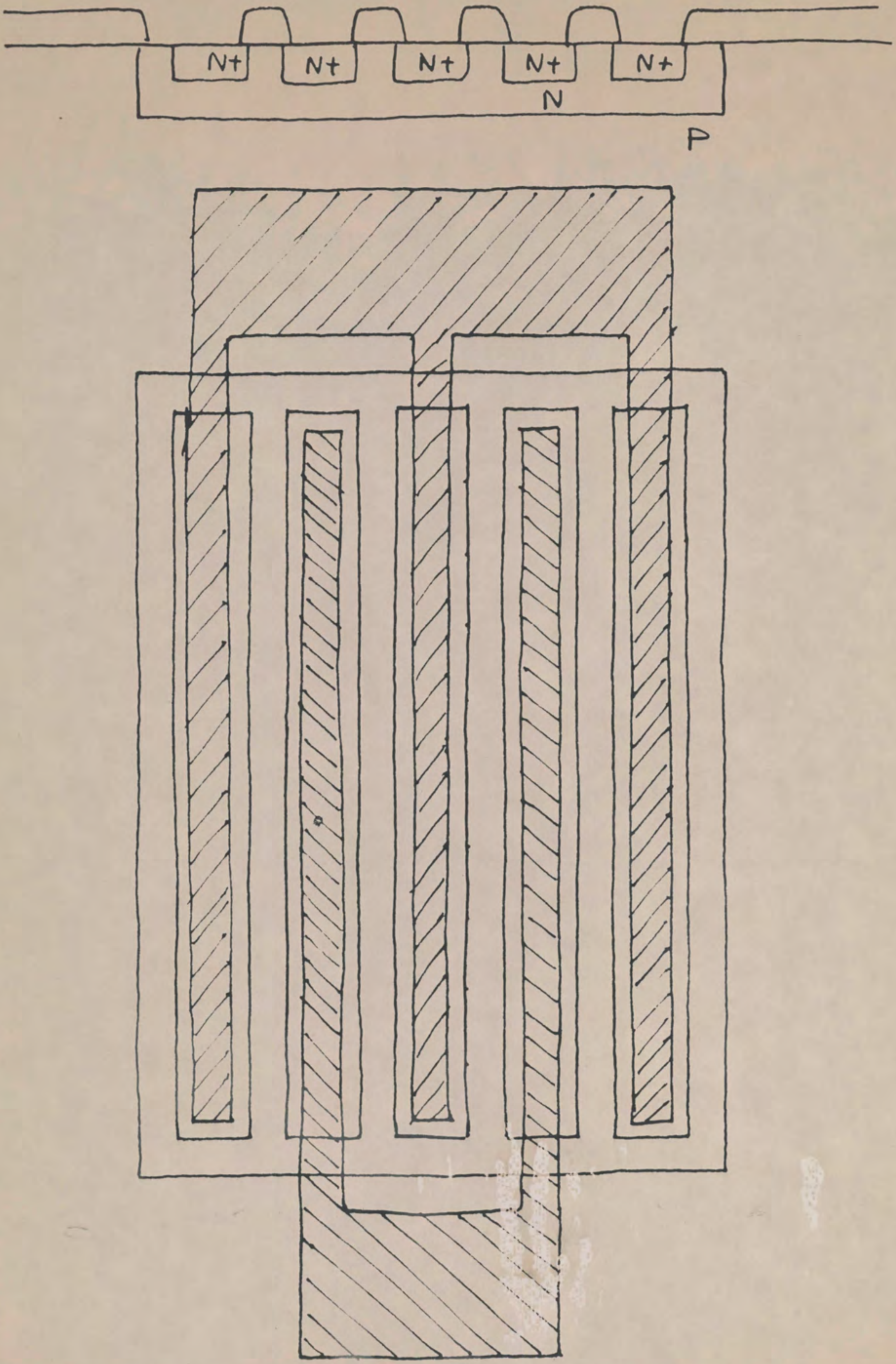
   Dave Hilbiber has expressed interest in a device with the approximate characteristics $I_{DO} \overset{\sim}{=} 10$ μa, $F_p = 2 - 5$ volts $I_{GS} \overset{\sim}{=} 20$ μμ a at 20 volts. Some devices with similar characteristics have been supplied.

   a. Nothing specific on this device.

4. Metal Over Oxide FET

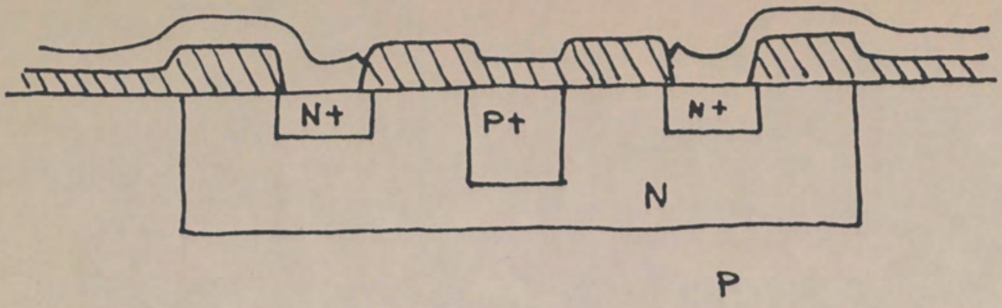
   Provision has been made in this new Pentode Replacement masks for a gate over the oxide if deisred.

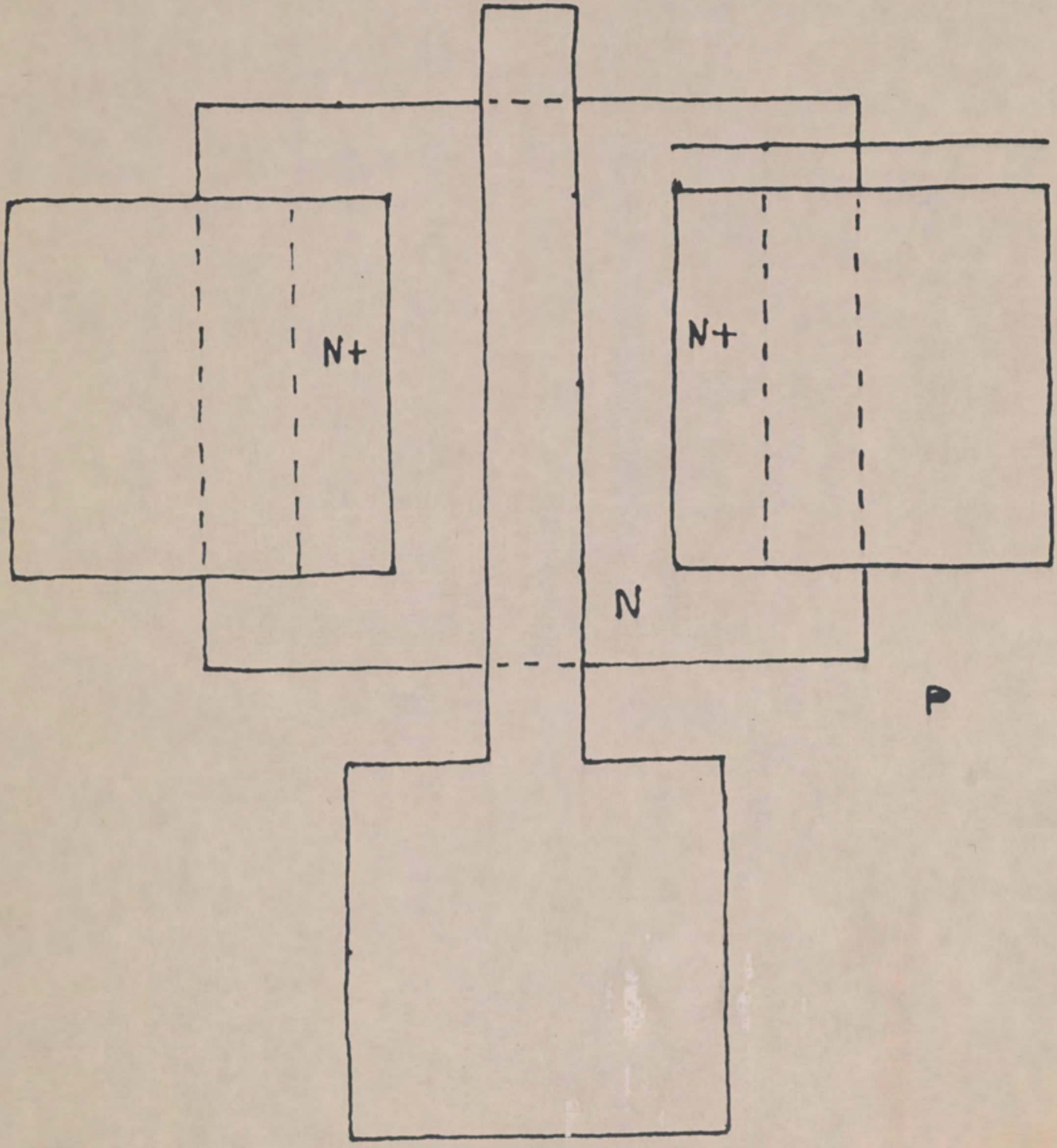
   a. Some devices of this type will be made when masks are available (January 1962)



CHOPPER XFE 50D

PENTODE REPLACEMENT XFE 50E





<u>T-MB</u> Some choppers are in the mill. These will be out next week. As soon as data on these is available, we will meet and decide <u>exactly</u> how to get a SOA field effect out on the market. I want personally to tie the loose ends together on this one.

Product layout meeting – Diode

Dec 14, 1961

Ferg.
Beadling
Bay
Adeli
Noyce
Sugiuchi
Moore

Topics for discussion :

1. FDA 1, 2, 3 (Adam)
2. Ultrafast — in Xfer mill
3. 100 μa Zener — " " "
4. 7½ ma " — Transfer ~ March
5. Gen. Purpose Zeners – We will take general cut – let them make fill-ins
6. Small Adams
7. High V. rectifier — not a product under development
8. PNPN light sens. Kill
9. Controlled Rectifier — S.R. import. Meet ~ Feb 1 – ~ Sept Xfer objective
10. High V, I rectifier } – see →
10a. H.V. Stacks
T. 11. Variable capacitors and varactors – R&D will diddle
12. IBM Plastic photodiode
T. 13. Multiple Diode. – Lets crank this out!!!

Microdiode:

If S.R. wants, they can pick up our info and go.

R&D will continue to investigate high voltage junctions.

Agenda for 12-14 diode meeting

1. FDA 1, 2 and 3 (Adam)
2. Ultra fast
3. 100 micro amp zener
4. 7 1/2 millimap zener
5. General zener
6. Small Adam
7. High voltage rectifier
8. PNP 2 terminal PNPN light sensitive
9. Controlled rectifier
10. High voltage - high current rectifier
    high voltage stacks epoxy
11. V~~e~~aricaps and v~~e~~ar~~i~~actors
12. IBM plastic package photodiode

→ 13. Multiple diode

~~14. Charged storage diode~~

~~15. Tantalum capacitors~~

Meeting to consider the use of scribing for dicing pL units – Dec 18, 1961.

O'Keefe
Seigel
Blough
Crosby
Foster
Ames

Moore
Yarosh
Hall
Crippen
Ferguson
Faring
Gwynn
Gault
Norman

Data review:

On 137 each way

	scribed	etched
A	70	68
B	19	15
Open	4%	12%
Droptest	0 out of 8	2 out of 8

Looking at 30 random electrical rejects (scribed) found 14 with cracks.

New data on temp cycled, high voltage, high temp. When this is collected, we will make a "yes" or "not yet" decision.

Many hopes to have this by 1/10/61. We will meet then. ~~By~~ Charlie Blough will call the meeting.

Meeting concerning A C Spark device Dec 19, 1960

Hammond Grinich
Ferguson Moore

2N1724 } both of T.I.
2N1937 }

Used @ 2½ amp
20 amp rating (used as 10 by A.C.) 7/8" plug. T.I. got a contract to produce 400 units for burn-in. This is the one they really need

1. Can 7000 go in instead of 2N1724 - direct plug-in. - If so, they will plug some in. If this goes, then they will assume that we can make the 2N1937.

We will supply samples to THB for ACSP - 6 by Jan 1.
" " start the masks for the X-8000 device that should do the 10 amp job easily.

Meeting concerning header elimination on a cheap SGS Xstor 12/20/61

Noyce
Sello
Levine
Grinich
Spohn
Moore

To get solid effort @ SGS, Si must be cheaper than Ge devices. The problem is one of cutting materials cost to a minimum.

SGS can make an unplated Kovar header now for ~$0.08. Can hope for $0.05

We are talking of a selling price in the 15¢ price range.

A Japanese header is being evaluated. It should cost ~$0.04. We (R+D) shall
ME look at non-Au plated die attach possibilities. We will restrict our effort to this task. Mtn View will supply the header. We will check cheap Ge units for ideas. Try a Cu plate?

Project 140 Strain Gauge Elements

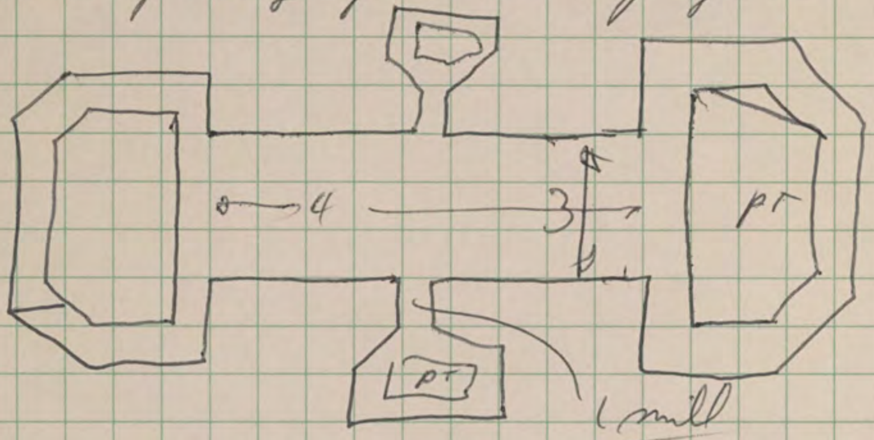
Kibell
Vrile
Pearson
Moore
Smith

12/21/61

Review:

The shear gauge is having to do more technology development. There is a need for a lowly doped p^- type layer. For this reason outdiffusion is not so good. Epitaxial material is just arriving. The use of the opposite polarity (n-type gauge) loses us a factor of 2. In any case it looks like the 5 volt output objective is hanging on the 28 v power supplies. The bridge gives 5 v at ~ 1600 μ strain.

The present geometry of the shear gauge is



Points:
1. Leads run out
2. All Si diaphragm

Measurement of strain is still a major problem. Need fantastic precision to do on the temp - in-clear - structure

For use the thing must be attached to the diaphragm. How is a problem.

We will proceed to make a test vehicle to use the dead weight tester to get evaluation of the all Si beam and shear gauge. Time scale

Project Plan for Project #140

Strain Gauge Development

Project Leader: G. Vick

Approved Section Head: ______________________

Approved Director's Office: ______________________

PROJECT OBJECTIVE:

1. Increase output of shear gauge.

   The quantity $\frac{V_o}{V_{in}\epsilon}$ should be increased from its present value of 50 to a value of 84 to 100 as compared to 125 for a strain gauge bridge. This will permit outputs of 2.5 volts with 25V to 30V in at strain of .001 in/in. The quantity $\frac{V_o}{P_{in}\epsilon}$ should also be increased to permit these output levels at reasonable power consumption.

2. Improvement of temperature dependence.

   The principal temperature effect consists of change with temperature of the zero strain output. This output may be attributed to (a) misalignment of output terminals, (b) residual strains due to die down, (c) imperfect contact areas, (d) inhomogeneities in the crystal or diffusion. The new mask and all-silicon beam are expected to reduce this problem to manageable proportions.

   only (d) might still be of significance

3. Determine limits on linearity.

   With the all-silicon sensor base, the maximum strain that may be applied is limited by the linearity of the output rather than by the breaking point of the silicon.

   — Should result in a paper in longer term

4. Improved measuring techniques.

   now ok

   Implementation of 2 and 3 will require improvement by an order of magnitude in our present measuring and control of temperature and in our measurement of strain. The temperature problem can be circumvented by temperature compensating the sensors with temperature sensitive resistive networks. Measurements of relative strain, which are now measured to 0.1% of full scale (.001 in/in) will be improved to 0.01% fs.

5. Design of transducers commensurate with improved strain elements. Design objectives will be twofold: 1) Improve the accuracy over existing devices (e.g., 3SG), and 2) provide performance similar to existing devices at lower cost. Specific design objectives to be determined upon examination of market survey results.

PROPOSED PLAN FOR NEXT SIX MONTHS:

1. Service to Los Angeles will continue as requested and will be charged to #167.

2. Study of diffusion techniques for attainment of minimum X_j and C_o for shear gauge. Primarily a study of the applicability of epitaxial deposits and of repetitive low temperature oxidation--HF cycles to achieving low doping and thin structures. This will require one man for the next six months. The design of transducers is not dependent upon the results of these tests and can proceed concurrently. The

improvement will be seen in reduced power consumption for a given output and will not necessitate redesign of transducers.

3. Determine and attempt to eliminate source of zero offset voltage and zero drift in the shear gauge. The possible causes of zero offset voltage are listed above. Evaluation of the new mask and the all-silicon beam with respect to zero offset should be completed by February 15. If these do not reduce the problem to acceptable levels, the effects of crystal homogeneity and surface condition will be examined. This will require a one-man-effort until completed, at which time this effort will be rechanneled.

4. Linearity studies.

   There are two effects which contribute to nonlinearity of shear gauge output versus strain. 1) Change in the piezoresistive coefficient with strain, and 2) a geometric nonlinearity resulting from E and J being in different directions (Hall effect shows an analagous nonlinearity). These are in opposite directions and should tend to cancel. Both are subject to a degree of control which can be used to enhance the cancellation. In addition, there is the nonlinearity due to strain not being directly proportional to beam deflection. This is also subject to control a and can be used to cancel whichever of the above is predominant.

   a. This area is where the improved measuring techniques both of temperature and of strain required. The temperature effects can be improved by temperature compensating the experimental sensors, and the strain measurement by a careful redesign of our test speciments. These will be complete by February 1.

b. Study of the nonlinearities and the development of a sensor with optimum linearity should be complete by June 30.

This will require a one-man-effort for the next six months.

5. Transducer development.

This may be divided into three phases as follows:

a. Market survey. Assistance will be provided to Gordon Goodrich in his market survey as required. The results will be studied as they become available.

b. Concurrently with (a), new materials and methods for design of transducers will be investigated both theoretically and experimentally (e.g., ceramic materials for pressure diaphragms and springs; configurations which will eliminate soldered mechanical linkages, etc).

c. By the end of the first quarter of 1962 we should have enough information to begin to design and build a prototype pressure transducer and linear accelerometer. Prototypes will be made and tested by the end of the second quarter.

d. Feasibility studies will also be made from time to time for additional new devices such as microphones.

6. Tunnel diode effects appear interesting and should be pursued as time permits throughout the next six months.

7. Develop a $7,536 3SG accelerometer for Project #923.

8. Resolution: Noise level will be investigated

PERSONNEL:

G. Vick	Engineer	full time	1,000 hrs.
N. Pearson	Engineer	full time	1,000 hrs.
H. Scherling	Technician	full time	1,000 hrs.
M. Dragmire	Technician	50%	500 hrs.
S. Mizote	Technician	30%	300 hrs.
B. Fallis	Data Clerk	100%	1,000 hrs.

CAPITAL EQUIPMENT:

Equipment for precise measurement of displacement (10^{-7}in) to be determined. Est. $5,000.

Power Supply—voltage—for driving constant current supply. Est. $300.

Project 173

Pre-Meeting Summary for Review of Etching Studies Projects

The two chief projects in this category at present are the electropolishing of silicon (work being charged to No. 133) and oxide etching (work charged to No. 173).

Electropolishing silicon

Project objective: To etch silicon wafers controllably leaving a flat, highly polished surface, free from damage and significant imperfections. Wafers to be subsequently used as epitaxial substrates, and other uses.

Proposed plan; tentative outline:

January 15 - Preparation of low resistivity p-type material reasonably satisfactory. Agreement established on standards and evaluation of samples prepared.

January 31 - Low resistivity n-type feasibility established and reasonable success obtained. (Slotted wheel needed before this work can be performed; is on order.) ↖ needs photo-injection

February 15 - Low resistivity n-type being run fairly routinely and with reasonably satisfactory results.

February 28 - Some exploration of alternative plates or treatments; training of other personnel if desired. Duplicate apparatus constructed for larger scale preparation of wafers.

Personnel and estimated hours:

Past: W. Smart full time since middle of November; approx. 210 to date.
M. Buenz before October; part time.

Future: W. Smart January, 1962,	174 hours.
E. Duffek January, 1962,	40 hours.
W. Smart February	150 hours.
E. Duffek February	30 hours.

Technician from another group (if training desired) say 30-40 hrs.

Beyond February, 1962: see below

Capital Equipment: No major expenditures anticipated. Apparatus used can be constructed, or duplicated, for relatively small sum. Power source borrowed or relatively inexpensive. (Total, less than $1000.)

After the end of February it is proposed to continue similar work, under No. 173, "Etching Studies" with somewhat broadened objectives. Other materials should be used, with gallium arsenide being given first attention, perhaps already in February.

Project Objectives: To etch materials controllably leaving a flat, highly polished surface, free from damage and significant imperfections.

Proposed plan:

Schedules to be set as work progress and laboratory needs indicate.

Personnel and Estimated hours:

Continuing effort will utilize probably:

E. Duffek	30 hours/month
W. Smart	60 hours/month

Capital equipment needed: No major new equipment anticipated. Perhaps a Lapmaster or polishing wheel; perhaps a small power source. At present, need for surface roughness meter ($5,000 - $10,000 as at Bell Labs) not adequately established.

Oxide Etching

Project Objectives: To obtain improved control over etching silicon oxide formed under a variety of conditions, and with the admixture of other oxides such as those of boron and phosphorus.

Proposed Plan:

To initiate work again as soon as the constant temperature bath can be obtained. It is now on loan, pending the repair of the one used by diffusion and other personnel.

Parameters to be studied include temperature, etch composition, oxide preparation (steam, dry O_2, anodic, thermal decomposition of silanoids), oxide composition (including some boron or phosphorus oxide).

Personnel and Estimated Hours:

None recently; year to date on No. 173, as given in monthly reports.

Future: M. Buenz, 100-150 hours/month, depending on relative priorities of this and other projects.

Capital Equipment Needed:

No expensive purchase of items anticipated, if constant temperature bath again made available.

Miscellaneous Etching

Special short projects to be undertaken as needed by other Sections, but no other major efforts now planned for near future.

W. Waring

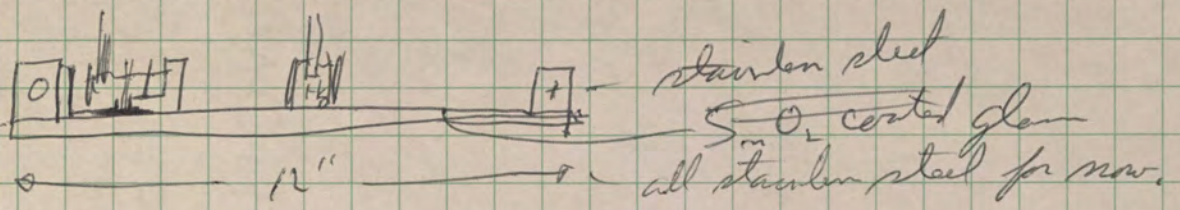
W. Waring
December 21, 1961

WW/nm

Project 173 - Etching Studies Dec 22, 1961

Includes oxide etch, electropolishing
We made some isolated sleeved film chemical etches.

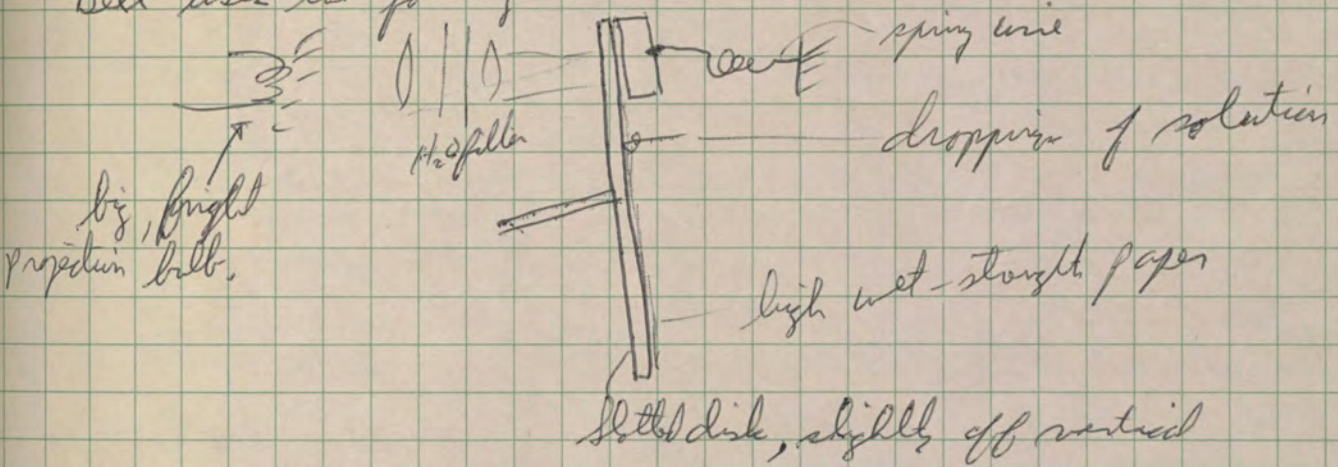
Contact is made by Ni plating and soldering on lead which is then ~~potted~~ stuck into a pool of Hg



Electrolyte is 2.5% HF in 50-50 glycerine & H_2O
We use current of ~ 1 Amp/wafer.

Surface on 1Ω-cm P-type is not good yet.
SnO_2 gets reduced very rapidly.

Bell uses the following



They etch at very low currents now, but don't seem particular. Their jig to hold wafers uses parafin and spring contacts.

Meeting on the Step & Repeat Camera – 1/5/62

Nall
Greig
Folk

Kleiner
Moore

Summary of Costs expended as of 6 Jan '62

Farrand Contract	28,950	
" Ext for Column	1 525	
Moore Pedestal	500	
Master Slide	1 310	
Column "Extension"	250	(495 allocated for 2 units)
Lapping Magnets	90	(180 " " ")
Magnetic Chuck (raw plate)	45	(90 " " ")
Bodine Motor & Controller	275	
Dayton Motor Reducer	30	
Vernac Scale System	943	
Diaphrams	45	
Microscope Bodies	850	
Micrometer Thimbles	112	
Dayton Blower	37	
Power Supply (RD #257-50)	2058	
Miscellaneous	500	(estimate)
Sub-total (1)	37610	

Autocollimator	2500	estimate
" mirrors	500	estimate
B&L LENSES	1000	"
Sub total (2)	4000	

Costs Unexpended

Microscope Frame	900	(1 Bid)
Light Box Assy (fab) }	1095	(firm)
purchase items }	150	(estimate)
Traveling Microscope	650	estimate
2×2 Plate Holders	150	"
Magnetic Chuck machining	133	firm
" " lapping	275	"
Autocollimator Mtg Brk.	100	
Sub-total (3)	3453	

(cont.)

Costs unexpended (cont.)

Shipping Cost		
	(freight)	1080
	(insurance)	260
	(unloading)	28
	Sub-total (4)	1368

Assembly and check out cost } Guestimate 4 men for 4 weeks, or 80 man-days @ $30/day = $2400 sub-total (5)

Funds expended

Sub total (1) 37610
(2) 4000
Ⓐ $ 41610

Funds unexpended

Sub total (3) 3453
(4) 1368
(5) 2400
Ⓑ $ 7221

Total expected Cost

Ⓐ 41,610
Ⓑ 7221
total $ 48,831 (not including Engineering Costs)

Project Budget approval

$ 47,508

Deficit = $ 1,323 plus engineering costs.
(approx 180 man-days) 3 men, 3 mnths
@ $30/day = $5400

A.L.G.
6 JAN '62

Jan 6, 1962
11:00 AM.

Talked to Al Johnson this morning Jan 6, 1962 regarding delivery of our machine to Farrand. He says the machines still look almost ready and he thinks ~~they~~ our machine could be shipped possibly Tuesday or Wednesday and not later than Friday of next week. Delivery to Farrand would be made by Moore's own truck and should not take over one day!

He doesn't know where Farrand got its info about Moore being 3 weeks late.

Leo Greig

MOORE SPECIAL TOOL CO. INC.
Toolmakers
MOORE BPT CT TOOLS
Jig Borers · Jig Grinders

P. O. BOX 4[illegible]88
800 UNION AVE., BRIDGEPORT 7, CONN., TELEPHONE FOREST [illegible]224

JANUARY 3, 1962

FAIRCHILD SEMI-CONDUCTOR CORP.
844 CHARLESTON ROAD
PALO ALTO, CALIFORNIA

ATT: A.L. GREIG

GENTLEMEN:

THIS IS TO CONFIRM OUR CONVERSATION OF JANUARY 3.

WE CAN ASSURE YOU THAT WITH OUR MACHINE, INSTALLED IN A TEMPERATURE CONTROLLED ROOM FOR OPERATOR COMFORT OF APPROXIMATELY 75° F, WILL PERFORM TO OUR USUAL SPECIFICATIONS FOR JIG BORERS AND JIG GRINDERS EVEN THOUGH WE CHECK THEM OUT AT 68°F.

WE WILL SHIP A GALLON OF PAINT ALONG WITH THE MACHINE.

VERY TRULY YOURS,

MOORE SPECIAL TOOL CO., INC.

A E Johnson

A.E. JOHNSON

AEJ:ES

DESIGN & FABRICATION FOR STEP & REPEAT CAMERA		6 JAN · 12 JAN · ~~10 FEB~~ · Mar 12 ~~23 FEB~~ · 4 WEEKS FOR · April ~~23 MAR~~
GENERAL LAY-OUT ($28,950) FARRAND CONTRACT P.O. 2899	STARTED WITH MOORE CONCEPT OCT 12, 1961, MOORE MACHINE ORDERED THAT DATE -	EXPECTED DELIVERY TO FARRAND. (CONFIRMED JAN 6 BY PHONE → 4 WEEKS WORK AT FARRAND · 7 to 10 days delivery OF UNIT · ← ASSEMBLY & CHECK OUT →
SPECIAL MOORE COLUMN ($1525) FARRAND CONTR. PO2899 EXT 2		SAME AS ABOVE →
MAGNETIC CHUCK PEDESTAL MOORE CONTRACT ($500)		SAME AS ABOVE →
MAGNETIC CHUCK	STARTED DESIGN NOV 30, 61 FINISHED DESIGN 12/18/61 ESTIMATED COST $600 (WORK IN PROGRESS) SCHEDULED COMPLETION → 1 FEB '62	FABRICATION → · ASS'Y. OF COMPONENTS
LIGHT BOX DESIGN BY MT. VIEW	DESIGN COMPLETED 7 DEC, 1961 (LOWEST BID FOR FABRICATION $1095 RECEIVED 3 JAN '62) ESTIMATED COMPLETION 2 FEB '62	FABRICATION → · ← ASS'Y OF COMPONENTS →
COLUMN EXTENSION & MTR. BRK	DESIGN COMPLETED 14 DEC. 1961 FABRICATION TO BE COMPLETE, (WORK IN PROGRESS) BY JAN 12, 1962 COST $250	FABRICATION → · ← ASS'Y ON COLUMN →
MICROSCOPE BODY FRAME	DESIGN COMPLETED JAN 5, 1962 PRELIMINARY ESTIMATE (FOSTER) $900 - ESTIMATE COMPLETION 2 FEB '62	FABRICATION → · ← ASSEMBLE COMPONENTS →
2×2 PLATE HOLDERS	MOCK UP DESIGN COMPLETED 20 DEC FINAL DESIGN EXPECTED 10 JAN. 1962 EXPECTED COST $150 - EXPECTED COMPLETION 2 FEB '62	→
AUTOCOLLIMATOR MTG. BRACKET	COMPLETE DESIGN BY 12 JAN EXPECTED COST $100 " 2 FEB '62	→
VERNAC SCALE MTG. DETAILS	COMPLETE DESIGN BY 19 JAN. 62 EXPECTED COST $50 "	→
MODIFY "MASTERS" SLIDE	EXPECTED COST $100 "	→
TRAVELING MICROSCOPE	"JURY-RIG" AVAILABLE FINAL DESIGN TO START 15 JAN. ESTIMATED COST $650 ACTUAL COMPLETION NOT CRITICAL, BUT SHOULD BE READY ABOUT MARCH 15, 1962	→
MODIFY BODINE DRIVE MOTOR	THIS WORK HAS BEEN COMPLETED FOR R&D	
MODIFY DAYTON DRIVE MOTOR	" " " "	
MODIFY 10 MICROSCOPE BODIES FOR FRAME	BODIES ARE ON HAND, SHOULD BE MODIFIED BY 2 FEB SO THAT ASS'Y CAN BE STARTED } ESTIMATED $100 COST	MODIFY →

MINIMUM EXPECTED COMPLETION OR S&R 23 MAR. 1962

(COULD BE 2-4 WEEKS LATER)

G.L.G.

FET – 1/8/62 (See pp 88, 89)

Sah
Schultz
Leistiko
Hubbler
Flint

Kabell
Bowtein
Ferguson
Marra
Lamond

The chopper is presently a 5-stripper ½ × 10 mils.

The pentode is a 2-stripper ½ × 2 mils

Old business:

1. Diffusion calculation didn't agree before.
Assuming perfect out diffusion of acceptor and perfect pile up of the ~~accepter~~ donor, there still seems to be too much conductance observed – ie, too much P still.

2. The chopper runs in the mill came thru
– to get into production

Program: Using new 2-stripe masks with B-diffusion and either Al-P or Ga P Xtals – choice by Sah today.

Make ~500 sealed devices representing several Xtals and at least 5 diffusion runs. Ø TO-18

Schedule:

Have these made by Feb 28.

Life tests:
10 units 300 °C storage
10 " 200 °C storage
10 – 40 v V_{sd}, gate tied to source.

Monitor I_{sdo}, I_{go}, V_p, g_m

Otto will Xfer in to device devlpmt to make these. He will then go back to Phil Flint.

SCT - Jan 9, 1962

Solt
Sah
Bozant
Tremere

Lamond
Fergeron
Grinich
Moore

Life test data

15 unit 400 mw (40 ma 10 v) grounded base
gate tied to emitter supply at -10 v.

After 100 hours
BV_{CBO} - ok
I_{CBO} - ok
g_m (0v, 10ma) stayed the same or decreased - worst is 8000 μmho → 400 mho.

The effect was really a shift of the g_m vs V toward higher +V.

These units were not ~~at~~ 300 °C aged.

We need a greatly expanded set of conditions:

We will do the following

	Condition	Read at	Compare
a	300°C storage	1, 3, 10, 30, 100, 300, 1000	1. Al wire vs Au wire - 200°, 300°C life
few	200°C storage		
	$V_g = -10v$, $I_c = 40$, $V_c = 10$		2. 300° for 60 hrs for stabilization
units	$V_g = 0$ 40 10		if no short.
	$V_g = +10$ 40 10		
early	V_g at $g_m = max$, 20 ma, 10 v		
	V_g ±10 v, $T \geqq 200°C$		

By Friday we should know if the Au wire units on the grid show a tendency to short.

There was more, but I left early.

COMPANY PRIVATE

January 9, 1962
(Steve Sandor)

PROJECT PLAN FOR PROJECT 158

GaAs

Project Leader: ____________________
Approved Section Head: ____________________
Approved Directors' Head: ____________________

I. OBJECTIVES

A. Produce a high frequency GaAs Transistor by diffusion

a planar diode
Oxide (or other coating) masking against dif.

II. PLAN

A. Evaluate sources of material supply
B. Study contacts and alloying
C. Closed tube diffusion of Zu, Cd, Mu, Te, and Se
D. Coating with SiO_2
E. Masking
F. Predeposition and diffusion Zu, Cd, Te, and Se
   1. Carrier gas system
   2. Vacuum system

III. SCHEDULE

A. Project was started in December: S. Sandor 15% / 200 = 30
B. Future: S. Sandor - 30% time
   Assistant - 40% time

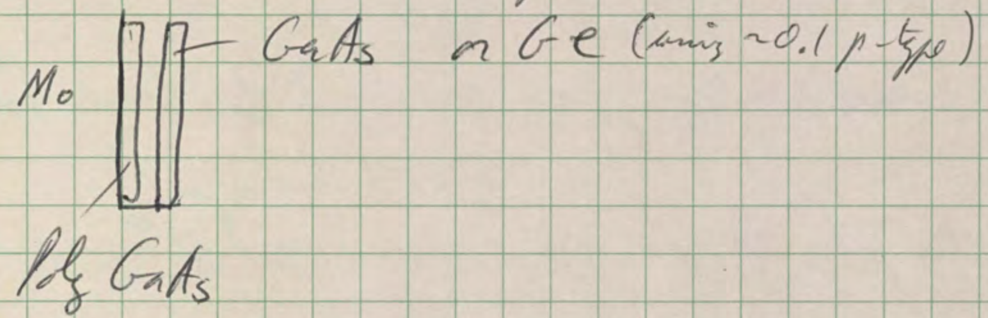
158 - GaAs - Jan 10, 1962

Fok
Sander
Wigton
Holt
Moore

2 - faced - 1 material
2 on technique

1. Review by Wigton on GaAs.

Transfer by Cl-containing atmosphere across short distance



With the GaAs substrate we never got a good junction. It is difficult to make 4-point probe measurements and thermal probe readings.

With Ge substrate (p-type) and undoped GaAs (n-type) this gave good hard 60 v junction on curve tracer.

T We will can some of these and make ~~[illegible]~~ V-I vs T measurements to locate the junction.

T Steve will supply a GaAs page or 2 for Basic Data Book.

The layer thickness was ~12 μ. - Hank is still aiming at 10μ.

My speculation is that the present junction is caused by Ge diffusion into GaAs

We will push along in this. The people making them will be in on the evaluation.

2. Steve will work along toward the objective of 11/6/61

Discussion with Hank Wigton and Tom Sah re service.

The service are

1. Wafer supply
    - growing
    - slicing
    - inventory control
    - coordination with Peterson
    - polishing

2. Epitaxial (special)
    - " (semi routine)

back lapping and regular lapping are transfered to Device Development.

It looks reasonable to put George Santos in under Ernie to do the service.

SCT – Jan 16, 1962, ref: page 98 – Life data

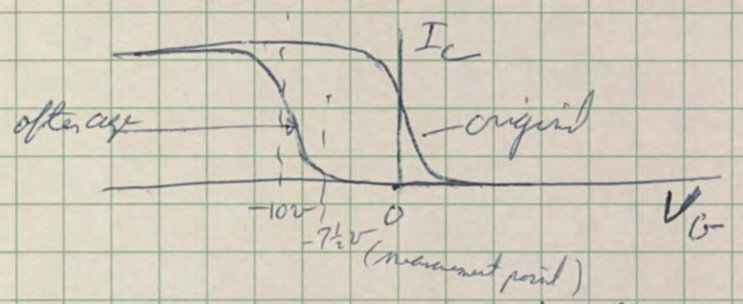
Sah
Bogart
Tremere

Grinich
Lamond

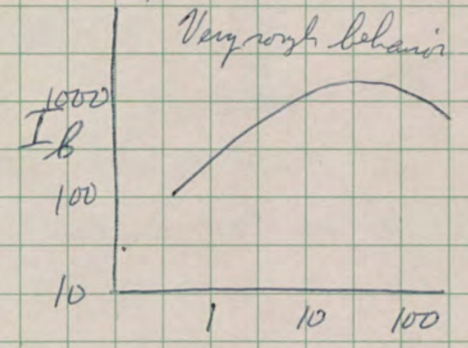
300°
Temp cycle
Power age
200°C

I 300°C – 60 hrs (10 devices)	C_{g-be} (0v)	g_m (max @ 10ma)	V_g at g_m-max	h_{FE} 10μa Vce -7½v
9 changed	18pf–16.5pf	unchanged	0 to -10v	10 – 0.3

These moved the opposite way of the original ones under power age.



II 300°C looked at early



III 200°C (6 devices)
All changes less than 20% except on two very low h_{FE} units.

IV Temperature cycling 18 units
2 units went very big

The effect is in such a direction the point of bias on the grid during power aging (and probably high temp) moves toward 0 v.

Three things to try
1. Higher base doping
2. Thicker oxide
3. Sealed in H_2

Epitaxial switching problem meeting Jan 17, 1962

Ferguson
Sah
Lamond
Wiglin
Moore
Grinich

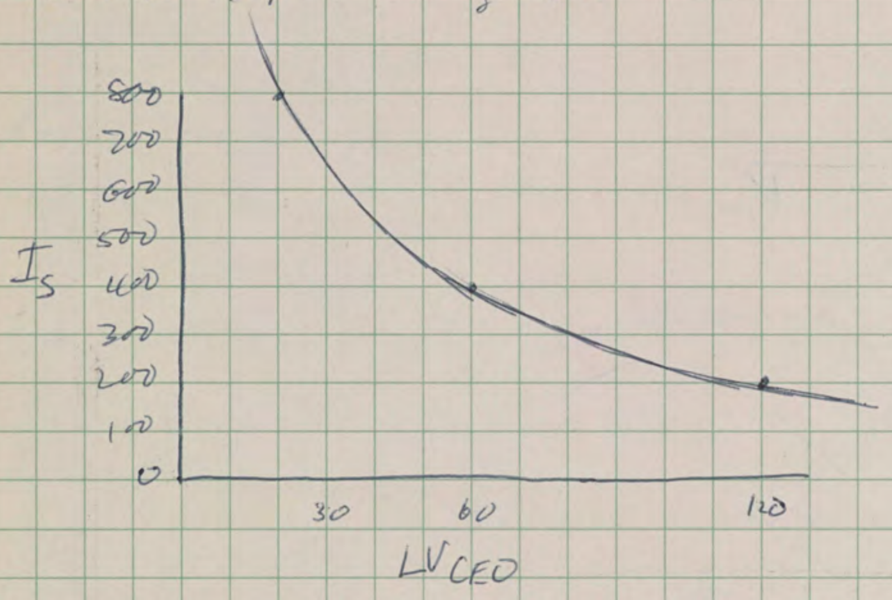
It looks like avalanche injection

For a 1341
$J_{sw} \cong 3 \times 10^3$ a/cm^2

The current density at which we get to limiting velocity should be ~ 1.6×10^4

Tom points out that M ~ 0.05 is all we need to switch, ∴ 50 amps/cm^2 could do.

Read tech rept #1 by Prince



LV_{CE} vs I_S with ~~Xepi~~ W_{ex} as a parameter

I_S vs geometry at const h_{FE}

I_S vs pulse width

178

PROJECT PLAN FOR PROJECT # 162

Art Hale

OBJECTIVE:

1. Best or practical method and procedure for magnetic film deposition
2. Most efficient geometry for thin magnetic film memory elements
3. Memory elements compatible with micrologic elements. That is, memory bits on the same silicon chip as the micrologic elements.

SCHEDULE TO JUNE 1962:

1. Evaporated film preparation defined by June so that a practical procedure is available. Parameters to be varied are:
    - a. Alloy composition
        1. Ni-Fe
        2. Ni-Fe-Co
        3. Other
    - b. Deposition parameters
        1. Substrate temperature
        2. Evaporation rate
        3. Magnetic field enclosing the substrate
        4. Vacuum
    - c. Annealing
        1. Temperature
        2. Time
        3. Quench
        4. Magnetic field during annealing and cooling
    - d. Substrates
        1. Microscope slides and cover glasses
        2. Silicon (oxidized?)

178

PROJECT PLAN FOR PROJECT # 162

Art Hale

Page 2

- e. Surface preparation of substrates
  - 1. "As is" with usual cleaning
  - 2. Mechanically polished and cleaned
  - 3. Etched and cleaned
- 2. Electrodeposition of magnetic films
  - a. Literature search completed by February 1
  - b. Experimental schedule available by February 1
  - c. Electrodeposited magnetic films by April 1
- 3. Vapor deposited magnetic films
  - a. Literature search completed by February 1
  - b. Experimental schedule available by February 1 if literature search is favorable
- 4. Comparison of the films by various methods to be studied by June 1962
- 5. Memory elements of special construction
  - a. "Sandwich" construction available by June 1962
  - b. Closed loop construction by June 1962

T.

PERSONNEL:

1.	Art Hale, Engineer	100% time on 162 178 to June 1962
2.	R. Oldham, Sr. Technician	100% time on 162 to June 1962
3.	W. Augros, Technician	100% time on 162 to June 1962
		3,000 hours

OTHER:

1.	Analysis - Chemical and X-ray	Approx. 150 hours
2.	Shop	Approx. 200 hours
3.	Photo resist and masks	Approx. 300 hours

178

PROJECT PLAN FOR PROJECT # 162

Art Hale

Page 3

EQUIPMENT NEEDS:

1.	"Dirty Vacuum System"	500 - 1,000
2.	Power Supply (high current)	< 425
3.	Ultra High Vacuum System (?)	< 10,000

Project 178, Magnetic Films Jan 17, 1962

Hale
Sanders
Sah
Grinich
Moore

Project Review:

Mostly on equipment

1. Now have a system to evaporate in 10^{-6} range

Anything else needs bakeable system.

There is no real evidence that an ultra-high vacuum is a real advantage.

2. Electron beam heater now on the air, ok.

3. Jigging ok

4. Hysteresograph — some measurement problem
   get coercive force
   saturation magnetiz.
   anisotropy (?)

5. Pulse tester — a probe with drive & sense winding

The present probe is a gross thing being made with wires. It could much better be made by some thin film techniques.

6 Bitter patterns $\bar{c}$ colloidal Fe_3O_4 has given only pin-holes.

Films now have many pinholes — like looking at a starry sky.

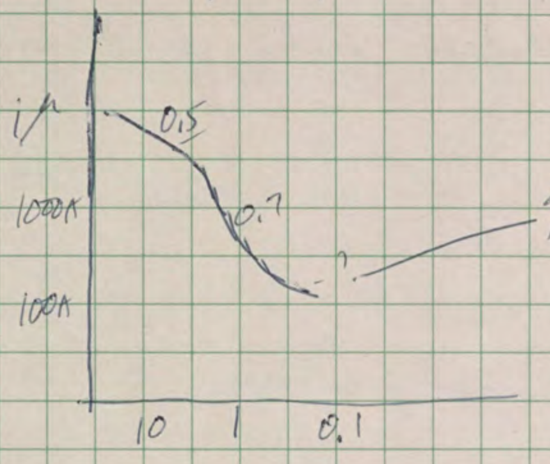
T. We are badly needing the pulse measurements to evaluate.

Project # 109, 114, 163 — Jan 18, 1962

Sprinl Flint
Holt Spl
Waring Moore
Sandor

105 Oxidation Studies

Review
Rates – essentially complete vs T, steam, O_2.
Some deviation from parabolic have been observed. Biggest at low thickness and low temp



This lower rate is not understood

For oxygen we get a nice activation energy of ~ 1.7 ev.
For steam we have a lot more curvature problems — we disagree considerably with Atalla.

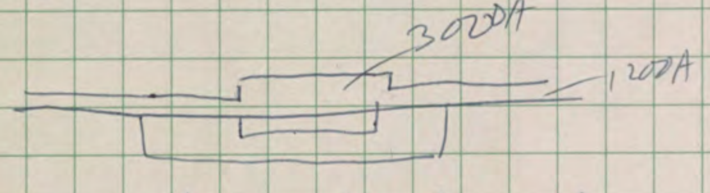
Bomb work at high P has been @ 1200 psi and 500°C. Bomb is of 316 stainless. By using the quartz ampule in the bomb

There is some ~~data~~ indications that the low temperature oxide have "interesting" electrical properties.

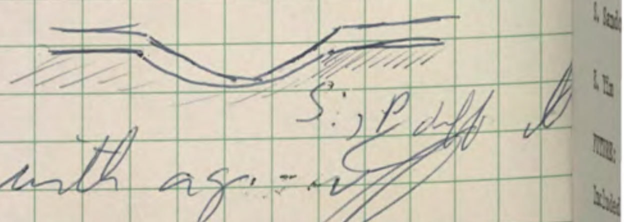
T. Lets get so we can grow the high pressure oxide

WHG T. Check the pyrolytic oxide for the high breakdown possibilities

As far as growth rate w/ doping is concerned, we have the following:



Also Jerry Parker has done the following



with ag-

PROJECT PLAN FOR PROJECT # 114

SPECIAL DIFFUSION RESEARCH

J. E. Sandor

OBJECTIVES:

Project A: Develop techniques to measure small diffusion profiles of <u>P</u> in Silicon.

Project B: Develop techniques to measure Diffusion profiles of As in Fairchild's epitaxial silicon.

PLAN PROJECT A:

* 1. Sample preparation: Oxidation under various conditions

*2. "Slicing" technique development

3. Neutron irradiation of samples

4. Slicing and etching the anodized Si

5. Activity measurement

6. Calculations

*Note: Steps 1 and 2 have been performed

TIME:

S. Sandor	2 1/2 months	30%	=	120 hrs.
Lab Technician	1 1/2 months	30%	=	72 hrs.

FUTURE:

S. Sandor	1/2 month	=	120 hrs.
Lab Technician	1 month	=	48 hrs.

PLAN PROJECT B:

X 1. Preparation of alumina discs

X 2. Grinding with Stanford's Microgrinder

3. Neutron irradiation of discs

4. Count activity

5. Calculation

TIME:

S. Sandor	1 1/2 month	(included in previous project)	
E. Yim	1 month	=	10 hrs.

FUTURE:

Included in project A.

Collect data on the growth rates of oxides with diffusion time on ~~the~~ wafers which have had the standard emitter predeposition times. Worden will see that these are saved for etch-rate studies.

114: O Special diffusion studies

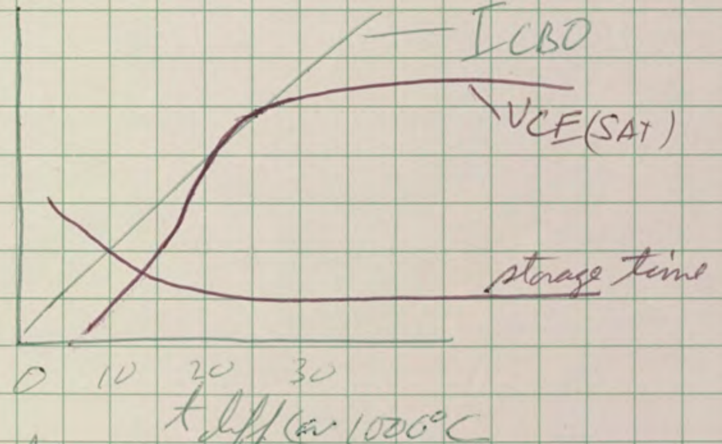
A. Gold diffusion studies (Phil Flint)

The data still doesn't fit the theory, but the theory is subject to an adjustable parameter (ie, what is the Au energy level at the diffusion temperature. Difference is ~×10

Tom doubts the neutron activation data and wants an independent check.

The samples are Au diffused @~10hr @ 800°C, for example. These were then etched 3 times in HNO_3 + HCl, CP8, etc, etc.

Taking 4200's and doing Au diffusion



It was found that a quench held in more Au at 1000 than the 4100 gets at 1050.

We should look for a dopant to control p-n-p.

The cryostat

1. It leaks like a seive

Cont on p 107

PROJECT PLAN FOR PROJECT # 115

NOISE STUDIES

P. O. Lauritzen

A. PROJECT OBJECTIVES

Generally the objectives are to study the important and not well understood basic noise sources in semiconductor devices. Primarily this will concern silicon transistors and field controlled devices. This type of study should lead to:

1. Understanding the causes and characteristics of noise in new devices.
2. Information and insight into the influence of device construction and geometry on noise. Possibly, devices can be built designed for low noise specifically.
3. Knowledge of how circuits should be designed to minimize the effect of the noise sources in a device.

Another function of the noise project is to provide equipment and personnel capable of making accurate noise measurements on a wide range of devices. This is a service function for those who are interested in noise measurements for specification purposes or other reasons.

B. PROPOSED PLAN

1. FET Noise

a. The characteristics of the noise induced on the gate electrode will be investigated. This noise should correlate with the circuit properties of the device just as the induced grid noise on vacuum tubes does.

The FET high frequency noise figure is very sensitive to the source impedance and it is desired to determine how good this is.

b. The device construction appears to affect the magnitude of the shot noise in the channel. How? and Why?

c. 1/f noise in FET. Practically nothing is known about this, except that it is presently slightly lower than the best transistors. How much lower is possible?

PROJECT PLAN FOR PROJECT # 115 - NOISE STUDIES
P. O. Lauritzen

2. SCT Noise

At present some basic measurements of approximate characteristics are being made. This is a complicated device and more measurements may be made if they seem promising.

3. Transistor Noise

   a. Study of 1/f noise

   This can be pursued along several lines.

   1. Further use of SCT devices to measure the effect of surface fields on the noise

   2. Correlation with I_{EBO}

   This may be an easy way to select low 1/f noise units

   3. Experimental verification of proposed theory for circuit optimization of performance in the 1/f noise range.

   4. Attempt to corellate different transistors and fabrication techniques with noise. This appears to be a surface problem. Radiation damage may give insight here.

   b. High frequency Noise Measurements

   This is a new area to possibly move into, but no definite plans are formulated now.

4. Diodes

This looks like the most promising direction to go in order to measure the effect of space charge generation-recombination on the junction shot noise. It is difficult to observe this in transistors since the transistor gain drops too low when appreciable space charge generation occurs.

C. PERSONNEL AND HOURS CHARGING TO THIS PROJECT

This has been and probably will be one professional and one non-professional persons charging full time to this projects.

About four days per month have involved noise measurements specifically for other people and groups not generally related to the noise research work.

PROJECT PLAN FOR PROJECT # 115 - NOISE STUDIES

P. O. Lauritzen

D. MAJOR CAPITAL EQUIPMENT TO BE PURCHASED

1. Equipment for quicker and more accurate low frequency noise measurements (10 cps to 100 cps).

   a. Low frequency band pass filter (to be purchased or built)?

   b. Vidar DC to frequency converter. $800.00

   c. Counter (Possibly can be borrowed) $200.00

2. Wayne Kerr Audio Frequency Bridge $800.00

3. Equipment for high frequency (above 30 mc) if it is decided to go into this.

Project 115, Noise studies

Sah
Lauritzen
Ferguson

Grinich
Solt
Moore

Add to write up:

Project Objective:
1. Add study of avalanche noise

Review:

FET has a feed-back noise mechanism.

Crystalonics achieve a greater reduction of the shot noise than we do. (We have other compensating effects).

Even with bulk pinch-off we can get 1/f noise.
It's not due to leakage current.
Pete thinks this is a bulk effect!! CTS thinks this would be tough.

Some FET noise vs lifetime killing will be looked at.

Program:

1. FET Mechanism
2. SCT to study 1/f
3. Diode recomb.-gen noise
4. Avalanche noise

We will study FET's vs irradiation
Diodes vs Au
SCT vs V_g
etc.

Project 114, con't from pp 104-105 Jan

Sandu:

Wants to measure diff profiles using radio tracer

Present plan is to oxidize wafers and "section" by anodization. He is using ~ 900-930 Å. This is ~ 200 volts of anodization.

The present wafers

Agent	T	time
steam	1200	1hr
"	"	2hrs
"	1100	
O_2		

	Steam		O_2	
1100	1hr	2hrs		
1200	1hr	2hr	1hr	2hr
1300				

Questions:

1. What is the value of k.
2. Is there direct evidence of pile up
3. Dependence of k on T & conc and H_2O or O_2 if k is observable as a non-zero quantity.

On the conc. profile on epitaxial samples.

The data on selective diffusion at interface is something we can get easily.

Meeting on Scribing of μL dice - Jan 21, 1962

Tolbert
Ferguson
Farley
Farina
Siegel
Plough

Crippen
Crosby
Gault
O'Keefe
Hill
Norman

Total of 15 people

Questions I want answered:

1. Do cracks under a metal conductor short or open on life?

2. What happens if the ball goes over a crack?

Decision: Scribe carefully.

1-22-62
D. Thorn

TEST	SCRIBE			CHEM. ETCH		
	RUN # & QTY.	NUMBER FAILED	FAILURE ANALYSIS	RUN # & QTY.	NUMBER FAILED	FAILURE ANALYSIS
Max. Shock 3800 g's 20 impacts	G-30-A-1 (8)	none		G-30-A-2 (8)	2	Bonds Lifted
Dynamic Environmental & Temp. Cycle	G-30-A-1 (8)	none		G-30-A-2 (8)	1	Bond Lifted
150°C Storage for 1000 hrs.	G-30-A-1 (8)	none		G-30-A-2 (7)	none	
Repeat of Environmental	G-30-A-1 (8)	none		G-30-A-2 (7)	1	Bond Lifted
Dynamic Environmental	G-30-A-1 (50)	1	Lead bond snapped at post	G-30-A-2 (50)	20	Bonds lifted from pads
Max Shock 4600 g's	G-30-A-1 (16)	none		G-30-A-2 (16)	none	
300°C Storage 740 hrs.	G-30-A-1 (16)	none		G-30-A-2 (16)	none	
150°C Storage 1860 hrs.	G-30-A-1 (4)	none		G-30-A-2 (4)	none	
300°C Storage 1860 hrs.	G-30-A-1 (4)	none		G-30-A-2 (4)	none	
Thermal Shock Liq. Nitrogen to Boiling Water-10 cycles	G-36-A-1 (10)	none		G-36-A-2 (10)	none	
Thermal Shock Liq. Nitrogen to Boiling Water-10 cycles	F-201-15 (10)	none				
Thermal Shock Liq. Nitrogen to Boiling Water-10 cycles	F-205-S (10)	none				
Thermal Shock Liq. Nitrogen to Boiling Water-10 cycles	F-209-S (10)	none				
Thermal Shock 20 v. V_{cc} to heat device, then to liquid nit.	G-30-A-1 (1)	none		G-30-A-2 (1)	none	
"	G-5003-S (cracked) (1)	none				

Process: Dice Wafer

Chemically

1. Mount wafer on slide with black wax - face up
2. Wash off excess black wax
3. Reheat slide to settle wafer
4. Place mask in position - alignment time & handling considerations
5. Coat rubber stopper with hot black wax
6. Press wax coated stopper onto mask to print wax on wafer leaving dicing lines clear.
7. Remove stopper & mask from slide
8. Melt out wax to completely cover each pattern
9. Immerse slide in HF to remove oxide from dicing lines
10. Etch wafer thru dicing lines, using acid, until gold is visible
11. Immerse in Aqua Regia to dissolve gold.
12. Remove dice from wafer by soaking in TCE
13. Clean dice with hot TCE to remove remaining wax
14. Place dice in Soxhlet extractor for 30 min to finish cleaning
15. Dry dice & move to next process station

Scribing

1. Mount wafer on scribing block with paraffin - face down
2. Orient wafer on scribing block for use on scribing jig - align.
3. Scribe using diamond point - backside
4. Cover surface with light coat of paraffin
5. Heat scribing block & slide wafer off onto bibulous paper
6. Cover with bibulous paper & roll with light pressure to fracture wafer along scribe lines
7. Rotate 90° & roll again to ensure complete wafer break-up
8. Rinse dice 3-4 times in TCE to start cleaning process
9. Clean dice with hot TCE
10. Place dice in Soxhlet extractor for 60 min to finish cleaning
11. Dry dice & move to next process station

Advantages

Known technology

No cracks generated in dicing operation

Dice any shape

No black wax - bonding implications
- lack of uniformity from batch to batch of wax

Closer spacing - more dice/wafer

Time savings - dicing operations
- operator training

Material cost savings - operator safety - less floor space required

Increased die uniformity - Auto assembly implications

FAIRCHILD SEMICONDUCTOR

Scribe Program:

Runs supplied to compare scribe to chem etch. A 1 group are scribed.

G-30 A1 and A2	Supplied during November, 1961
G-36 A1 and A2	Supplied during December, 1961
G-143 A1 and A2	Supplied on January 20, 1962

Tests to be preformed:

1. Classify
2. Environmental - Standard MIL 19500B.
3. Storage for 1000 hours at 150°C and 300°C.
4. Classify
5. Environmental - Standard MIL 19500B.
6. Additional Testing

Results of tests to date:

1. Classification results.

Run Identity	%A	%B	%Rejects	%Opens
30A1 (Scribe)	70	19	1	4
30A2	68	15	17	12
36A1				
36A2				
143A1				
143A2				

2. Environmental results.

3. Storage results.

4. Environmental results.

5. Additional tests planned.

Runs supplied to check good electrical but cracked scribe dice:

Run	Qty.
Gates	8
F-201	21
F-205	52
F-209	43

Test to be preformed:

1. Classify.
2. Environmental.
3. Storage at 300°C.
4. Temperature shock.
5. Additional testing.

Results of Tests:

1. Environmental.

3. Storage at 300°C.

4. Temperature shock.

5. Additional test planned.

Chlorine Etch:

Results - Times greater than 5 minutes resulted in over etching the dice.

Adjustments were made and 2 minute etch was used with the same results.

Etching time of 2 seconds was used with no etching.

NO. 41,310. DATA SHEET, GENERAL PURPOSE.
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS. PRINTED IN U.S.A.

4500 TYPICAL JUL 60

APPLICATIONS
1025 – 5 only for Berni

No. OF UNITS	CONDITIONS	TIME							% CHANGE	1064 (64) 300°C STORAGE	1080 (16) P=600mW	1095 (15) 300°C STORAGE	1112 (17) I_E=20 I_C=0	1180 (68) V_{CB}=48 I_C=I_E=0	1196 (117) 300°C STORAGE	1218 (22) 300°C STORAGE	MOST EXTREME UNITS IN % OF CHANGE (0-1000 hr)	
		0	20	75	125	250	500	1000										
	P=600mW I_c=20 V_{cB}=30																	
10	h_{FE} @ I_c=150ma	49	45	43	42	42	40	39	–20	51	45	48	40	39	48	49	43→31	34→32

I_{CBO} (mμa) (V_{cb}=20V)	GROUPING		
	<10	10-100	>100
0	4	6	0
1000	6	2	2

HUGHES 2N1132 MAY 61

APPLICATIONS
1175 – 5

No OF UNITS	CONDITIONS	TIME							% CHANG @ 1001 hr	TREND	MOST EXTREME UNITS IN % OF CHANGE (1001 hr)	
		0	65	129	241	546	1001	2001				
	h_{FE}											
	P=600mW											
5	I_c=150ma	54	48	48	48	48	45	45	–17	↓	84→71	45→41
	P=1000mW											
5	I_c=150ma	51	42	42	41	43	39	38	–23	↓	52→35	63→58
	I_c=300, I_b=50											
5	I_c=150ma	58	45	46	44	44	41	39	–29	↓	52→28	91→73

QA LIFE TEST "FAILURES" – 1000 hr TESTS

PRODUCT	INCL. WEEKS	CONDITIONS	TOTAL UNITS	TOTAL REJ.	%	I_{CBO} REJ	%	I_{EBO} REJ.	%	h_{FE} REJ	%	OPENS	%	COMMENTS	FAILURE LIMITS			
																MAX I_{CBO} mμa	MAX I_{EBO} μa	h_{FE} RANGE
TA-4500 HB	1961	200°C	1750	4	.0023	2	.0011	–	–	–	–	2	.0011		CLASSIFICATION	50	100	33-81
	01 to	300°C	1749	35	.020	23	.013	9	.0051	–	–	3	.0017		END LIFE	2000	200	22-112
I_c=17.1ma V_{cB}=35	39	600mW	390	13	3.34	2	.51	–	–	11	2.82	–	–	ALL h_{FE} REJ LOW				
TB-4500 HB	1960/37-	200°C	600	6	1.00	5	.80	1	.20	–	–	–	–		CLASSIFICATION	50	100	33-81
	34/61-	300°C	600	27	4.50	22	3.67	3	.50	–	–	2	.32		END LIFE	2000	200	22-112
I_c=11.4ma V_{cB}=35	12-39	400mW	110	2	1.84	–	–	–	–	1	.91	1	.91	ALL h_{FE} REJ LOW				
TB-1740	1961	200°C	549	13	2.37	1	.18	5	.91	2	.36	5	.91	h_{FE} – 1 HIGH, 1 LOW	CLASSIFICATION	1	–	23-108
	11-32	300°C	553	135	24.6	42	7.60	60	10.8	7	1.27	26	4.71	h_{FE} – 5 HIGH, 2 LOW	END LIFE	100	20	15-150
I_c:20ma V_{cB}=18		360mW	109	4	3.67	1	.92	3	2.75	–	–	–	–					

4700 PA

MID DEVELOPMENT
units from R&D details Reiss

Nov 61

APPLICATIONS
1172-22

Ga Vs. no Ga. (+ TRIMMED OXIDE)

No. OF UNITS	GROUP	CONDITIONS		TIME 0	65	173	340	508	TREND	MOST EXTREME UNITS IN % OF CHANGE		ICBO (mμa) (VCB 20V)				
		5X-5B No GA + Tr. Ox.											<1	1-100	>100	# CHANNELED
10		200°C I_c	.1 ma	13	12	12	12	12	—	11→5	11→12	0	8	1	1	0?
			10.	26	28	31	29	29	↑	22→25	36→38	508	9	0	1	2
10		300°C	.1	12	14	15	15	14	↑	11→15	12→12	0	8	2	0	2
			10	26	28	28	26	25	—	30→24	44→41	508	8	1	1	0
10		P=600 mW	.1	11	11	11	11	11	—	9→8	9→10	0	7	2	1	1
			10.	26	27	28	25	25	—	26→24	24→25	508	6	4	0	2
		6X-5 A&B Ga + Tr. Ox.														
10		200°C I_c	.1 ma	67	56	58	60	57	↓	42→31	83→71	0	9	1	0	2
			10.	74	76	82	78	76	—	80→85	105-96	508	10	0	0	0
5		300°C	.1	46	47	4 UNITS 51	43	40	↓	30→20	56→62	0	4	1	0	0
			10.	63	65	68	61	58	↓	64→58	65→62	508	3	2	0	0
3		P=600 mW	.1	47	46	46	46	46	—	56→53	42→42	0	3	0	0	0
			10.	61	63	68	62	60	—	66→62	58→55	508	3	0	0	0

4700 MV

SHALLOW STRUCTURE
1740 diffusion - done in Mtn View

Aug 61

APPLICATIONS
1148-9

No Ga. TRIMMED OXIDE
Ga. TRIMMED OXIDE
STD. OXIDE

No. OF UNITS	GROUP	CONDITIONS		0	64	128	250	509	1010	TREND	MOST EXTREME UNITS IN % OF CHANGE		ICBO (mμa) (VCB = 20V)				
		h_{FE} P = 1000 mW															
		Tr. OX. NO GA												<1	1-100	>100	# channeled
10	1A	I_c	.1 ma	7	18	22	21	7 UNITS 13	8 UNITS 12	↑	7→27	8→11	0	8	2	0	0 .500 mμa
			10.	31	30	28	27	26		↓	33→25	24→22	1010	7	0	3	1 +1 Possible
		Tr. OX. + GA															
10	1B		.1	13	17	20	23	24	30	↑	9→33	35→53	0	6	4	0	0
			10.	41	42	42	41	40		↓	41→33	31→33	1010	8	2	0	0
		STD. OX. + GA															
10	1C		.1	17	20	22	24	28	31	↑	10→32	22→25	0	3	5	2	0
			10.	53	52	51	50	48		↓	52→45	65→63	1010	3	5	2	0

CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS. PRINTED IN U.S.A.
NO. 41,310. DATA SHEET, GENERAL PURPOSE.

1740 1st MV

Aug 60 - start of lifetest

APPLICATIONS 1032-9

W 300°C BAKE-OUT
No Ga.

ALL CHANNELED
(OV $C_{OB} \approx$ 40-60 pf)

No of Units	Conditions	Time 0	135	250	500	Trend	Most extreme units in % of change	
	P = 300 mW							
	h_{FE}							
19	I_C 1. ma	36	27	27	25	↓	80→54	25→21
	10. ma	42	30	29	29	↓	13→10	87→61
19	I_{CBO} (mμa) V_{CB} = 20V	54	43	44	38	↓	66→24	16→16

1740 MV

PRODUCTION MAY 61

APPLICATIONS 1115-9

c̄ Ga

No. of Units	Group run #	Conditions	Time 0	15	60	125	288	521	995	Trend	Most extreme units in % of change		I_{CBO} (mμa) (V_{CB} = 20V)	<1	1-100	>100
		h_{FE} P = 400 mW														
10	80	I_C .1 ma	19	20	21	22	24	31	44	↑	4→30	8→9	0	7	3	0
		10.	56	56	56	54	55	57	60	↑	39→61	75→71	995	5	2	3
10	82	.1	24	27	28	31	38	52	76	↑	15→72	45→111	0	9	1	0
		10.	84	86	86	82	86	89	96	↑	35→45	124→124	995	4	3	3
10	86	.1	28	29	30	32	42	61	112	↑	13→77	16→56	0	9	1	0
		10.	96	98	98	96	106	118	138	↑	67→124	48→59	995	5	4	1
10	89	.1	18	20	20	22	24	30	49	↑	31→125	33→35	0	7	3	0
		10.	64	66	66	65	68	71	81	↑	113→161	53→57	995	5	2	3
10	91	.1	10	10	11	11	14	19	28	↑	3→15	14→27	0	7	3	0
		10.	33	34	34	34	37	38	42	↑	29→53	42→39	995	5	5	0

1740 B.Vs Ga.

MV PRODUCTION SEPT 61

APPLICATIONS 1154-9

No of Units	Group	Conditions	Time 0	50	174	1012	Trend	Most extreme units in % of change	
		h_{FE} 50hr. 25°C + P = 400 mW							
10	B	I_C .1 ma	8	7	9	9	—	7→10	8→7
		10.	35	33	35	35	—	26→35	45→39
10	Ga	.1	22	22	24	29	↑	6→23	11→5
		10	56	56	55	56	—	38→46	68→60
		50hr 300°C + P = 400 mW							
10	B	I_C .1 ma	9	10	11				
		10.	42	45	39				
10	Ga	.1	32	42	36				
		10.	64	71	54				

NOTE: BORON UNITS HAD A VERY HEAVY TREATMENT i.e., $BV_{CBO} \approx$ 16-18V
Ga UNITS $BV_{CBO} \approx$ 35-55V

No of Units	Group	Conditions	Time 0	50	174	1012		Most extreme units in % of change		I_{CBO} (mμa) Grouping	<1	1-10	>10
		I_{CBO} (mμa) (V_{CB} = 10V) 50hr 25°C + P = 400 mW											
10	B		.051	.044	.113 .053 w0 1@.650	.401 .058 w0 1@ 4.4		.1→3.8	.033→.009	0	10	0	0
										1012	9	1	0
10	Ga		.117	.122	.265	1.84 .201 w0 1@ 15.0	± 1@ 2.20	.072→15.	.053→.050	0	10	0	0
										1012	8	1	1

1741

EARLY MV PRODUCTION OCT. 61

APPLICATIONS 1164-96

BV_{CBO} in 30-60 volt range (generally in the 40's)

No of Units	Group	Conditions	Time 0	63	248	488	992	1520	Trend	Most extreme units in % of change		I_{CBO} (mμa) (V_{CB} 20V) Avg. 0	992	1520		Grouping <1	1-10	>10
		P = 300 mW																
10	5	I_C .1 ma	25	26	28	27		37	↑	21→42	50→67	.12		.16	0	10	0	0
		10.	72	64	66	65		69	↓	56→67	65→65				1520	10	0	0
10	6	.1	45	46	53	48		62	↑	67→166	6→6	.14		.56	0	10	0	0
		10	86	91	93	83		94	↑	26→125	185→161				1520	8	2	0
10	8	.1	19	19	19	20		34	↑	23→91	12→14	.09		.33	0	10	0	0
		10	55	54	55	55		65	↑	69→116	42→42				1520	10	0	0
		P = 400 mW																
10	5	I_C .1 ma	38	32	39	48		66	↑	13→67	33→62	.16		.16	0	10	0	0
		10.	57	61	66	69		74	↑	43→66	66→71				1520	8	2	0
10	6	.1	47	31	35	41		62	↑	11→71	33→40	.08		.56	0	10	0	0
		10.	60	58	63	67		74	↑	60→105	134→134				1520	10	0	0
10	8	.1	36	24	30	41		64	↑	25→143	25→50	.11		.33	0	10	0	0
		10.	58	58	63	70		86	↑	72→130	70→80				1520	10	0	0
		300°C STORAGE																
[illegible]	5	I_C .1 ma	32	59	62	58	6 units 62		↑	3→42	59→100	.09	.02 to .38 ma 6 units		0	10	0	0
		10.	70	86	86	7 units 72	6 units 77		↑	33→45	42→46				992	4	0	2
10	6	.1	34	65	65	64	60		↑	8→40	67→62	.08	.04		0	10	0	0
		10.	78	95	95	94	86		↑	28→48	167→143				992	9	1	0
9	8	.1	15	32	37	30	6 units 34		↑	13→40	14→7	.09	.08 8 units		0	10	0	0
		10.	50	71	70	67	8 units 70		↑	68→125	50→50				992	8	0	1

Meeting - Project Review Microcircuits Product Development #175 1/29/62

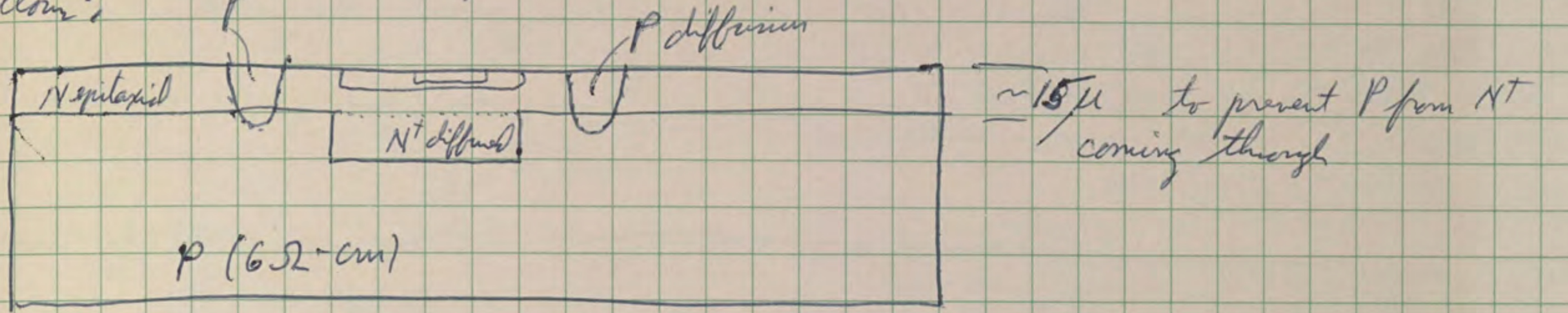
Nall
Seifer
Ferguson
[illegible]
Dummer

Farina
Grinich
Moore
Talbert

2nd family

Trying to "go for broke" on the epitaxial method of isolation in order to get the speed. The analysis is still going on.

The structure being considered is as follows:



Identical Xstors made this way gave a factor of ½ in the isolation capacitance compared with old pL for same area. The isolation looks very hard. The capacitance is low enough for the speed we need. We can use P for the N+ and B for the isolation ok.

While these devices had pt gold, they were short of the 1310 Au. This could clobber the isolation leakage.

For the top-side collector contact one looks like we can get by by the emitter diffusion alone.

We can still get by with diffused resistors here.

The masks have been layed out for a 4-input gate. Everything is laid out with the ~~[illegible]~~ ½ mil tolerance that we usually want. The Xstors have 2 mil square emitters and a 1 mil square base.

These masks can be in this week!! — They will.

These should use pt diffusion furnaces where ever possible, but should not sacrifice the >10 MC performance.

Kit and R-element.

Masks are recycling. Sam says its the copy camera, although there is no ~~A~~ general agreement.

The kit in smaller chamber needs doing. Doing in this morning. Reaffirm that the kit must represent the existing.

Micromemory:

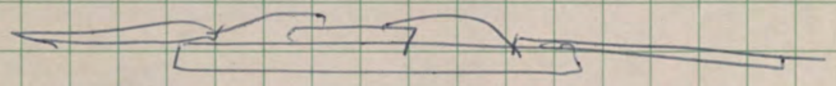
μ ckty product development, cont 1/29/62

For the low-level job we need more resistor job technology. The use of current sources is ok.

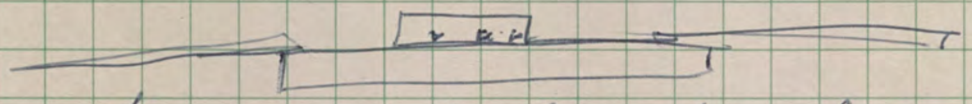
Summary of packaging:

Brownie is working on 14 lead T.I. package

We have some that are glassed in for one of these:



or



1st units ready for potting by end of Feb.

Don Farina will look at PNPN shift register structure to understand and make preliminary layout.

Priority:

1. Kit I
2. TTG
3. PNPN register
4. Memory
5. Diff. Amp.

Zener diode - Project # 171 1/29/62 Ferguson Hogle Lamond Grinich Moore

56-800

last on page 82 (12/14/61)

New ground rule: San Raphael will be working on a Zener (officially) by the end of Feb. This will be either

a) The low current one
b) The 7.5 ma one
c) Some other we come up with
or d) The ones that are obvious S of A planar devices with them doing everything necessary with us only as consultants.

Review of 100 μamp one:

Have some **data** on some Ni gettered ones. Have lower Zener impedance by ~200Ω to 450Ω.

0.002% Dave Hillbiber has some life data on some early 1340's. These looked like ± 0.002%/time for 50% of the units. The other half ~~diffused~~ drifted more. (X10) During the first 100 hours the drift may very well be quite a bit more.

Units aged at 1 ma all drifted.

Data is not coming out because we do not have the necessary digital equipment.

We gave ~50 units to San Rafael
" have ~20 " left. We can make an arbitrarily large number.

We will power age, temperature store, temp cycle and try to stabilize.

San Rafael diffusion looks like the way to fly. We will deliver wafers until then.

Dave Hillbiber will put together the outline of a few application notes for this diode.

We have some data on the noise spectrum of these devices but not very much.

This product still looks good. It will be in San Rafael by the end of Feb.

Zener (Project 171, cont)

7.5 ma Zener

The 1st group has 8 - 13.5 Ω Zener impedance (non epitaxial material). [Competition in this range is 10-15. Can get < 10 (but > 7.5 Ω) on special order.] We are at least 4 Ω higher than we should be.

When dummied using epitaxial [illegible] we get 4-5 Ω
" " " non " " " " 7-8 Ω.

Experiments to see if we can make a 10 Ω guarantee will be there in 2 weeks. We then can schedule this as a product.

By definition this will use the std. 10 ma Zener furnace.

Present schedule looks like we probably have a product. 90% of the devices will be in the ± 0.005% range, but very few in the ± 0.0005% range.

Pierre will summarize data, data on dummies and the competition in ~ 3 weeks when he has the data with a recommendation th regarding the product and a time scale.

We will fill this family out with G.P. diodes and later with power packages. Aim at ~ 90% of Zener market coverage by end of year.

Diode input is that other things being equal that they would prefer the G.P family before the 7½.

172 Adv. Microcircuitry Tech   Jan 30, 1962

Ferguson	Talbot
Leifer	Farina
Price	Dummer
Waite	Campbell
Martin	Nall
	Smith

Nichrome resistors:

Contact reliability:

Al over Nichrome looks reliable

5000 hrs of 300°C on sealed units. In general (<u>except bad runs</u>) the resistance has not changed more than 1%. These have Al lead wire wedge bonded.

No data exists with Au leads!!

Nichrome adheres very well to the SiO_2 – can't scratch with tweezers, it has not pulled off in centrifuge.

~~Karma~~ Nichrome runs 100-250 ppm/°C.

Karma " 25-250 ppm/°C.

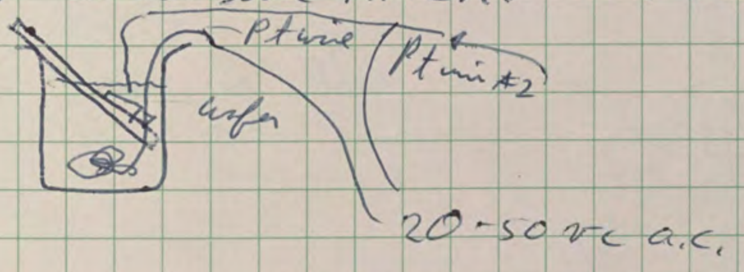
Write a description of the system including the in-jar jigging and the deposition tech.

Control:

Some trouble with monitor. The monitor is always low by 10% or so.

Have done better than ± 3% in σ over 12 wafers.
Reproducibility is probably ~5%.
The monitor must be made to agree with the run.

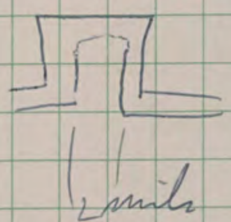
Etching: Must use KMER. Etch with std Hoerni black dip



3/4 HAc
1/4 HNO_3
a dash of HCl

Takes ~ 15 seconds to etch a wafer.

A "squiggle" doesn't etch out well



Make ~100 each of resistors representing at least 5 evaporation runs for distribution purposes.

Project 172, cont

b) Ti - Ta resistors.
For Ta one can get up to several hundred Ω/□
" Ti probably up to >1000 Ω/□

It looks like the Ti is the best possibility.

We have sputtered Ta and Nichrome films. Preliminary results looked encouraging.
The thinnest film of Ta had a − TCR, the thicker one has a +.

c) High resistors in small areas:
SnO_2 − has suffered somewhat from lack of time.

Corning has sprayed [$SnCl_2$, Sb_2Cl_5, HAc, EtOH H_2O] onto hot glass. They run ±50% a run on control.
For heavily doped films the TCR is low
Resistors are stable (in oxidizing atmosphere).

Our results in the tube furnace in [illegible] − (order of magnitude similar)

PdO
We could get ~3K/□ with TCR < 200 ppm
Contacts were ok.
Stability with temperature was a problem.

d) Film du Pont resistors − we will do and supply to Mtn View c silk screen printer and miniature furnace

Summary of resistor program:

Priority	Ω/□	line width	TCR	Precision & stability	For	Possibilities
1	30-300	1 mil	~200	5%	G.P. [illegible] as R arrays and to integrate c semiconductors	Nichrome
2	> 100,000 Ω in a 10 × 10 mil area		<5000	$\overset{\times}{\div}$2	"	C, Si, SnO_2 PdO
~~4~~	30-300	1	200	1%	Integration (may adjust)	du Pont group
3	>100,000 in 10 × 1000		< carbon film	10%	use on ceramics for special products	

172, cont

Capacitors:

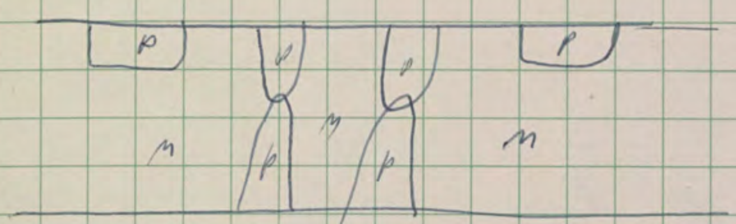
Diffusion : Get typically 0.1 pf/mil□ for ~10v breakdown.

MOS : Up to 0.8 pf/mil□ (400 Å)

1/31/62 — 172, cont.

Diode Matrices:

Presently 8X8 with double isolation

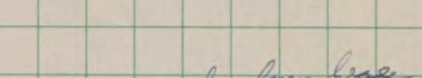


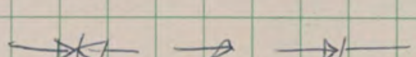
Yield of isolated region is 97% at single, much higher at double.

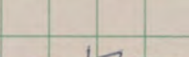
With ~~bath~~ 0.5 Ω-cm n-type we got ~98% yield
" 10 Ω-cm " " " " >99.8% " (500 all good)

This is isolating 64 separate areas
In the old technique where we did a whole column

Fusing techniques

1. Thin metal films - a problem is making  with Ag fuses it looks better, but no reliability data yet.

2. Reverse-biased diode destruction  <1Ω added

3. Oxide breakdown  added resistance unknown
The yield of capacitors is adequate. One big problem is the fact that this can't be checked.

With high ρ bulk the B does not seem to be adequately masked.

We are ready to try to make a programmable array. As an objective that is useful try for 8 X 10.

before:
BV > ±10 v @10 μa
BV < ±300 v @ 100 ma
all lines to isolation <10 μa @10v
Each line to isolation <1 μa @10v

after:

MICROELECTRONICS RESEARCH SECTION

PROJECT PLAN

Date: 1-29-62

Project #172 Approved Section Head: __________

Project Engineer: J. Campbell Approved Office of Director: ________

Project Objectives

1. Resistor Technology - Development of a resistor technology capable of integration with our regular microcircuitry techniques. An arbitrary test vehicle is to be a Y-shaped array of three resistors having values of 1 megohm, 100 kilohms, and 1 kilohm, all to tolerances of ±10% and having temperature coefficients of ±100 ppm/°C. This array is to be within a 50 mil square.

2. Capacitor Technology - Development of a capacitor technology capable of integration with our present microcircuitry technology. An arbitrary test vehicle is to be a .01 μf capacitor having a 10 volt rating within a 50 mil square.

3. Diode Matrix - Development of an array of diodes, each having a forward equivalent resistance less than 20 ohms at 1 ma current and having a reverse breakdown of 20 volts or greater. The array will have several hundred such diodes with the X and Y coordinates brought out and so designed that by pulsing the proper combination of lines a desired pattern of open diodes may be established.

4. Evaporated Field-Effect Devices - Development of a field-effect device having all components, including the active regions, formed by the evaporation of material onto an appropriate substrate.

Proposals for Continued Projects

1. Resistor Technology
   a. Nichrome-Nichrome resistors can presently be made having surface resistivities in the range of 25-300 Ω/□ . These resistors have been shown to be reliable, are easily made, and are compatible with aluminum contacts.

b. Tin Oxide - Furnace deposited films have been made having good apparent quality, and the films can be etched to form devices. Control of the resistivity is impossible at present, however, and the films appear to be incompatible with aluminum contacts. A "chicken-cooker" apparatus originally conceived to overcome difficulties of control has been virtually abandoned. Further efforts will be concentrated along the lines of furnace deposition using an organic tin compound both at atmospheric and reduced pressures, and along the classical spray deposition lines.

c. Resistor Compositions - It is proposed that a feasibility study be made of the resistor compositions being made by DuPont and others, applied by means of silkscreening techniques. This sub-project will be concerned with two main problems: the quality and controllability of resistors using the composition and the resolution and registration problems associated with the silk-screen process.

d. Ti, Ta Resistors - It is proposed that a feasibility study be carried out on the use of evaporated or sputtered Titanium or Tantalum films for use as resistors. This study will be carried out within the outline of the general project objectives.

2. Capacitor Technology

a. Junction capacitors - A short series of runs has given us some feel for the properties and problems of large area junction capacitors. Standard predep and diffusion cycles have been followed. Success has been variable in that control of capacitance has been rather poor and yields of high breakdown units (>10 volts) often low. Capacitance of course is voltage and temperature sensitive. This project has been idle the past two months.

b. MOS Capacitors - Results of the MOS project appear encouraging. Thin uniform oxides can be grown to give capacitors of 0.8 pf/□ mil, breakdowns > 20 volts, and yields above 80% for 50 mil square devices.

Typical value of Q is 1800 @100kc. Diffusing under the oxide eliminates the minor voltage sensitivity experienced with 0.5 Ω-cm N type material. Temperature coefficient up to 150°C is unmeasurable, though Q is reduced a factor of two or three. It appears that the capacity value for this system has about reached its limit. Better handling techniques could be employed to improve the yield.

c. Titanium Dioxide Capacitors - It is proposed that the feasibility of TiO_2 as a dielectric material be studied. This project should be broken into several parts, each concerned with a method of formation of the film: evaporation of TiO_2, sputtering of TiO_2, anodizing of Ti film, thermal oxidation of Ti film. The study should determine the feasible values of capacitance per unit area and of the temperature coefficient for the different methods.

3. Diode Matrix

Present work is concentrated on an 8 x 8 matrix with "double-isolation" between diodes. High resistivity substrate material is advantageous with respect to diode yield and higher breakdown voltages, but at present poses problems in isolation diffusion technology.

Future work on the diode matrix involves a solution of the problem of isolation diffusion into high-resistivity material, evaluation of the long-term reliability of the matrix and in particular of the silver fuses, evaluation of a matrix with base-emitter type diode configuration, this being a single-sided structure, involving lead cross-overs utilizing either the substrate material as a cross-conductor or by means of oxide insulating layers.

Three distinct fusing systems have been considered, (1) thin metal films, (2) reverse-biased diodes, and (3) thin oxide films.

Good silver fuses have recently been fabricated: no figures as to yield are available so far. Reverse biased diodes and thin oxide films are both "inverse fuse" systems: the former involves fabricating twice as many good diodes on the matrix, with a consequent reduction in yield, the latter system appears to be highly reliable, but involves problems in testing the matrices for good diodes.

4. Evaporated Field-Effect Devices

Silicon has been evaporated in thicknesses up to 2 1/2 microns onto quartz substrates, and it has been demonstrated that such films remain adherent after a standard furnace treatment (gallium predeposition). The films are amorphous by X-ray diffraction before such heat treatment. The resistivity of the films is too high to measure, but they are N-type, when N-type material of .72 ohm cm is used. N-type material of $\sim$ 100 Ω-cm produces similar results. An attempt to reduce the resistivity by using a gallium predeposition eroded the film badly, apparently removing about 2 microns of the film. The resultant films were P-type, but the resistance was too high to measure. Future work will aim at the production of films of controlled resistivity, by protection of the film during predeposition with a pyrolytic oxide layer, and (alternatively) by the use of boron-doped starting material. Feasibility studies of the device can follow.

Project Schedules

1. Resistor Technology
   - a. Nichrome- Transfer to Microelectronics Engineering Section by 4-1-62.
   - b. Tin Oxide
     Design and construction of simple spray-coating apparatus - 2-15-62.
     Design and construction of glassware for low-pressure furnace - 3-1-62.
     Evaluation of atmospheric pressure furnace technique - 3-1-62.
     Feasibility study completion - 5-15-62.
   - c. Resistor Compositions
     Purchase of silkscreen machine, compositions, construction of sample masks - 3-15-62.
     Feasibility study completion - 5-1-62.
   - d. Ti, Ta Resistors
     Construction of sputtering and evaporation jigs - 3-15-62.
     Feasibility study completion - 5-15-62.

2. Capacitor Technology
   a. Junction Capacitors - terminated.

   b. MOS Capacitors - terminated.

   c. TiO_2 Capacitors - same as for Ti, Ta resistors.

3. Diode Matrix

   Life tests on silver fuses - 3-1-62.

   Preliminary life tests on matrices - 3-1-62.

   Tests on matrices (in large quantities) - 5-1-62.

4. Evaporated Field-Effect Device

   Evaluation of oxide-coated films - 3-1-62.

   Evaluation of boron-doped films - 3-1-62.

   Feasbility study completion - 5-15-62.

<u>Personnel</u>

1. Resistor Technology

a. Nichrome	
R. Martin, Engineer	60 hours
b. Tin Oxide	
J. Campbell, MTS	500 hours
M. Parker, Tech.	150 hours
c. Resistor Compositions	
J. Price, Engineer	500 hours
M. Parker, Tech.	150 hours
d. Ti, Ta Resistors	
R. Waits, Engineer	500 hours
M. Parker, Tech.	150 hours

2. Capacitor Technology
    a. Junction Capacitors - terminated.
    b. MOS Capacitors - terminated.
    c. TiO_2 Capacitors - same as for Ti, Ta resistors.

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    Life tests on silver fuses - 3-1-62.
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    Evaluation of oxide-coated films - 3-1-62.
    Evaluation of boron-doped films - 3-1-62.
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<u>Personnel</u>

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3. Diode Matrix

J. Price, Engineer	500 hours
M. Parker, Tech.	150 hours

4. Evaporated Field-Effect Device

J. Campbell, MTS	500 hours
M. Parker, Tech.	150 hours

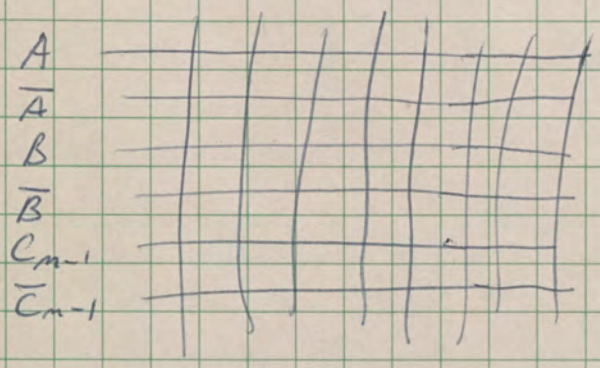
<u>Equipment Needs</u>

Silkscreen apparatus	$600
Belt Furnace	N.A.
Shop Time	400 hours
Silkscreen manufacture	75 hours

172, cont

Other useful diode arrays:

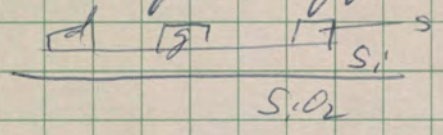
1. A full 1 bit adder.



Takes about a 6X10 matrix to 2 output lines and 6 input lines.

A more useful one is a binary-decimal unit. We will tackle this one and will make it with all topside contacts, metal leads crossed.

Evaporated field effect device:



get 2½ μ of Si in 15 min

Extremely high resistivity film amorphous!!

Project 146 4500 series development Feb. 1, 1962

Grinich Carlson
Ferguson Moore

Review:

Recent data on 3501's taken by the remnants of the RED looks terrible. All I_{CO}'s show order of magnitude change (low range). We don't believe the data.

Critical survey of PNP life data to date:
on 4500 300° bake raises h_{FE}
high current degrades
can be cycled
no 200° bake relieves problem considerably.

∴ 4700 done without 300°C age showed essentially no β change at 600 mw operation.
BUT on 300°C storage they didn't increase much (12 → 14 in 1000 hrs).

Our data on 3501 is sick – sick – sick (very early units)

1741's seem to hold for 600 hrs under power and then drift from 600 – 1500 hrs. on β. This seems to be real, but the cross over point in time varies.

PNP problem summary:

1. β degradation (on current age (after 300°C))
2. β increase, especially at low current, on Ga treated units under power age – can have ~600 hours induction time.

3. Channels form and increase on power age, all except occasional Ga treated units – or maybe only on occasional Ga treated units and all others.

4. Softness (B-C) forms on planars (no mesa data) on high temperature storage (>200°C) and power age

5. Resistive shorts form that may be related to softness above.

Meeting on thick epitaxial problem 2/5/62

Torgeson Yuin
Lamond Moore
Wrighton

Review of data on thick layers

1 group 48-52 (grown by Ernie). As doped substrate 3001 → } gave eccentric characteristic
7000 } from origin.

They were all like this (100 ma @ 100 v)

Hank feels that the contamination problem is an impt part of the problem.

There is really no evidence that our thick material is worse than thin material. The real problem is that our thin material has never given any yield either.
(Except on the 3001 we did get some yield usually, but not always.

All data has been fed in for Hank to supply material. He thinks that evaluation is need.

The old mechanically polished wafer on ⊕ CeO gives a surface that is pitted & scratched upon etching, although mirror flat. On this we have an Al_2O_3 wet to give one that is not as mirror ~~flat~~ like, but it doesn't etch badly.

We have only 1 wafer polisher. - Can

There are 5 substrate preparation to consider

A Chem. etch
B Alumina mech. polish
C CeO Mech polish
D BorC + SiO_2 - etch method
E Electro Polish

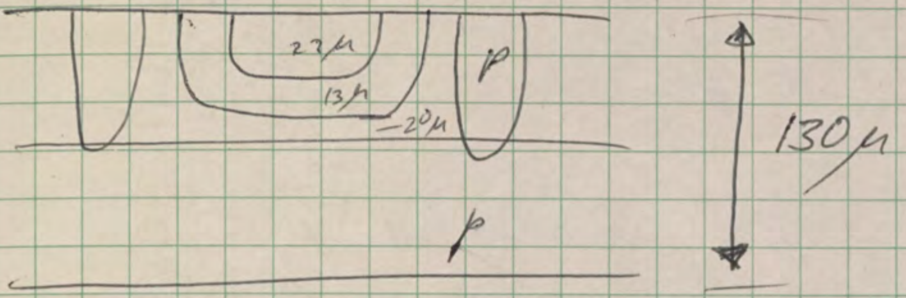
106 - Controlled Rectifiers 2/6/62

J.P.F
VHG
Prince Brennan

Porter Jones

Review:

Structure: 1. Planar
~200 geometry



Start $\bar{\rho}$ ~10Ω-cm
Boron diffused @ 24 hrs, 1280°C

By checking diodes alone we have 400 volt junctions - after oxide removal. Probably on the final device something like a 40μ 2nd base is needed.

Project divided into two parts:
a) get high voltage junction

b) make device.

Work on making high voltage units using the pyrolytic oxide.

Objective
V_{BO} 400
V_R >400
(I_f ~20 amp
T - 175°C) if possible

Plan - Study breakdown voltage vs (stuff) for a month or so lay out the available volume in n-dimensional space

Meet ~ April 1 to review and lay out detailed 1st.

Transfer - 1st device Albert Sept 1.

1120 Project 170 – Photodevice Development Feb 6, 1964

Beyel
Wheeler
Ulmer
Kobell

Leifer
Ferguson
Shiel
Moore

Review of XP-3:

On top of Al(Si)-Cu there is an insulating layer that the Sn will not stick to.

Present
Metallizing ~~10~~ 5% Si in Al, alloy ~~10~~ 5 min @ 580°C.
~~solder~~ thick Au plated preform

Same done by a blunt, glass insert and heat-cool.

There are several areas of trouble here

1. Plating
2. Etching preforms
3. Shop –
4. Dicing ~~is beyond the capability of our process~~.
5. Masking (~~paper~~)

Get everything together so that we can make 1000 good ones.

This requires that I grease the skids to get
a) plating
b) etching
c) shop for molds & bending jig.

As back up order the headers (experimental)

Photodiode arrays.

We need ≥ 400 volts. Have now yield @ 250 v. One run came through at up to 1100 volts.

The problem to solve is the mounting.

Project 126 - Masking Tech Development

Noll
Fok

Van Ness
Moore

MICROELECTRONICS RESEARCH SECTION

PROJECT PLAN

Date: 2-6-62

Project #126 - Masking Technique Development   Approved Section Head:____________

Project Engineer: Samuel S. M. Fok   Approved Office of Director_______

PROJECT OBJECTIVES

1. Maintaining our technological leadership in the photolithographic field.
2. Preparation of original masks, working plates and the use of these masks to etch structures in metal and silicon oxides.
3. Advancing as well as maintenance of mask making service and the R&D photoresist services.
4. Provide consultation and transferring technological advances in mask making and new photoresist techniques for Transistor Plant in M.V.

I. MASK MAKING TECHNOLOGY

A. Technical Status

	Past	Present	Future
1. Finest working mask	0.5 mil	0.25 mil	0.1 mil
2. Alignment tolerance	0.5 mil	0.25 mil	0.1 mil
3. Master resolution	0.3 mil	0.2 mil	0.1 mil

B. Specific Tasks

1. New step-and-repeat camera with Farrand Control should be on the air 4/62.
2. Second coordinagraph in operation 2-15-62.
3. New copy camera to be ordered 2-62, approximately 60-90 days delivery, installed in new R&D building in 5-62.
4. Check out and consult with M.V. on total mask making capability. Including the following:

Microelectronics Research Section
Project Plan #126

- Coordinagraph
- Copy camera with step and repeat back
- Step and repeat camera
- Printing technique
- Inspection technique
- Process checking, control and scheduling

5. New technique development;
   - Lens resolution and aberration tests
   - Exposure and focusing control
   - New photographic processing techniques

II. MASK MAKING SERVICE

A. Status	Past	Present	Future
1. Capacity (sets/wk)	1-2	2-3	3-4
2. Residence time (weeks)	2-3	1-2	< 1

B. Specific Tasks

1. Up-grade present drawings in more permanent forms.
2. Cataloguing and cross-indexing of drawing file.
3. Provide alignment proofs in various checkpoints.

III. PHOTORESIST TECHNOLOGY

A. Technical Status	Past	Present	Future
1. Sharpness or edge definition (mils)	0.15	0.05	0.02
2. Line resolution (mils)	0.5	0.25	0.1
3. Cleanliness	Very poor	Poor	Better
4. Alignment tolerances (mils)	0.5	0.25	0.1
5 Resist removal: oxide	Difficult	Easy	Easy
metal	Difficult	Some problem	Easy
6. Pin holes and imperfections	Very poor	Poor	Better
7. New resists handling techniques	KPR	KPR KMER	KPR KMER KOR KPL New KMER

pment

Nall
Fole

Van Hess
Moore

	Past	Present	Future
8. Exposure Methods	Carbon arcs, poor	High pressure Hg, (good), and carbon arcs	Completely on Hg lamps

B. Specific Tasks

1. Optimizing developing techniques.
2. Increase resolution to 0.1 mil device.
3. Minimum density with optimum exposure.
4. Reduction of pin-holes and imperfections.
5. Optical alignment aids for extremely small patterns, i.e., jigging, reticle, etc.
6. Projection printing directly on wafers.
7. Coating method control.

IV. PHOTORESIST SERVICES

A. Status	Past	Present	Future
1. Capacity (runs/month)	<600	600-800	*
(w+c/month)	<4000	4000-6000	*
2. Residence time (hrs/run)	>20	11-19	*
3. Photoresist workshop	None	Working well, not fully utilized	More usage

* Depends on new facility and division of work loads with Device Development.

B. Specific Tasks

1. Complete conversion of all carbon arc lamps into high pressure Hg lamps.

2. Provide enough optical jigs for the service.

3. Provide consultation and assistance in establishing a routine photoresist service in Device Development Section.

4. Provide consultation and assistance in transferring new techniques to Device Development Section of R&D, and Process Development at M.V. plant.

Noll
Fok

Van Ness
Moore

5. Establish written procedures for approved processing photoresist techniques.

6. Training programs for new operators and new techniques.

V. NEW EQUIPMENT AND FACILITIES IN NEW R&D

A. Mask Making Area

1. Constant voltage supplies for all printers (5 required at $250)

2. Processing sinks (need 3 more at $800 ea)

3. Printers (2 more at $250)

4. New copy camera (1 at $14,000)

5. Work benches and cabinets. __________will work out with Plant Engineering.

B. Photoresist Rooms (3 rooms)

1. Constant temperature baths (need 2 more at $125)

2. Experimental acceleration control for all spinners (1 required first at $144, possibly 4 eventually)

3. Air-shield hoods for coating and drying (3 required)

4. Microscopes DMETR, 3 more required

C. Metal Etching

1. Spray tank and electrolytic etching tank.

2. Exposure facility

VI. PERSONNEL

A. Mask Making

1. Experimental

C. Van Ness, Dev. Asst.	100% time for 6 mos.	= 1000 hours
M. Hoar, Technician	50% " " " "	= 500 hours
S. M. Fok, MTS	50% " " " "	= 500 hours

pment

Noll
Fok
Engvall

Van Ness
Moore

Microelectronics Research Section
Project #126

2. Service

S. M. Fok, MTS	25% time for 6 mos.	= 250 hours
M. Hoar, Technician	50% " " " "	= 500 "
5 women operators	100% " " " "	= 5000 hours

B. Photoresist and Metal Etching

1. Experimental

A. Engvall, Res. Engineer	80% time for 6 mos.	= 800 hours
1 woman operator	50% " " " "	= 500 "
(Experimental technician to be hired)	100% " " " "	= 1000 "
S. M. Fok, MTS	20% " " " "	= 200 hours

2. Service

C. Gunter, Senior Tech.	100% " " " "	= 1000 hours
13 women operators	100% " " " "	= 13,000 "
A. Engvall, Res. Engineer	20% " " " "	= 200 hours
S. M. Fok,MTS	5% " " " "	= 50 hours
M. Focht, Senior Tech.	100% " " " "	= 1000 hours

February 7, 1962

133

PROJECT PLAN, NO. ~~119~~, ANODIC OXIDATION OF SILICON

Project Objective: To produce oxide films on silicon by an ambient temperature process of anodic oxidation. Two primary objectives are to prepare wafers for device fabrication and evaluation, and to characterize oxide properties and assure high quality.

Applications of Method: If successful this technique could replace thermally grown oxides for masking against diffusants and for passivating the surface of a finished device. In addition it may be possible to improve the properties of thermally grown oxides, and to incorporate various ionic species controllably in the oxide layer. This last effect may influence channel conductance and capacitance properties of oxide layers.

Proposed Plan:

1. Evaluation of oxides from the anodization process in comparison to the thermal steam oxide prepared at 900 or 1200°C. This includes empirical determination of best conditions for forming anodic oxide layers, evaluating the thickness, porosity, electrical properties, and resistance to diffusion.

2. Preparation of a large number of simple p-n junction diodes and evaluating breakdown voltages. Preliminary studies have indicated breakdown voltages of about 175 - 200 volts can be obtained for anodically formed oxides versus 75 - 100 volts for thermal oxides.

3. Continuation of investigation of means of filling pinholes in steam oxide. Use of anhydrous media as anhydrous H_3PO_4, dimethyl formamide, etc.

4. Continuation of kinetics of anodic oxidation to characterize the physical and chemical properties of oxide and relate to device parameters.

Personnel and Estimated Hours:

Past: D. Borror full time since August, 1961. Worked on kinetics of anodic oxidation of silicon. — also evaluation

E. Benjamini full time since September, 1961, except 1-1/2 months on gold diffusion. Worked on improving properties of thermally grown oxide on silicon (Tech. Report No. 62).

E. Duffek 1/3 time, approximately 24 hours since January 29, 1962.

Future: D. Borror full time - 40 hours/week.

E. Benjamini full time - 40 hours/week for next 3 - 4 months.

E. Duffek 1/3 time - 12 hours/week.

Capital Equipment:

Infra-red spectrophotometer with NaCl optics.

Electrolytic conductivity bridge. (G.R. Impedance Bridge 1650-A - $450.00)

Also adaptation of a power source on hand to yield constant current at 50 to 500 volts.

Proj. 133 (partial) Anodic Oxidation 7/7/62 Waring Moore
Dasfek Jerfer

Two principal areas:
1. pinholes
2. are there any interesting properties of this oxide?

Most work is in 0.1N H_2SO_4

Oxide seems to be uniform, except where contact effects exist. We have grown up to ~3000 Å.

1. Thickness by step
2. From Beckman DU.
3. Dielectric constant by MOS capacitor.

Possible advantage
1. elimination of surface breakdown
2. ~~ch~~ inversion layers ?
3. ~~pin holes~~ low temp, ∴ no change in diffusion

Work c̄ Pierre
Len Carlson

1. pin hole plugging - can be studied by FET masks

Project 170 - reopened

We have swamped the metal masks & plating.

Peter has asked for

Our etching capacity is 125-130 metal masks/mo

Last week 120 sheets of 24 - 18/24 of the pattern are good.

∴ run ~ 2000/wk absolute **max capacity.**

Possibility of getting Japanese made by electroforming or laser.

Peter says that he could get by with ~ **6** sheets/day, 18/24 **good.**
Another pair of hands could help. - Possibility of 4 hr overtime or of the use of a girl.

Possibly needs shop priority.

Plating:

Stop - no go.

Diode is willing (but are they able?).

Degrease
Alk
Rinse
Bright Dip
Rinse 14
HCl 15%
H_2O
DI
Ni —
Rh
R
Au —

Conclusions at end:
Etching will supply 6-7 per day
We will send samples out for plating
We will try to set up a plating area
across the street to do this
We will continue to supply the plating
for the next few days from our
chem section facility.

Feb 27, 1962 SCT review Proj 142

Shinil Bogart
Sah Grenne
Schultz Lanard
Ferguson Moore

Review of data since last time.

Can reproduce anything but point of max g_m.

Varies from -22v to 0v.

Several different type runs have been life tested - all drifted

Comparison of N_2 and forming gas anneal - all drifted badly.

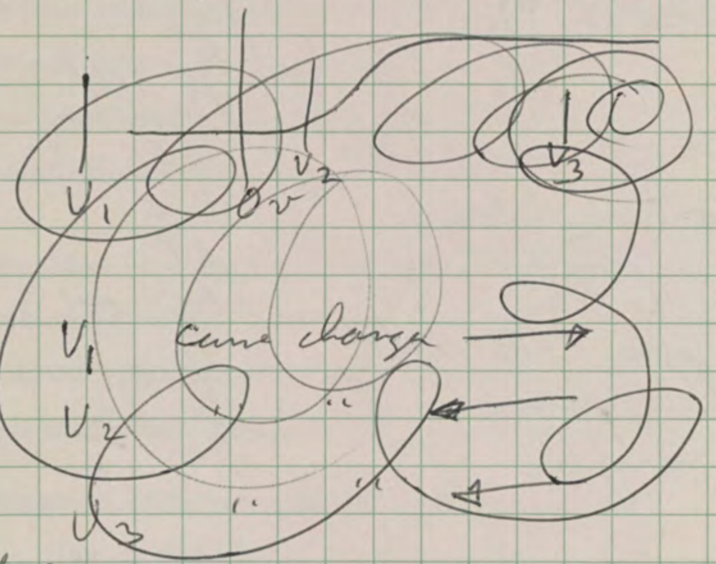
Au vs Al units - all drifted.

Some thick oxide (~0.5μ) units showed some similar effects, but the point of max g_m was always + a very large voltage (40-75 before

17-60 after 300°, 50-70 after power age after 300°C age).

The changes are always such that the point of bias inferred to the V_g curve come closer to 0v.

ie,



Do life test

$V_{GB} = 0$
300°
200°
125°
250°
Burn on

DATE 23 Feb 19 62
EQUIP. USED
TAKEN BY
REQUESTED BY

FAIRCHILD SEMICONDUCTOR
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

ENGINEERING DATA

( ) FT CLASS
REMARKS SCT LIFE TEST
GROUP

Slow pull

LOT No.	DE.	OP.	GR.	TYPE No.	CL.	TE.	COND.	DATE	ELAPSED TIME	SP.	SP.	

LOT No.	UNIT No.	.0 gm max μ mho	1 VG	2 Ichle Ic = .1ma VG = 0	3 Ichle Ic = 10ma VG = 20	4 Cgt 0V pf	5	6	7	8	9
HB-14				μa	.16						
	1	2000	+73.	3.2	.17	5.4					
	2	2000	+72	3.5	.18	5.6					
	3	1900	+72	3.9	.21	5.4					
	4	1960	+71	4.2	.24	5.7					
	5	1600	+74	4.4		8.3					
HB-16											
	20	2550	+58	1.8	.10	6.2					
	22	3400	+65	1.2	.052	6.2					
	22	3200	+60	1.5	.066	6.2					
	23	3300	+53	1.1	.050	5.7					
	24	2700	+44	1.6	.077	6.1					
HB-14				μa	ma						
	1	1700	+48	2.9	.13						
	2	1830	+60	3.0	.13						
	3	1750	+60	3.4	.14						
	4	1460	+60	4.2	.18						
	5	1760	+43	4.0	.17						
HB-16											
	20	2000	+17	89	.30						
	22	2600	+22	37	.18						
	22	2550	+33	6.9	.11						
	23	2700	+42	1.1	.050						
	24	2300	+20	60	.24						
HB-14				μa							
	1	1900	+65	2.6	.12						
	2	1900	+67	2.9	.12						
	3	1820	+66	3.4	.13						
	4	1600	+70	3.9	.17						
	5	2000	+57	3.5	.15						
HB-16											
	20	2460	+50	1.7	.081						
	21	3000	+53	1.0	.050						
	22	2920	+54	1.3	.060						
	23	2960	+57	1.0	.048						
	24	2850	+53	1.3	.068						

predep
V/I = 30
after dif. ~57

predep
V/I = 40

0 HOURS
IN AT 1730
23 FEB
@ 300°C
(LEADS TWITSED)

63 HOURS
OUT AT 0800
26 FEB.

POWER LIFE
1200 26 FEB

VCB = 10V, IC = 30MA
VEB = -30V
TCASE ≈ 65°C

OUT 0800
27 Feb.

20 HOURS POWER
LIFE

Meeting concerning NSA proposal 3/13/62

Norman Ferguson Schmitt Moore

Phase I - Ckt determination (paper study)

Phase II - Bread board by bit element

Phase III - Ckt fab of one unit.

Who will do Phase I.
Phase I should be compatible with the bit
with Automatics ckts
etc.

Bob Norman should be responsible. (Total time to complete 6 weeks)

Bob Norman —
Howard Bogart —
Henry Rugg —
Dick Crippen —
Dave Talbert —
Dick Anderson —
Don Farina —

Total $ engr man mo
= 800 engr hrs
\+ 300 tech

Phase II - Breadboards
for typical unit!
Prototype - 5 man days (tech)
next 19 - 5 man days (tech)
Translate ckt requirements to test spec and procedure — 300 engr hrs 40 40 20 tech +1 ~~1 engr mo~~
Eg. assembly — 100 engr 200 tech
test performance — 30 engrs 100 tech
Documentation - drawing
test reports — 10 ~~50~~ 20

440 em ~~700 tt~~ 600

divide by two ——— 220 300

X 9 for 9 ckts — 1980 2700

Phase III Integrate

	Engr	Tech	Assembler
Masks	20	20	100
Fabrication	200	100	200
Assembly	100	200	200
Test	50	200	
Report	100		
	470	520	500

General Studies: Engring Tech

Packaging:

Brown
Angelides } 1 manager
Siddiqi
~~Dunnell~~

Interconnecting:
Dunnil

Summary of full-scale PNP product planning mtg., 3/12/62.

We have a commitment to make Autonetics a 1132 replacement.

We will make masks for new 3501 – gets rid of the failure mode and meets C_{TE}.

We will see that material (epitaxial) will get ordered for delivery.

At 3 weeks we will run in parallel.

4500 – no change
4700 – run as going until 4701 material comes in
4701 – run some until 3501 masks come in.
3501 – make masks, run in parallel in R&D & Mtn View.

~~3510 – after 3010~~

1731 – We will need both ~~[illegible]~~ high voltage (20v) and low voltage (8v) just like we did on the 1321.

Schedule: Low voltage first. Ready for scheduling.
We will help with diffused wafers.
Mtn View will crank through any material we give them.

1741 – Is now a 12v LV_{CEO}
1746 – ~~[illegible] at LV_{CEO}~~ Use 3501 Material, 1740 diffusion
get LV_{CEO} > 35v

7500 – R&D will make the first 100 – before the 7500 Xfer the 2000 should be flying.

RECEIVED
MAR 30 1962
GORDON E. MOORE

INTERNAL CORRESPONDENCE

FAIRCHILD SEMICONDUCTOR CORPORATION

TO: D. Yost
DATE: March 29, 1962
FROM: G. Livingston
CC: See List
SUBJECT: New Product Developments - PNP Section

The purpose of this memorandum is to summarize the March PNP Product Meeting to assure that staff groups are informed of the general plans concerning new and potential products. Future product meetings will be summarized by the respective product managers and distributed as required.

4500

No changes are anticipated in the near future. Ultimately this product will be replaced with a planar PNP.

4700-4701

Both of these devices are in the line development stage. The planar structure is an immediate requirement to relieve the tap test problem, particularly in the TB package which is not crimped. This product will not meet the requirements of the 2N1132, but it should be a satisfactory replacement for the 2N722 except for 300°C storage. By May 15, the TB-4500 final seal schedule will be made with the TB-4700. The shift to epitaxial will be made as material becomes available.

3501

This product, which is similar to the 3001, is a potential replacement for the 4500 except for 300°C storage. Pilot runs were being made at Mountain View in parallel with R&D, but all 3501 production has been scrapped because of problems on operating life. R&D is preparing new masks which should be available the first week in April. At that time, Mountain View will begin line development. Development of this product is the top priority project of the PNP section.

1740-1741

All production has been shifted to epitaxial on this product. A reasonable inventory of non-epitaxial units is on hand, and the epitaxial version should meet most requirements.

1746

In order to obtain higher voltage devices ($LV_{CEO} > 35v$) with the characteristics of the 1741, the 1746 was evolved. This device will utilize 3501 material and the 1740 diffusion processes.

1711-1721-1731

These devices have been designed for maximum speed using low voltage material as it becomes available. They are all variations of the interdigitated structure. The 1731 (3 emitters, 2 bases) will replace the other types and is the only one being started.

3510

This device is still in R&D scheduled for line development after the 3501 is optimized.

7500

This device is still in R&D scheduled for line development after the 7000 is optimized.

General Comments

We intend to shift as rapidly as possible to a series of planar, epitaxial PNP transistors which will range from a fast switching device for computer applications to power devices. Additional emphasis will be placed on types which can replace germanium units in existing designs, but in general we will have more success in new and redesigned equipment.

It should be emphasized here, that no planar PNP devices will be guaranteed to meet 300°C storage and that they will not receive our normal 60 hour bake. A storage temperature of 200°C should present no problems.

G. Livingston

G. Livingston, Head
Mesa Section

GL/sm

List:

T. Bay
J. Farley
J. Magarian
G. Moore
W. O'Keefe
C. Sporck
N. Walker

Discussion with Mel Phelps on Autonetics policy

March 16, 1962

D-26 – Low frequency machine – TI is still in this

D-28 – Either 1Mc, low power or
10Mc
They have proposed in this area, but they have yet no contract

MM (advanced) – Anticipated but not in hand.

Titan – Asked to bid.

Rough schedule (10Mc)

1st design samples in July – August to them of gate
By June 1 we will be ready to lay out family samples during 3rd quarter.

Low level, 1st block samples, by ~Aug.

March 19, 1962 - Xducer discussion

Bay
Goldrich
Smith

MICRO SYSTEMS MSI INCORPORATED

PIONEERS IN SOLID STATE SENSORS
FOR STRAIN, TEMPERATURE, FORCE,
PRESSURE, LIGHT, AND DEFLECTION.

ENGINEERING BULLETIN

PRESSURE TRANSDUCER SERIES P01

The P01BG5 Pressure Transducer offers the following features for extremely high pressure requirements:

- High Accuracy
- Exceptional Overload Capability
- Small Size
- High Output
- Rugged Design
- Uni-Body/Sensor Construction

The P01 series pressure transducers are machined from 17-4 PH steel with an extremely small sensor volume to minimize stored energy problem. Micro Sensor$^{\text{tm}}$ Semiconductor Strain Gages are arranged in a wheatstone bridge to produce a high level output signal. Unusually large overload protection is afforded from the design utilized.

SPECIFICATIONS - Type P01BG5

Ranges	0-10,000 PSIG, 0-25,000 PSIG 0-50,000 PSIG, and 0-100,000 PSIG
Maximum Allowable Pressure	1.5 times rated capacity (over 3 times to burst)
Pressure Media	Liquids and gases compatible with 17-4 PH steel
Bridge Resistance	500 ohms nominal
Excitation	10 volts
Output	0.5 volt nominal at full scale
Non-Linearity and Hysteresis combined	±1% of full scale
Resolution	Continuous
Acceleration Sensitivity	Less than 0.01% of full scale per G from 0-100 G in any plane
Operable Temperature Range	-65°F to +250°F
Compensated Temperature Range	+30°F to +130°F
Thermal Zero Shift	2% of full scale over 100°F
Thermal Sensitivity Change	2% of reading over 100° F
Pressure Connection	Standard super pressure fitting with 60° chamfer seal
Electrical Connection	Cannon WK5 case mounted connector, mating connector supplied
Physical Configuration	1.5 inches O.D. x 2 inches long Approximately 7 ounces
Price Schedule	1 - 4 units $395.00 5 - 9 units $370.00 10 - 19 units $350.00

Portable self contained readout unit available.

MICRO SYSTEMS **MSI** INCORPORATED

PIONEERS IN SOLID STATE SENSORS
FOR STRAIN, TEMPERATURE, FORCE,
PRESSURE, LIGHT, AND DEFLECTION.

ENGINEERING BULLETIN

PRESSURE TRANSDUCER, TYPE PO3BA4

The Type PO3BA4 pressure transducer represents a state-of-the-art advance in transducer concept. Within its miniature housing solid-state strain elements are bonded to the back side of the pressure sensing diaphragm and wired in a full-bridge circuit to convert pressure induced strains to a high-level electrical output. The RC-01 Transducer Driver, supplied with each PO3BA4, allows precision operation from an unregulated 28-volt dc source. The Transducer Driver is stackable for minimum space consumption, and can be located remotely up to 500 feet (AWG-20 wire) from the transducer without sacrificing performance. In many applications, the use of amplifiers can be eliminated, resulting in improved system reliability. The exceptionally high natural frequency resulting from the 1/4-inch flush diaphragm eliminates response to vibration encountered in most severe applications.

The integral flange allows custom installation of the PO3BA4 with minimum case distortion. Mounting adapters are available if desired, to suitably connect the PO3BA4 for either flush mounting, or conventional pressure fitting applications. (See back side of bulletin for adapter information.)

SPECIFICATIONS

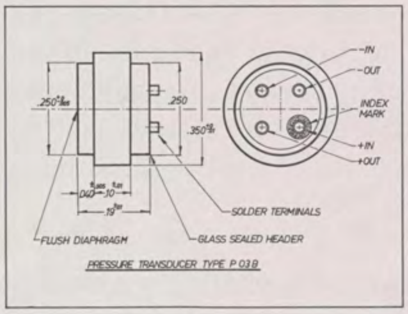
Ranges	0-100, 0-200, 0-500, and 0-1000 psia
Material in Contact with Working Fluid	NI-SPAN C
Overpressure	150% without recalibration
Burst Pressure	300% minimum
Bridge Resistance (Input or Output)	500 ohms ±20%
Zero Balance	±5% of full scale
Excitation	28-volts dc ±10% to driver (approx. 10 volts to transducer)* 30 milliamperes
Open Circuit Output	0.5 volts full scale (minimum) 0.75 volts full scale (maximum)
Non-Linearity and Hysteresis . . .	±1% of full scale
Resolution	Continuous
Natural Frequency	100 psia = 40 k cps, 200 psia = 55 k cps, 500 psia = 75 k cps, 1000 psia = 100 k cps

(over)

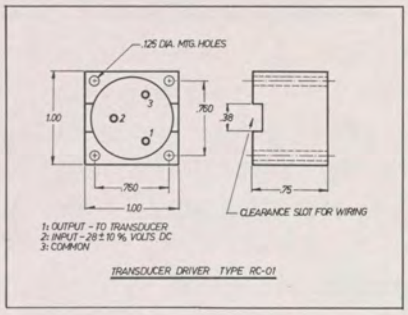
EMT-4-2/62-8M

Acceleration Response (to 2300 G)	0.002% of full scale/G max. in any plane
Vibration Response (all axes)	0.002% of full scale/peak G (35 G, 0-10,000 cps)
Operable Temperature Range	-65° F to +250° F
Compensated Temperature Range	+30 to +130° F
Thermal Zero Shift	within 2% of full scale over compensated range
Thermal Sensitivity Shift	within 1% of full scale over compensated range
Repeatability	±0.5% of full scale
Weight	
Transducer	0.05 ounce
Transducer Driver RC-01	1.0 ounce
Electrical Connections	hermetic seal header, solder terminals, supplied with 2-feet of four conductor cable
Price	$395.00 each

* Transducer, less RC-01 driver, can be operated from an ac source, but temperature compensation specifications will be somewhat poorer.

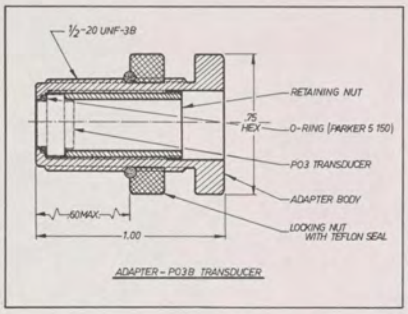


PO3B



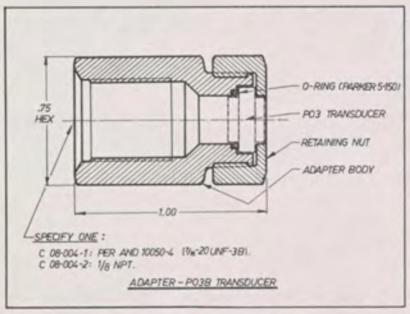
RC-01

PO3BA4 MOUNTING ADAPTERS*



TYPE CO8-003 (For Flush Mounting Application)
The CO8-003 mounting adapter allows flush mounting of the PO3BA4 pressure transducer in materials of varying thickness from 0.06-inch to 0.6-inch. A teflon seal is provided between the adapter and shell to which the PO3BA4 is to be mounted. 300 series stainless steel is used.

Price . . . . $17.50 each



TYPE CO8-004 (For Conventional Application)
The CO8-004 mounting adapter allows use of the PO3BA4 in conventional "plumbing" applications, such as standard AN fittings. Minimum volume is maintained through its use, thus preserving the high natural frequency of the PO3BA4 to as great an extent as is possible. 300 series stainless steel is used throughout.

Price . . . . $15.00 each
(CO8-004-1 and CO8-004-2)

* Adapters with electrical connectors available upon special request.

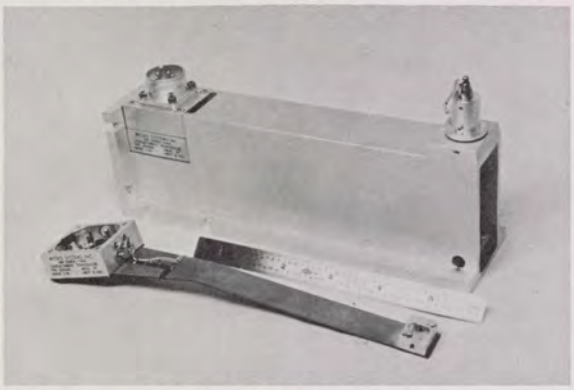
MICRO SYSTEMS MSI INCORPORATED

PIONEERS IN SOLID STATE SENSORS
FOR STRAIN, TEMPERATURE, FORCE,
PRESSURE, LIGHT, AND DEFLECTION.

ENGINEERING BULLETIN

DISPLACEMENT TRANSDUCER, SERIES D01 FOR STRUCTURAL TEST APPLICATIONS

The D01 AU5 transducer constitutes a significant improvement in displacement measurement for structural tests over existing pot type or differential transformer type sensors with the following outstanding features:



- Ruggedness
- Infinite Resolution
- No Wearing Parts
- Built-in Deflection Stops
- High Output
- Simple Associated Circuitry

The type D01 AU5-2000 displacement transducer is an extremely rugged and reliable precision instrument composed of a bending beam in a cast aluminum housing. The beam is instrumented with solid state strain gages arranged in a full Wheatstone bridge to give high sensitivity as well as infinite resolution over the entire operating range. The housing provides two surfaces at 90° to each other for easy mounting. Overload protection is incorporated in the transducer to allow no more than 15 pounds force to be applied before the loading hook or wire will break. The loading hook and wire can be replaced in a matter of minutes.

SPECIFICATIONS, TYPE D01 AU5

Full Scale Range	0-2 inches or ±1 inch (other ranges available)
Bridge Resistance	350 ohms, nominal
Excitation	10 volts
* Sensitivity	2 volts nominal at full scale
Linearity, Hysteresis and Repeatability combined	Less than ±0.75% of full scale
Resolution	Continuous
Zero Balance	±2% of full scale
Operable Temperature Range	-65°F to +180°F
Compensated Temperature Range	+50°F to +150°F
Thermal Zero Shift	1% of full scale over 100°F
Thermal Sensitivity	1% of deflection over 100°F
Loading Force	
Full Scale	Approximately 3 lbs
Break Out	Approximately 1 lb
Physical Configuration	8'' (L) x 2'' (W) x 2-1/2'' (H) Approximately 18 ounces
Electrical Connection	Case mounted connector type WK5 mating connector supplied

* Dropping resistors to attenuate output to other standard values optional.

Price Schedule

1 - 4 units	$325.00	25 - 99 units	$260.00
5 - 24 units	$290.00	100 - units or more	$250.00

RET-4Oct. '61

EMT-2 9/61-5M

319 Agostino Rd., San Gabriel, California • ATlantic 7-0584 • A subsidiary of Electro-Optical Systems Inc.

PI-120
(former designation
AFF-SAC-2014)
November 1957

SPECIFICATION

FOR

PRESSURE TRANSDUCER

INSTRUMENTATION SYSTEM

Approved:

B.F. Rose, Jr., Manager
Architect Engineer Division

AEROJET GENERAL CORPORATION
Architect-Engineer Division, Covina, California

PI-120
(former designation
AFF-SAC-2014)

SPECIFICATION
FOR
PRESSURE TRANSDUCER
INSTRUMENTATION SYSTEM

SECTION 1. GENERAL REQUIREMENTS

1-01. SCOPE. Furnish and deliver pressure transducers in accordance with this specification.

1-02. CODE CONFORMANCE. Electrical components, materials and details of construction and assembly shall conform with requirements of latest issue and revisions of "National Electrical Code" of National Board of Fire Underwriters and "National Electrical Safety Code" of United States Department of Commerce. Approval of above agencies is not required, but equipment shall be designed, constructed and assembled so that intent of Codes will be fulfilled at least to extent that equipment shall not constitute fire hazard nor unguarded source of electrical shock to operating personnel.

1-03. DRAWINGS. Submit six (6) certified prints showing dimensions and mounting details.

1-04. DESIGN AND WORKMANSHIP. The design and construction of all components, assemblies and associated wiring shall reflect the most modern practice and finest degree of workmanship for this type and class of equipment. Construction and workmanship of components, assemblies and wiring not so specified shall conform to the highest standards of practice as regards ease of maintenance, mounting rigidity and neat appearance.

1-05. DEVIATIONS from these specifications may be made only after written authorization is obtained from Buyer. No change in work involving an increase or decrease in Contract price will be authorized except by Purchase Order change.

1-06. INSPECTION AND ACCEPTANCE. Seller shall furnish a certificate to show full compliance with specifications. Final inspection and acceptance will be made after installation at Buyer's facility.

1-07. WARRANTY. Seller shall warrant performance of equipment to meet or exceed the requirements of this specification, and in addition, shall warrant complete unit to be free of defects in material and workmanship for one year of operation. Defects found during warranty period shall be repaired or replaced by Seller without delay and at no additional cost to Buyer.

SECTION 2. TECHNICAL PROVISIONS

2-01. GENERAL CONDITIONS.

(a) Pressure of 25 per cent above nominal range shall not cause a change in signal greater than 0.5 per cent of full scale at zero gage pressure. An overpressure of 100 per cent shall not cause permanent damage.

(b) Shock of 50 g peak intensity and 10 millisecond duration shall not cause permanent damage.

(c) Materials exposed to pressure medium may be AISI Types 302, 303, 347, 350, 410 or 416 stainless steel, iso-elastic, ni-span C. and Teflon impregnated Fiberglass.

(d) Connector: Cannon WKH-5-32, or equal, mounted on transducer case with suitable seal. Sealing gasket shall be satisfactory for use in hydrocarbon atmosphere, liquid oxygen, and nitric acid fumes, and provide a water tight seal. No connection shall be made from cable shield to a connector shell or transducer case.

The wiring code shall read:

Connector	Transducer	
1	Positive Signal)	For Increasing Pressure
2	Negative Signal)	
3	Negative Excitation	
4	Positive Excitation	
5	No Connection	

(e) Leakage Resistance to case or shield shall be 1000 megohms minimum when tested at a potential of 50 volts DC.

2-02. CONDITION AT 80 DEGREES F,

(a) Input Impedance: 350 ohms plus or minus 3.5 ohms.

(b) Output Impedance: 350 ohms plus or minus 35.0 ohms.

(c) Rated excitation: 10 volts DC.

(d) Output Signal at zero gage pressure shall not exceed plus or minus 2.5 per cent full scale at rated excitation.

(e) Pressure Sensitivity: 3 mv/v plus or minus 0.015 mv/v for full range. Determine by change in output signal produced by increase in applied gage pressure from zero to full range pressure level.

(f) Accuracy: Error, including hysteresis and non-linearity, shall be within 0.5 per cent of full scale.

(g) Difference in Pressure Sensitivity due to non-repeatability under identical conditions shall not exceed 0.3 per cent. This value is based upon an estimated 0.15 per cent test error and 0.15 per cent instrument error.

(h) Terminals for keying in a shunt type calibrating resistor shall be 2 and 3. The calibrating resistors shall provide outputs as indicated below.

Calibrating Resistor (ohms)	Output Provided - (Fraction of positive full scale)	Tolerance (% of output)
37,280	0.75	± 0.20
56,000	0.50	± 0.25
112,200	0.25	± 0.30
280,700	0.10	± 1.00

(i) Static Acceleration Sensitivity at a maximum level of 10 G shall not exceed 0.02 per cent of full scale per G along any axis.

(j) When Pressure Transducer is vibrated lineally along any axis according to the following schedule, acceleration response shall not exceed 0.3 per cent of full scale at any time.

0.25 in. peak-to-peak displacement 10 cps to 20 cps
10 G peak 20 cps to 1000 cps

Note: Applies to 500 psi ranges and above.

2-03. CONDITIONS UNDER TEMPERATURE EXTREMES.

(a) Pressure Sensitivity shall not vary more than 0.25 per cent of plus 80 degrees F value between plus 30 degrees F and plus 130 degrees F and 1 per cent between minus 65 to plus 30 and plus 130 to 250 degrees F.

(b) Output Level at zero applied pressure shall not change more than 1.0 per cent of full scale per any 100 degree F range between minus 65 to plus 250 degrees F.

(c) Output produced by application of any one calibrating resistor shall not vary between plus 30 degrees F and plus 130 degrees F by more than 0.3 per cent of the reading.

2-04. TEST EQUIPMENT. Standards for determining conformance to specifications shall be:

(a) Electrical: Leads and Northrup type K2 potentiometer, or equal, with Eppley Laboratory's standard Weston type cell and a suitable null indicator.

(b) Gage Pressure: A precision dead-weight tester with manufacturer's rating of 0.1 per cent accuracy. Ashcroft Gauge Tester Type 1313-A or equal.

2-05. PREPARATION FOR SHIPPING. Pack and crate equipment as a unit in such a manner that will insure it against damage due to mechanical vibration, shock or strain in transit and handling. Equipment shall be so enclosed and protected as to preclude damage by exposure to ambient temperature and humidity while in transit and storage.

MIKE DOW – MGR LIQUID PLANT
ERROR BAND .25 OR BETTER

PI-121
(former designation
AFF-SAC-2030)

SPECIFICATION
FOR
PRESSURE TRANSDUCER
TABER TELEDYNE MODEL 176
INSTRUMENTATION SYSTEM

SECTION 1. GENERAL REQUIREMENTS

1-01. SCOPE. Furnish and deliver Taber Instrument Corporation Model 176 strain gage pressure transducers, or equal, in accordance with this specification. Transducers shall have a ni-span C. strain sensitive element.

1-02. CODE CONFORMANCE. Electrical components, materials and details of construction and assembly shall conform with requirements of latest issue and revisions of "National Electrical Code" of National Board of Fire Underwriters and "National Electrical Safety Code" of United States Department of Commerce. Approval by above agencies is not required, but equipment shall be designed, constructed and assembled so that intent of Codes will be fulfilled at least to extent that equipment shall not constitute fire hazard nor unguarded source of electrical shock to operating personnel .

1-03. DRAWINGS. Submit six (6) certified prints showing dimensions and mounting details.

1-04. DESIGN AND WORKMANSHIP. The design and construction of all components, assemblies and associated wiring shall reflect the most modern practice and finest degree of workmanship for this type and class of equipment. Construction and workmanship of components, assemblies and wiring not so specified shall conform to the highest standards of practice as regards ease of maintenance, mounting rigidity and neat appearance.

1-05. DEVIATIONS.from these specifications may be made only after written authorization is obtained from Buyer. No change in work involving an increase or decrease in Contract price will be authorized except by Purchase Order change.

1-06. INSPECTION AND ACCEPTANCE. Seller shall furnish a certificate to show full compliance with specifications. Final inspection and acceptance will be made after installation at Buyer's facility.

1-07. WARRANTY. Seller shall warrant performance of equipment to meet or exceed the requirements of this specification, and in addition, shall warrant complete unit to be free of defects in material and workmanship for one year of operation. Defects found during warranty period shall be repaired or replaced by Seller without delay and at no additional cost to Buyer.

SECTION 2. TECHNICAL PROVISIONS

2-01. GENERAL CONDITIONS..

(a) Pressure of 25.0 per cent above nominal range shall not cause a change in signal greater than 0.5 per cent of full scale at zero gage pressure. An overpressure of 100 per cent shall not cause permanent damage.

(b) Shock of 50 G peak intensity and 10 millisecond duration shall not cause permanent damage.

(c) Materials exposed to pressure medium may be AISI types 302, 303, 350, 347, 410 or 416 stainless steel, iso-elastic, ni-span C. and Teflon impregnated Fiberglass.

(d) Strain Sensitive Element: Ni-span C.

(e) Electrical Connection to Transducer: Cannon WKH-5-32, or equal , hermetically sealed connector attached to transducer case. Provide a waterproof gasket seal between connector and transducer. Seal shall be satisfactory for use in hydrocarbon atmosphere, liquid oxygen, and nitric acid fumes. The wiring code shall read:

Connector	Transducer	
1	Positive Signal)	- For Increasing Pressure
2	Negative Signal)	
3	Negative Excitation	
4	Positive Excitation	
5	No Connection	

(f) Leakage Resistance to case or shield shall be 100 megohms minimum when tested at a potential of 50 volts DC.

2-02. CONDITIONS AT 80 DEGREES F.

(a) Input Impedance: 350 ohms plus or minus 3.5 ohms.

(b) Output Impedance: 350 ohms plus or minus 35.0 ohms.

(c) Rated Excitation: 10 volts DC.

(d) Output Signal at zero gage pressure shall not exceed plus or minus 2.0 per cent full scale at rated excitation.

(e) Pressure Sensitivity: 3.0 mv/v plus or minus 0.015 mv/v for full range. Determine by change in output signal produced by increase in applied gage pressure from zero to full range pressure level.

(f) Accuracy: Error, including hysteresis and non-linearity, shall be within 0.5 per cent of full scale.

(g) Differences in Pressure Sensitivity due to non-repeatability under identical conditions shall not exceed 0.3 per cent. This value is based upon an estimated 0.15 per cent test error and 0.15 per cent instrument error.

(h) Terminals for keying in a shunt type calibrating resistor shall be 2 and 3. The calibrating resistors shall provide outputs as indicated below.

Calibrating Resistor (ohms)	Output Provided (Fraction of Positive Full Scale)	Tolerance (% of Output)
37,280	0.75	± 0.20
56,000	0.50	± 0.25
112,200	0.25	± 0.30
280,700	0.10	± 1.00

(i) Static Acceleration Sensitivity at a maximum level of 10 G shall not exceed 0.02 per cent of full scale per G along any axis.

(j) When Pressure Transducer is vibrated lineally along any axis according to the following schedule, acceleration response shall not exceed 0.3 per cent of full scale at any time.

0.25 in. peak-to-peak displacement 10 cps to 20 cps
10 G peak 20 cps to 1000 cps.

Note: Applied to 5000 psi ranges and above.

2-03. CONDITIONS UNDER TEMPERATURE EXTREMES.

(a) Pressure Sensitivity shall not vary more than 0.25 per cent of plus 80 degrees F value between plus 30 degrees F and plus 130 degrees F and 1 per cent between minus 65 to plus 30 and plus 130 to 250 degrees F.

(b) Output Level at zero applied pressure shall not change more than 1.0 per cent of full scale per any 100 degree F range between minus 65 to plus 250 degrees F.

(c) Output produced by application of any one calibrating resistor shall not vary between plus 30 degree F and plus 130 degree F by more than 0.3 per cent of the reading.

2 -04. TEST EQUIPMENT. Standards for determining conformance to specifications shall be:

(a) Electrical: Leeds and Northrup Type K2 potentiometer, or equal, with Eppley Laboratory's standard Weston Type cell and a suitable null indicator.

(b) Gage Pressure: A precision dead-weight tester with manufacturer's rating of 0.1 per cent accuracy. Ashcroft Gauge Tester Type 1313-A, or equal.

2-05. PREPARATION FOR SHIPPING. Pack and crate equipment as a unit in such a manner that will insure it against damage due to mechanical vibration, shock or strain in transit and handling. Equipment shall be so enclosed and protected as to preclude damage by exposure to ambient temperature and humidity while in transit and storage.

PI-122
(former designation
AFF-SAC-2031)
November 1957

SPECIFICATION
FOR
UNBONDED STRAIN GAGE ACCELEROMETER
INSTRUMENTATION SYSTEM

Approved:

B. F. Rose, Jr.

B. F. Rose, Jr., Manager
Architect-Engineer Division

AEROJET-GENERAL CORPORATION

Architect-Engineer Division - Covina, California

PI-122
(former designation
AFF-SAC-2031

SPECIFICATION
FOR
UNBONDED STRAIN GAGE ACCELEROMETER
INSTRUMENTATION SYSTEM

SECTION 1. GENERAL REQUIREMENTS

1-01. SCOPE. Furnish and deliver Statham Laboratory's unbonded strain gage accelerometer, or equal, in accordance with this specification.

1-02. CODE CONFORMANCE. Electrical components, materials and details of construction and assembly shall conform with requirements of latest issue and revisions of "National Electrical Code" of National Board of Fire Underwriters and "National Electrical Safety Code" of United States Department of Commerce. Approval by above agencies is not required, but equipment shall be designed, constructed and assembled so that intent of Codes will be fulfilled at least to extent that equipment shall not constitute fire hazard nor unguarded source of electrical shock to operating personnel.

1-03. DRAWINGS. Submit six (6) certified prints showing dimensions and mounting details.

1-04. DESIGN AND WORKMANSHIP. The design and construction of all components, assemblies and associated wiring shall reflect the most modern practice and finest degree of workmanship for this type and class of equipment. Construction and workmanship of components, assemblies and wiring not so specified shall conform to the highest standards of practice as regards ease of maintenance, mounting rigidity and neat appearance.

1-05. DEVIATIONS from these specifications may be made only after written authorization is obtained from Buyer. No change in work involving an increase or decrease in contract price will be authorized except by Purchase Order change.

1-06. INSPECTION AND ACCEPTANCE. Seller shall furnish a certificate to show full compliance with specifications. Final inspection and acceptance will be made after installation at Buyer's facility.

1-07. WARRANTY. Seller shall warrant performance of equipment to meet or exceed the requirements of this specification, and in addition, shall warrant complete unit to be free of defects in material and workmanship for one year of operation. Defects found during warranty period shall be repaired or replaced by Seller without delay and at no additional cost to Buyer.

SECTION 2. TECHNICAL PROVISIONS

2-01. GENERAL CONDITIONS.

(a) Static Acceleration of 300 per cent above nominal full scale shall not cause permanent damage. Positive limit stops shall be provided.

(b) Attached Cable 2 feet long shall be provided. Cable shall be Tensolite Insulated Wire Company, Inc., or equal, Specification No. 20030-L4, 4 conductor, teflon jacket, tinned copper shield, teflon insulation. Cable connector shall be Cannon No. WK-5-21C-3/8, or equal, with melamine inserts.

The wiring code shall be as indicated below:

Wire Color	Connector	Transducer	
Black	1	Positive signal	for positive acceleration
Red	2	Negative signal	
White	3	Negative excitation	
Green	4	Positive excitation	
Shield	5	No connection	

Cable connection to transducer case shall be waterproof. No connection shall be made from cable shield to connector shell or transducer case.

(c) Leakage Resistance from conductors to case or shield shall be 1000 megohms minimum when tested at a potential of 50 volts DC.

2-02. CONDITIONS AT 80 DEGREES F.

(a) Input Impedance: 350 ohms plus or minus 3.5 ohms.

(b) Output Impedance: 350 ohms plus or minus 35.0 ohms.

(c) Rated Excitation: 10 volts DC.

(d) Output Signal at zero acceleration shall not exceed plus or minus 2 per cent full scale at rated excitation.

(e) Acceleration Sensitivity: 3 mv/v plus or minus 0.030 mv/v for full scale (either positive or negative).

(f) Accuracy: Error, including hysteresis and non-linearity, shall be within 1.0 per cent of full scale.

(g) Differences in Acceleration Sensitivity due to non-repeatability under identical conditions shall not exceed 0.5 per cent full scale.

(h) Response to Transverse Acceleration shall not be more than 2 per cent of sensitive axis response for similar acceleration.

(i) Accelerometer: Damped with silicone fluid to 0.6 to 0.8 of critical damping.

(j) Terminals for keying in a shunt type calibrating resistor shall be 2 and 3. The calibrating resistors shall provide outputs as indicated below.

Calibrating Resistor (ohms)	Output Provided - (fraction of positive full scale)	Tolerance (per cent of output
37,280	0.75	± 0.20
56,000	0.50	± 0.25
112,200	0.25	± 0.30
280,700	0.10	± 1.00

2-03. CONDITIONS UNDER TEMPERATURE EXTREMES:

(a) Output Signal at zero acceleration shall not change more than 1 per cent full scale between plus 30 degrees F. and plus 130 degrees F.

(b) Damping Co-efficient shall not vary by more than a factor 2 from plus 80 degrees F. value between plus 30 degrees F. and plus 130 degrees F.

2-04. DEFINITIONS.

(a) Positive Acceleration is acceleration in direction of base of accelerometer.

(b) Acceleration Sensitivity is minimum detectable change in output signal from zero acceleration to full range acceleration.

(c) Positive Full Scale Output is the base used for calculations.

2-05. PREPARATION FOR SHIPPING. Pack and crate equipment as a unit in such a manner that will insure it against damage due to mechanical vibration, shock or strain in transit and handling. Equipment shall be so enclosed and protected as to preclude damage by exposure to ambient temperature and humidity while in transit and storage.

PI-123
(former designation
AFS-SAC-2016)
November 1957

SPECIFICATION
FOR
LOAD CELL

Approved:
B F Rose Jr
B. F. Rose, Jr., Manager
Architect-Engineer Division

AEROJET-GENERAL CORPORATION

Architect-Engineer Division - Covina, California

PI-123
(former designation
AFS-SAC-2016)

SPECIFICATION
FOR
LOAD CELL

SECTION 1. GENERAL REQUIREMENTS

1-01. SCOPE. Furnish and deliver Baldwin-Lima Hamilton Corporation Type U-1 Load Cells, or equal, fabricated in accordance with Baldwin-Lima-Hamilton Corporation specifications with the following modifications.

1-02. CODE CONFORMANCE. Electrical components, materials and details of construction and assembly shall conform with requirements of latest issue and revisions of "National Electrical Code" of National Board of Fire Underwriters and "National Electrical Safety Code" of United States Department of Commerce. Approval by above agencies is not required, but equipment shall be designed, constructed and assembled so that intent of Codes will be fulfilled at least to extent that equipment shall not constitute fire hazard nor unguarded source of electrical shock to operating personnel.

1-03. DRAWINGS. Submit six (6) certified prints showing dimensions and mounting details.

1-04. DESIGN AND WORKMANSHIP. The design and construction of all components, assemblies and associated wiring shall reflect the most modern practice and finest degree of workmanship for this type and class of equipment. Construction and workmanship of components, assemblies and wiring not so specified shall conform to the highest standards of practice as regards ease of maintenance, mounting rigidity and neat appearance.

1-05. DEVIATIONS from these specifications may be made only after written authorization is obtained from Buyer. No change in work involving an increase or decrease in contract price will be authorized except by Purchase Order change.

1-06. INSPECTION AND ACCEPTANCE. Seller shall furnish a certificate to show full compliance with specifications. Final inspection and acceptance will be made after installation at Buyer's facility.

1-07. WARRANTY. Seller shall warrant performance of equipment to meet or exceed the requirements of this specification, and in addition, shall warrant complete unit to be free of defects in material and workmanship for one year of operation. Defects found during warranty period shall be repaired or replaced by Seller without delay and at no additional cost to Buyer.

SECTION 2. TECHNICAL PROVISIONS

2-01. SPECIAL REQUIREMENTS.

(a) Input Resistance: 350 plus or minus 3.5 ohms.

(b) Output Resistance: 350 plus or minus 5.0 ohms.

(c) Open Circuit Electrical Output: 3 mv/v in compression plus or minus .015 mv/v for full range load applied. Load cell shall be tagged with output for tensile load.

(d) Rated Excitation: 10 volts DC.

(e) Full scale Load Rating: 50,000 pounds.

(f) Terminals for keying in a shunt type calibrating resistor shall be 2 and 3. The calibrating resistors shall provide outputs as indicated below.

Calibrating Resistor (ohms)	Output Provided - (Fraction of positive full scale)	Tolerance (per cent of output)
37,280	0.75	± 0.20
56,000	0.50	± 0.25
112,200	0.25	± 0.30
280,700	0.10	± 1.00

(g) Electrical Output produced by application of any one calibrating resistor shall not vary more than0.3 per cent of reading between plus 30 degrees F. and plus 130 degrees F.

(h) Electrical Connection to Transducer: Cannon WKH-5-32, or equal, attached to transducer case. Provide a waterproof gasket seal between connector and transducer. Seal shall be satisfactory for use in hydrocarbon atmosphere, liquid oxygen and nitric acid fumes.

The wiring code shall be as indicated below:

Connector	Transducer	
1	Positive Signal)	For Compression Loading
2	Negative Signal)	
3	Negative Excitation	
4	Positive Excitation	
5	No Connection	

2-02. PREPARATION FOR SHIPPING. Pack and crate equipment as a unit in such a manner that will insure it against damage due to mechanical vibration, shock or strain in transit and handling. Equipment shall be so enclosed and protected as to preclude damage by exposure to ambient temperature and humidity while in transit and storage.

Saxena
Sah
[illegible]
[illegible]

March 19, 1962 – Proj 177 – Thin film tunneling

Project review: (Saxena)

1. Make reproducible M-I-M film sandwiches

   a) Work has been done on anodized Ta. Large grained structures were made and Au coated after anodization.
   The variable parameters are the thickness + work functions)

   $$\underline{I} = I_0 e^{-\left(V_0/V\right)^{\frac{1}{2}}}$$ – fits well

   b) Si thermal oxide only worked once

   c) Would like to try Be

   d) Have tried Se-glass – got some results

2. Temp coeff of tunneling @ MIM packaged devices

3. Symmetry – studies – study many sandwich
   $Ta-Ta_2O_5-Au$
   $Ta-TaO-Ta$
   $Au-Al_2O_3-Au$
   $Au-BeO-Au$
   $Be-BeO-Au$, etc

4. Electron emission studies
   a) Mean free path in metal films
   b) Metal-insulator work functions

5. New materials
6. 3-terminal
7. Theoretical work

Apparatus needed:
1. Clean vacuum system
2. " " " for emission studies
3. Ellipsometer
4. Chemical setup (anodization)
5. Recrystallization sett
6. Ox. furnace
7. Dry box
8. Electronic equipt
   Curve tracer
   Pulse network
   Power supplies, etc

Study the MIM sandwiches

1. Mount some for detail meas.
2. Go toward smaller dots (say ~1 mil)
3. Aim toward thinner films, V_T ~1 volt or less
4.

March 20, 1962, Project 162 Epitaxial Growth

Wigler
Ferguson
Saly
Salt
Sumil
Yorin

Project Review:

E-C shorts - turned out to be B-C channels mostly

So far we have only a couple of good wafers on the 7000 out of ~ 20 tried.

There is substrate P problem

There is a Fe - Si(OH)$_4$ impurity problem.

1. no P — should start today

Push through some substrates

2. purer SiHCl$_3$ — about ready.

3. " H$_2$ — should start today

4. There is an indication that the substrate surface is important, but the Chem. people have not been able to supply more than sporadic samples.

On substrates the dislocation count has gone from 300 - 20,000

Hank & Erwin will get set up to count dislocations.

Our growing heat cycle of itself introduces ~ 10,000 dislocation.

Hank will continue to try to make films as good as the bulk material ~~but the~~ and the Merck. Hank will supply the wafers in any convenient thickness to Dev. Dev to process with some priority through 7000 masks.

Growth is still on outside of mandrel at an optical ~~sample~~ temperature of 1220 ± 10° (1320-1330°C). Lower T gives poor results. At ½ the growth rate things looked worse.

March 20, 1962

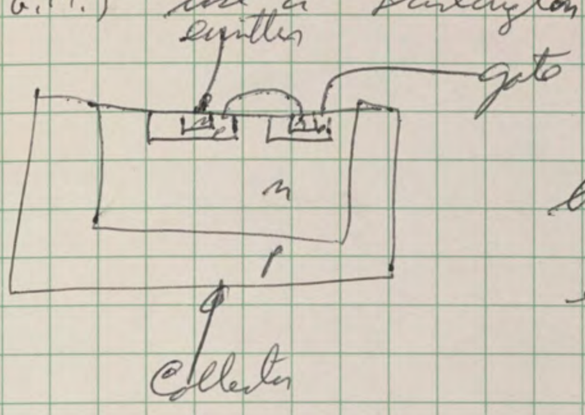
Sandor
Sah

GaAs Work. – Bob Broze

March 21, 1962   Project 106   SCR's   J.P.F
P.L.
W.G.
G.M.

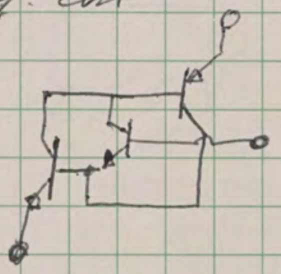
Preine has made a run of 600±200 v units. He got ~ 40% yield.

Invention: (G.M.) use a Darlington in a PNPN



This gives a high turn on voltage, but extremely low turn on currents.

eq. ckt



Tent. spec.

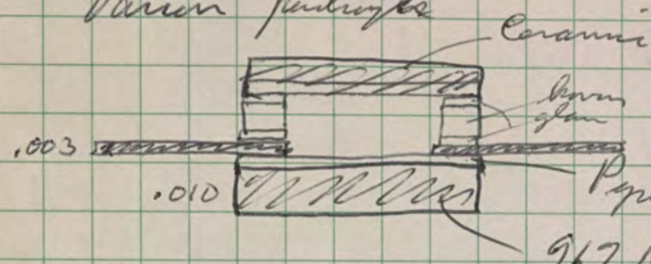
V_{BO} : 400 - 600
V_F = " "
I_H = 1 ma
Aim at TO5 - C package.

Project Review - Packaging of µckts 3/23/62

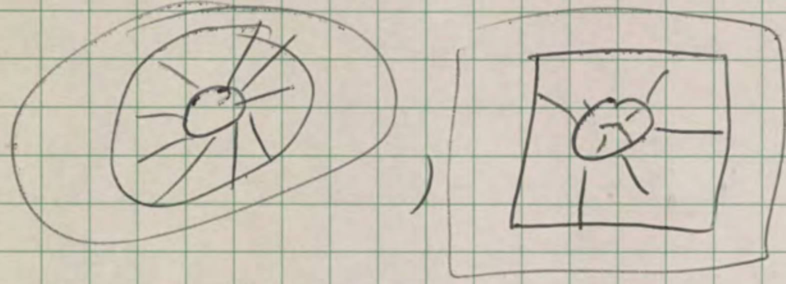
VHG
JPF
WW
Bob Brown
Lindsay

Farina
Durand

Various packages



This is the general structure of all of them



Some have been made with the device down on a flat ceramic wafer c lead bonds & potting — no existence proof. In fact data exists that the thermal oxide does not hold up to the pyroceram. It is not known if the potted ones are good or not

No info on the hermeticity

Easiest is the lead bonded in the package on top.
Next easiest is potted in glass
Most difficult is the full upsidedown.

Some work with bonding leads to T.C'd balls - Problem of common emitter lead over Si makes it pop off.

Some progress in Ag on Cr metallization - Fairly thick Ag over a big fat Cr layer. Makes very low resistance ohmic contact.
Etching needs KMER Ag in $Fe(NO_3)_3$
Cr in 60% HCl in ~~H~~Ac.

M.D. is anxious to get devices (4200?) for testing.

M.D. ought also to look at the pyrolytic oxide

Program:

1. Mo + CB or alumina
2. High temp metal
3. Preform – braze system
4. Mo fringe load system
5. Existence proof of low temp sealing
6. Metal – ceramic fine drum.

April 10, 1962 — Meeting with VHG - JPF on microcircuits

Problem: We are not cutting the ~~[illegible]~~ cord and feeding in masks for circuits at anywhere near the rate we should be.

After discussion it was decided that the following ideas were reasonable:

1. Drop the R if necessary to free manpower — we are not now learning anything from it. It would have to be completely re-done to be worth considering for production.

2. Continue to float along on TT6 with both resistor types — diffused and nichrome. Jim Campbell will be happy to arrange for several runs to go through his evaporator.

3. Run through four new sets of masks by the time I get back from Vacation, ~April 23. These will include two that require new techniques:

A. PNPN shift register

B. Differential amplifier using nichrome, center tapped resistor.

and two that use existing techniques, but new masks

C. A low level gate (MIT) using the sheet resistance under the emitter for the node resistor. Aim at 100 ns delay over 0 - 85°C, 1 mw/node and 3v power supply.

D. A 1 bit/chip diffused resistor memory device. Get speed & power level as best we can.

4/10/62

April 24, 1962   Project 170 - XPT-3 development

Ulmann
Wheeley
Hafel
Ferguson
Grinich
Moore

Review:

As a couple of weeks ago the devices were dying on photo response.

The epoxy seems exonerated, because the header with or without epoxy holds well.

The Ulmann pkg however, shows bad degradation. It seems almost certain that the low current β is going to pot.

This uncertainity is the problem.

Assembly has ~60% yield, most are opens and short. The shorts are mostly the shorting at the edge of the dice.

Other problem is pin holes - die sort yield is 1-2%.

We still do not have data on what changes - is it just time, is it voltage, or is it light?

The data on this will be out within ~1 week or so.

We still have the back-up package using std. solder down and lead bond. This is now doubly overdue.

May 1, 1962 — Microelectronics Res. Sect. Mtg

Me Adm

Van Ness
Fok
Price
Waite
Campbell
Engvall

Nichrome:

Waite is making a good jig
Talbot is " " small one (2 wafers)

* Talbot is not interested in many wafers - is not following existing process. This needs some definite straightening out.

The Radiation contract
Ablative adjustment

Jim Campbell:

SnO_2: Bad reproducible in coater. Thinks a epitaxial type system might work - but needs work

* We Need a sputterer — Bob Brown is dilly dallying with us again.

Si films.

1/2 - 2 1/2 μ now, heat treated doesn't craze.
The optical properties of the films are completely different before & after heat treatment. The absorption spectra & electron diffraction should be looked at.

* Data Book: Price, Campbell, Fok, Engvall

Make Comments on pr det. setup — also, what else.

Con't on May 2, 1962.

John Price:

Ink film resistors - ~~10~~ 15 mil lines are compatible now. 5K/□, width to 10K/□ - But John is getting ~30K/□

Fired at 730°C for 30 min.

Price needs Cu-plated ceramic plates for his resistive film.

Ed Try to think of a good way to make fine scaled ink patterns. }
Art Engsall suggests we consider a mortar & pestle. }

Diode arrays: 8X8 – Hopefully some any day.

The B-D converter is still up in the air. We will use this to lay out what the preferable processes are. – i.e. should we start from scratch, lay out a circuit and masks, or should we try to connect an 8X10 correctly.

Jim Campbell - Bob Waite are happy with the Michrome etch. The KMER technique for Michrome now approach the definition that we can get with KPR.

* Jim Mall was making aperture slits for John McCall of Graphics – Status – one delivered, specs, etc in Jim's file.

COMPANY PRIVATE

175 μ ckt Prod dev.
106 Controlled rectifier

RESEARCH & DEVELOPMENT PROJECTS LIST

TRANSISTOR & DIODE

Assigned Job Nos.	Job Title
108	7000 Series Dev.
143	1000 Series Dev.
144	1500 Series Dev.
136	2000 Series Dev.
145	4000 Series Dev.
146	4500 Series Dev.
147	6000 Series Dev.
148	Diode Development
~~191~~	~~Epitaxial Trans. Dev.~~
171	Zener Diode Dev.
169	Multiple Diode Dev.
107	7500 Series Dev.

IMPROVEMENT OF STANDARD TECHNIQUES

109	Diffusion Tech. Dev.
126	Masking Tech. Dev.
160	Packaging Tech. Dev.
156	Contact Tech. Dev.

PIEZORESISTOR DEVELOP.

140	Strain Gauge Element

NEW TECHNIQUES & MATERIAL

110	Glass & Ceramics Dev.
113	New Materials Prep & Eval
133	Electrochem. Tech. Dev
141	Microwave Physics
158	Gallium Arsenide Exploratory Device & Techniques
159	Surface Coating Dev.
162	Semiconductor Film Growth
158	Surface Protection Eval.

MISC. DEVICE DEVELOP.

Assigned Job Nos.	Job Title
117	Exploratory Dev. Research
~~118~~	~~Parametric Amplifier Diode Dev.~~
121	Data Storage Devices
~~125~~	~~Microwave Devices, Exploratory~~
142	S. C. T. Device
150	Tunnel Diode Dev.
170	Photo Transistor Dev.
179	Exploratory Photo Sensitive Device
189	Field Effect Transistors
105	Oxidation Studies

SUPPORTING RESEARCH

114*	Special Diffusion Research
115*	Noise Research
116	Basic Alloying Studies
119	Surface Research
120	Silicon Material Research
163	Pipes & Related Phenomena
164	Misc. Exploratory Research
173	Etching Studies

MICROCIRCUITRY

152	Micrologic Product Dev.
~~153~~	~~Micrologic Advanced Dev.~~
172	Advanced μcircuitry Tech.
174	Saleable μlogic Hardware

*New projects assigned-effective 7/7/61.

OTHER PROJECTS

Assigned Job Nos.	Job Title
161	Analytical Technique Dev.
165	Competitor Device Eval.

APPLICATIONS ENGINEERING

193	Factory Specification Engineering
194	Circuit Development
195	Application Reliability
196	Customer Applications
197	Micrologic Applications
178	Ferromagnetic films.

Revised 7/8/61

JOB No. TITLE PAGE

(TRANSISTORS + DIODES)

108 7000 Series Development
7/7/61 - Project Review - p. 2
12/8/61 - Review - p. 80-81

143 1000 Series Development
7/11/61 - Project Rev. - p. 12-13

144 1500 Series Development
7/7/61 - Project Rev. p. 2-3

136 2000 Series Development
7/7/61 - Project Review - p 2

145 4000 Series Development
7/10/61 - Proj Review - p 4-5

146 4500 Series Development
7/10/61 - Project Review - p. 3
12/6/61 - Review, p. 77-78

147 6000 Series Development
Not Reviewed

148 Diode Development
7/10/61 - Project Review, p. 6-7-89
9/8/61 - Reviewed - p. 50-51

106 Controlled Rectifiers
2/6/62 Proj Rev. p. 119
3/21/62 " " p. 135

Job No. Title Page No.

(TRANSISTORS & DIODES - CONT'D.)

171 Zener Diode Development
12/14/61 Project Review - p. 82-83
1/29/62 Proj Rev. - p. 111, 112

169 Multiple Diode Development
Not Reviewed

(IMPROVEMENT OF STANDARD TECHNIQUES)

109 Diffusion Technology Development
9/27/61 - Project Review - p. 55
10/9/61 - Review Continued - p. 59

126 Masking Techniques Development
7/20/61 - Project Review - p. 22-23
7/27/61 - Review Continued p. 32, 33, 34
2/6/62 - Proj Rev p. 121

160 Packaging Techniques Development
8/4/61 - Project Review - p. 40, 41, 42, 43
11/17/61 - Review - p. 70
3/23/62 Review p. 136, 137

166 Contact Techniques Development
8/2/61 - Project Review - p. 37

Job No. Title

(Piezoresistor Development)

140 Strain Gauge Element
7/17/61 - Project Review - p. 19
12/21/61 Review - p. 94-94A.

(New techniques & material)

110 Glass & Ceramics Development
9/20/61 - Project Review - p. 53
11/8/61 - Review - p. 65

113 New Materials Prep. & Evaluation
Not Reviewed

133 Electrochem. Techniques Development
~~Not Reviewed~~
2/7/62 Proj review p. 122

141 Microwave Physics
8/1/61 - Project Review - p. 35-36

158 Gallium Arsenide Exploratory Device & Techniques
~~Not Reviewed~~ See bottom of pp 63
1/10/62 Proj Rev - p. 99-100

159 Surface Coating Development
Not Reviewed

162 Semiconductor Film Growth
7/14, 7/19 Project Review 17,18,20 3/20/62 Proj Rev - p. 133
10/16 - Split of effort in [illegible] View 60
12/13/61 - Review of status of Si work 85,86,87

168 Surface Protection Evaluation
Not Reviewed

JOB NO. TITLE PAGE NO.

(MISC. DEVICE DEVELOPMENT)

117 Exploratory Device Research

7/25/61 - Project Review - p.25

121 Data Storage Devices

7/25/61 - Project Review p.29-30

142 S.C.T. Device

7/6/61 - Project Review - p.1

10/4/61 - Summary Review - p.57

11/15/61 - Review - p.68, 69

1/9/62 Proj Rev, p.98-101

2/27/62 " p.124

150 Tunnel Diode Development

7/19/61 - Project Review - p.21

170 Photo Transistor Development

7/21/61 - Project Review - p.24-25

2/6/62 " " p. 120-123

4/24/62 " " p. 139

179 Exploratory Photo Sensitive Device

7/21/61 - Project Review - p.25

189 Field Effect Transistors

7/12/61 - Project Review - p.14, 15, 16

9/19/61 - Rereview - p.52

12/13/61 - Review & Proj. Plan - p.88, 88A, 89

1/8/62 Proj Rev. p.97

Job No. Title Page No

(SUPPORTING RESEARCH)

114 Species Diffusion Research
8/10/61 Project Review - p. 44, 45, 46
1/18/62 " " p. 105, 107

115 Noise Research
8/21/61 - Project Review - p. 49
1/20/62 - " " p. 106

116 Basic Alloying Studies
8/2/61 Project Review - p. 37, 38

119 Surface Research
7/24/61 Project Review - p. 26, 27, 28

120 Silicon Material Research
Not Reviewed

163 Pipes & Related Phenomena
8/10/61 - Project Review, p. 44, 45, 46

164 Misc. Exploratory Research
Not Reviewed

173 Etching Studies
12/22/61 - Project Reviewed - p. 95

(MICROCIRCUITRY)

152 Micrologic Product Development
7/11/61 - Project Review - p. 10, 11
Job 153 - cancelled - see p. 61-62 - for Proj. Review

172 Advanced μcircuitry Technology
~~Not Reviewed~~ 1/31/62 Proj Rev p. 115, 116
2 Proj Review p. 113-115

174 Saleable μlogic Hardware
Not Reviewed

175 Microcircuitry Product Development
1/29/62 Proj Rev. p. 109, 110

105 - Oxidation Studies
1/18/62 - Proj. Rev. p. 104

Job No. | Title | Page No.

(OTHER PROJECTS)

161 Analytical Techniques Development

7/25/61 - Project Review - p. 31

165 Competitor Device Evaluation

8/3/61 - Project Review - p. 69

(APPLICATIONS ENGINEERING)

~~193 Factory Specification Engineering~~

~~194 Circuit Development~~ Cancelled

~~195 Application Reliability~~

~~196 Customer Applications~~

~~197 Micrologic Applications~~

(NEW AREAS)

177 <u>Thin Film Tunnel Devices</u>

3/19/62 Proj Rev p. 131, 132

178 <u>Magnetic Film Studies</u>

1/17/62 Proj Rev. p. 103

2/2/62

COMPANY PRIVATE

ROUGH DRAFT

PROJECT PLAN FOR PROJECT 170

Photodevice Development

Project Leader:..........E. C. Biegel..........

Approved Section Head:.........................

Approved Directors Office:.....................

PROJECT OBJECTIVE:

The development of new photodevices, the evaluation and product design necessary for transferring the devices to a manufacturing facility, and the support of manufacturing and marketing activities. This project consists of five main tasks at this time.

Task 1. Development of the XP-3 family of photodevices
Task 2. Development of photodiode arrays
Task 3. Development of light emmiting devices
Task 4. Investigation and development of special photodevices
~~Task 5. Support of manufacturing and marketing activities~~

TASK 1. DEVELOPMENT OF XP-3 FAMILY OF DEVICES

Task Objective: The development of a photodiode and phototransistor that can be manufactured for a prime cost of 10 cents maximum. The devices to be mounted in plastic and/or glass packages. The physical size of the package to be such that the device can be used to read an IBM card in parallel.

Principal Problems:

1) Development of lead attaching methods. Primary methods under consideration:
    a) High temperature die attach
    b) Tin die attach
2) Development of a plastic encapsulation method
3) Development of a glass encapsulation method
4) Diffusing devices with uniform photoresponse characteristics
5) Dicing of devices to tolerance required
6) Evaluation of devices with and without package

Schedule: Please see Appendix A.

TASK 2. DEVELOPMENT OF PHOTODIODE ARRAYS

Task Objective: The development of high density photodiode arrays for use in electrostatic printing and other applications. The devices should have breakdown voltages of approximately 500 volts.

Principal Problems:

1) The obtaining of the yield required. The main problems seem to arise in the photoresist and diffusion operation.
2) Slicing of the wafers into strips. Present equipment is inadequate, and new equipment should be developed.
3) Packaging of the arrays. Two methods are being investigated.
   a) This method consists of fabricating the devices on a silicon bar which will be a self-contained unit. The problems with this method are:

      Photoresist: Development of techniques for bringing a contact from the device around a corner of the bar to give a rubbing-type contact to the read out dielectric.

      Plating: The contact to the paper requires a hard surface to withstand wear. Rhodium will probably be used.

      Bar Fabrication: Techniques have to be developed to fabricate the bars in the shape required.
   b) This method consists of fabricating the devices on regular wafers and thenattaching the arrays to a bar of silicon (or other material) to make the electrical contact to the dielectric. The problems with this method are basicly the same as with method a) above. This method has the additional problem of requiring that electric connections must be made between the arrays and the bar. This connection will require the development of new techniques because conventional lead bonding would be too expensive except for developmental samples. This method has the advantage that the arrays can be built on standard wafers and the material used in the bar does not have to be high grade silicon.

Schedule: Please see Appendix B.

TASK 3. DEVELOPMENT OF LIGHT-EMMITING DEVICES

Task Objective: The development of high speed light-emitting devices with maximum light output and efficiency.

Principal Problems:

1) Evaluation of FT 6200 (FSP-102 & 103) light pulser
2) Fabrication and evaluation of FT 7000 for light pulser application
3) Development of measurement techniques. (Project No. 179)
4) Issue Technical Report on light pulsers

Schedule: Please see Appendix C.

TASK 4. INVESTIGATION AND DEVELOPMENT OF SPECIAL PHOTODEVICES

Task Objective: This task consists of development of photodevices for special application and investigation of the various Fairchild techniques and products as photodevices.

Work performed on this task is not scheduled in a formal manner. Most of the work is performed on a time available basis or depends on the time requirements of other projects. Items being covered by this task are as follows:

Intr Win, 4/1 1) XPT-2 Darlington phototransistor
only if application in line 2) Planar lateral photodevice
limbo 3) Photochoppers with associated electronic circuits
when needed 4) Special phototransistor array for data storage project
as time available 5) Special scanner photodiode for Sam Levine
   Problem: Hole in silicon wafer without developing cracks.
      Fabricating.

TASK 5. SUPPORT OF MANUFACTURING AND MARKETING ACTIVITIES

Task Objective: Assist other activities as required to manufacture and obtain sufficient information to specify and market the devices.

Project Plan for Project 170

This task consists of performing special tests required by other activities; it also includes answering customer inquiries, customer contact, training of application engineering personnel on the properties of photodevice and testing methods, and obtaining information for preparation and registration of devices.

PERSONNEL:

Name	Job Title	Estimated Percentage of Time	For Estimated Number of Months	Estimated Number of Hours
E. Biegel	Sr. Engineer	40%	6	400
P. Ullman	Sr. Engineer	80%	6	800
W. Wheeler	Research Assoc.	70%	6	700
O. Littrell	Sr. Laboratory Technician	80%	6	800
F. Rittiman	Lab. Technician	80%	6	800
Research Associate (to be hired)		25%	4	160
Electro-Mechanical Engineer (to be hired)		50%	4	320

EQUIPMENT NEEDS:

1 single bell jar evaporation system; approximately $5000; required approximately 1 June 1962

1 dice scriber for pilot line

2 dice probes with microscope; approximately 600

1 Tektronix square wave generator; approximately 400

APPENDIX A

PROJECT SCHEDULE

PROJECT No. 170 PRODUCT No. XP-3 FAMILY DATE 1-23-62 SHEET 1 OF 1

ITEM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
1. 50 Transistors mounted on headers per prel. spec.						
2. 1000 Transistor dice for Lead attach and encapsulation		(slipped - product problem)				
3. Lead attach and encap. 75 units each method.		1st Comp Comp				
4. Evaluate 50 units mounted in item 1.						
5. Evaluate 50 units of each group of item 3.		1ST COMP	COMP			
omit 6. Run of XP3 on Epitaxial material and evaluate 50 units on headers			FAB COMP EVOL COMP			
7. Prepare 900 dice using 2 lead trans. alt. optional unless necessary	(Only if new die needed)		1ST Comp COMP			
8. Prepare 900 dice using 2 lead diode with alt. config. if reqd			1ST Comp COMP			
9. Prepare 600 dice using 3 lead transistor conf. with alt. config if reqd			1ST Comp COMP			
10. Evaluate items produced in 7,8,9 as reqd. (50 units each group)			1ST COMP	COMP		
11. Dice Decision						
12. New Mask Stepped				X		
13. Envorimential testing and product evaluation.						
14. Pkg. and Mtd. decision					X	
15. 4 Prototpye runs of transistor config.					1ST COMP 2ND COMP	3RD COMP 4TH COMP
16. Evaluate 50 units of each run item 15.					1ST COMP 2ND COMP	3RD COMP 4TH COMP
17. Complete tent. spec. from XPT-3						X
18. 4 Prototype runs of diode config.					1ST COMP 2ND COMP	3RD COMP 4TH COMP
19. Evaluate 50 units of each run item 18.					1ST COMP 2ND COMP	3RD COMP 4TH COMP
20. Complete tent.spec. of XPD-3						X
21. Tooling discussion and spec. eval. of tooling.		TOOLING DISCUSSIONS WITH PROD			PROTOTYPE TOOLING EVALUATION 1SET FOR R+D	
22. Product transfer of XPT-3 and XPD-3						X
23. Procure and evaluate prototype mounting boards					DESIGN COMP	MASK COMP ITEMS COMP EVOL COMP

APPENDIX B

PROJECT SCHEDULE

PROJECT No. 170 PRODUCT No. XDA-1 and 1R DATE 1 February 1962 SHEET 1 OF 1

ITEM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
1. Development of diode arrays on wafers	←	—	—	—	—	→
2. Development of diode array mounting bar	←	—	—	—	—	→
3. Complete first prototype mounting bar			X			
4. Complete first working diode array on mounting bar			X			
5. Fabricate diode array in silicon bar- a. fabrication of diodes	←	→|				
b. contact techniques		|←	→|			
6. Tranfer operating array to project 190				X		
7. Have new mask stepped for diode array-regular				X		
8. Investigate shunt writing strip requirements			←	→		
9. Have mask stepped for shunt writing arrays					X	
10. Development of diode arrays for shunt writing					|←	→
11. Fabricate mounting board for shunt writing diode array						←→
12. Complete first working diode array for shunt writing.						X
13. Transfer shunt writing array to project 190						X
14. Development of diode arrays approx. 30% complete						X

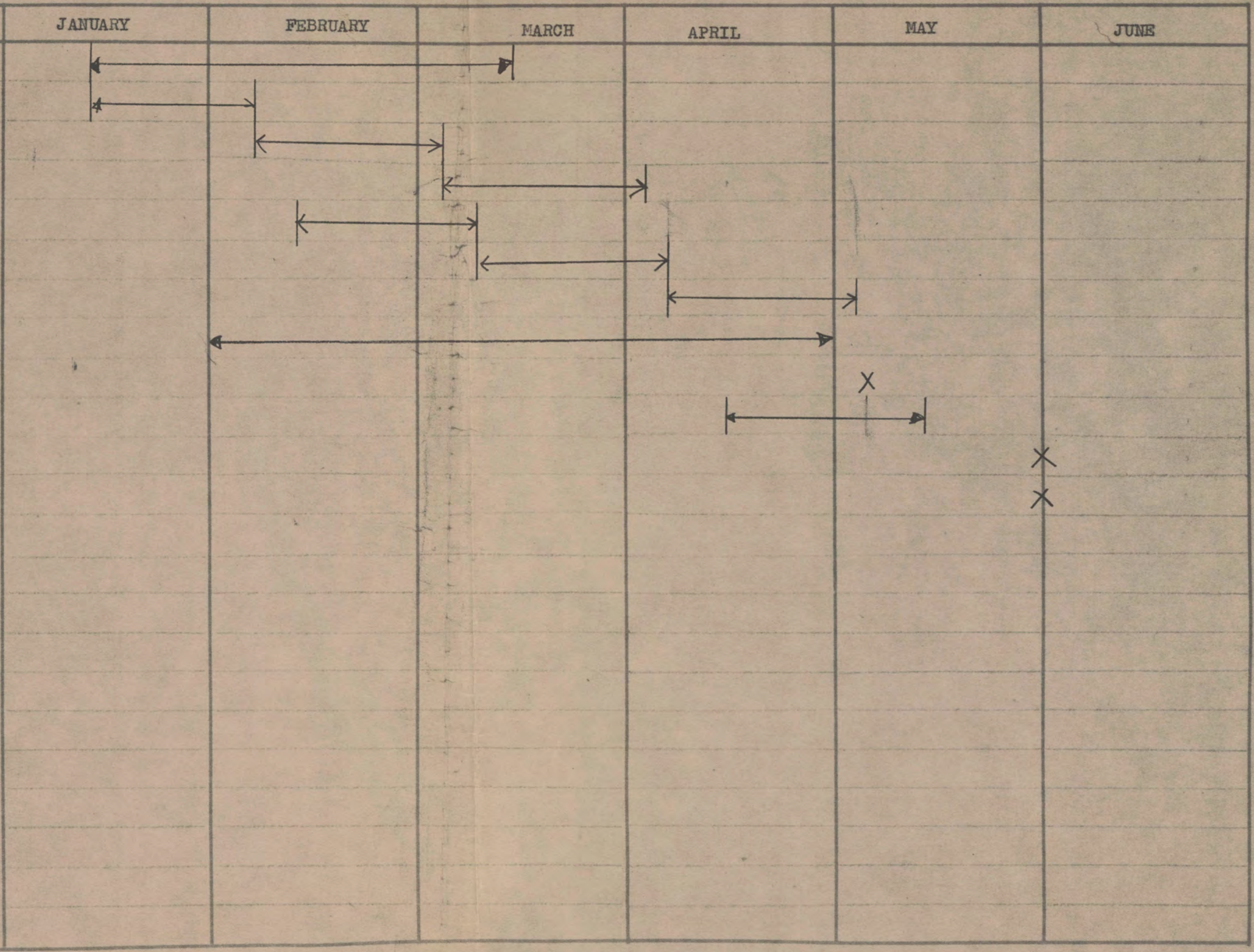
APPENDIX C

PROJECT SCHEDULE

PROJECT No. 170
PRODUCT No. XLP-3
DATE 1 February 1962 SHEET 1 OF 1

ITEM

1. CHARACTERIZE FLP-1
2. Fabricate light pulsers using FT7000 masks
3. Fabricate light pulser diodes using P-material
4. Fabricate light pulser diodes using N-material
5. Evaluate Light Pulser of item 2
6. Evaluate Light Pulser of item 3
7. Evaluate Light Pulser of item 4
8. Package investigation ~~of~~ for XLP-3
9. Decision on configuration for XLP-3
10. Enviorimental testing of XLP-3
11. Data Sheet Release for XLP-3
12. Manufacturing process specification release.



Project Review Schedule for week of Jan 29 - Feb 2

Need immediate review.

✓175 Microelectronic product devlpmt
✓171 Zener diodes
✓106 Controlled Rectifiers
✓172 Advanced µ circuitry technology
✓146 4800 Semi

Ready for review

143
144
145
~~146~~
169
107
126
160
166
133

141
121
170
179
116 (?)
119
161
177

No rush

110
113(?)
165

Recently done

140
173
189
142
158
178
109, 114, 163
115
102
105

COMPANY PRIVATE

RESEARCH & DEVELOPMENT PROJECTS LIST

TRANSISTOR & DIODE:

	Job. No.	Job Title
	106	Controlled Rectifiers
	107	7500 Series Dev.
12/8	108	Power Trans. Dev.
	143	1000 Series Dev.
	144	1500 Series Dev.
cancel 2/5	136	2000 Series Dev.
	145	4000 Series Dev.
12/6; 2/1	146	4500 Series Dev.
cancel 2/5	147	6000 Series Dev.
	148	Diode Development
	169	Multiple Diode Dev.
12/14; 1/29	171	Zener Diode Dev.

IMPROVEMENT OF STANDARD TECHNIQUES

1/18	109	Diffusion Tech. Dev.
	126	Masking Tech. Dev.
	160	Packaging Tech. Dev.
	166	Contact Tech. Dev.

PIEZORESISTOR DEVELOP.

12/21	140	Strain Gauge Element

NEW TECHNIQUES & MATERIAL

	110	Glass & Ceramic Dev.
	113	New Materials Prep & Eval
	133	Electrochem. Tech. Dev.
	141	Microwave Physics
1/10	158	Gallium Arsenide Exploratory Device & Techniques
cancel ? 2/5	159	Surface Coating Dev.
12/13	162	Semiconductor Film Growth
cancel 2/5	168	Surface Protection Eval.

MISC. DEVICE DEVELOP.

	117	Exploratory Dev. Research
	121	Data Storage Devices
1/9, 1/16	142	S. C. T. Device
	150	Tunnel Diode Dev.
	170	Photo Transistor Dev.
12/13; 1/8	189	Field Effect Transistors
	179	Explor. Photo Sensitive Dev.
	190	Experimental Hardcopy Dev.

SUPPORTING RESEARCH

Job No.	Job Title	
105	Oxidation Studies	
114	Special Diffusion Research	1/18
115	Noise Research	1/20
116	Basic Alloying Studies	
119	Surface Research	
120	Silicon Material Research	
163	Pipes & Related Phenomena	1/18
164	Misc. Exploratory Research	
173	Etching Studies	12/22

MICROCIRCUITRY

152	Micrologic Product Dev.	
172	Advanced μcircuitry Tech.	1/30
174	Saleable μlogic Hardware	
175	μelectronics Prod. Dev.	1/29

OTHER PROJECTS

161	Analytical Technique Dev.
165	Competitor Device Eval.
167	Special Fairchild Controls Dev.
176	Prep. of Proposals for Government Contracts

NEW AREAS

177	Thin Film Tunnel Devices	
178	Magnetic Film Studies	1/17

COMPANY PRIVATE

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