Swiss Engineers in Early Silicon Valley I Knew: Lessons for Strategic Management of a Fast New Growing Technology Domain

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Author Bio

Dr. Luc-Olivier Bauer (July 6, 1938) was born in Neuchâtel, Switzerland. After scientific studies (BS Physics, EPFL, Switzerland, '63, MS & PhD Engineering Science, Caltech 1964 & 1968), he started his semiconductor career with the Hughes Research Labs (HRL), in Newport Beach, California, starting with the ion implantation group in the fall of 1968. Key processes worked on there were p-well, threshold shifts for CMOS metal and Si gate.

He then joined Intersil/Eursosil in 1972 to become wafer fab manager of Eurosil, Munich, Germany. Dr. Bauer rose through the ranks to become president of Eurosil in 1978. He came back to California in the beginning of the 1980s, and again was involved in high volume (for the time) front-end manufacturing of CMOS Si gate SRAMs at IDT, multi-chip modules at nCHP/Flextronics, in the late 1980s, and LCoS devices for rear-projection TVs at sVision/Hana Microdisplay Technologies in the 1990s. From the early 2000s until now, Dr. Bauer has been a member of the Nanodimension team, a Swiss-Californian VC firm, investing in Life Science and Physical Science high technology companies in the US and Europe.

Introduction

To put these impressions in perspective, I started my career in semiconductors in 68 when I was 30, Fairchild was founded in 57 by people who were also in their 30's, so on average I am 10 years younger than they were: a pretty big difference at that age. However in this dynamic environment, contacts with top managers who were just 40, or so, were really easy, so I still managed to know to various degrees at least 4 of the "traitorous" 8 (Julius Blank, Victor Grinich, Jean Hoerni, Eugene Kleiner, Jay Last, Gordon Moore, Robert Noyce, Sheldon Roberts) as Shockley (inventor of the transistor together with Bardeen and Brattain) called them when they left Shockley Labs to create Fairchild: specifically: Jean Hoerni, Eugene Kleiner, Jay Last and Gordon Moore, so I could benefit greatly from interactions with these pioneers.
This industry growth has been phenomenal, but it was never smooth, even if always exciting, and it has gone through major upheavals even in the best managed companies. A lot of the painful and difficult choices made then, will also have to be made for the new companies venture capital is funding, so there are lessons to be applied from that historical period.

So the focus of this short memorandum, is to review the trends of the semiconductor industry management methods and important decisions over the first 35 years of the industry's history, what worked and what did not. Some effort was spent ensuring the accuracy of the facts mentioned, but I could still have made some mistakes, and I am sure I missed some most interesting facts and stories. I relied on my personal experiences but also on numerous authors whose contributions I am glad to acknowledge here.

There were few Swiss engineers and scientists that participated in the Silicon Valley adventure, but I knew the most famous one: Jean A. Hoerni well, having worked with him, off and on, for more than 12 years.

1957-1967 the glorious years of Fairchild

The company assembled the best and brightest scientists and engineers that had been carefully selected by Shockley. Many of the original team and those who joined them shortly after the founding of Fairchild went on to create the companies that would become the backbone of the US semiconductor industry and effectively launched the industry worldwide as Japanese companies quickly understood the significance of this new industry.

Creation of the industry infrastructure

A lot of energy was spent on creating the basic tools the industry needed to develop and then eventually manufacture the technology. All equipment was developed as needed, think: mask aligners, diffusion, oxidation, annealing tubes, and the basic processes to go with it: photoresists exposure, developing and bakes, etches of silicon oxides, silicon, etc. all that needed to be invented and developed inside Fairchild. Similarly, on the product design side, few software tools existed, and if they did exist, would be using cumbersome BASIC software running on IBM mainframes. The physical layout of transistors and early ICs was 100% manual, and would stay so for more than 10 years. The layout would be drawn by hand, on large tables 100 cm x 200 cm, for each mask of the process (8-10 masks at most at that time). A plastic composite of a dark red layer (rubylith) would be peeled from the underlying transparent plastic. A large reducing camera (200 x) would reduce the smallest features of the rubylith that could be drawn manually: from 2 mm to 10um. As can be guessed, those early processes, whether on the manufacturing or design side, were very manual and fraught with errors. Fairchild was instrumental in creating and continuously increasing the productivity and reliability of all of these tasks and in the process helping to launch new companies to serve all aspects of the semiconductor development and manufacturing tool requirements.

Creation of the basic semiconductor process architectures

One should not forget that in 1957, besides a few groups at Texas Instruments (TI), the dominant semiconductor material was Germanium (Ge) and not Si! The founders of Fairchild were convinced like TI, that Si was the right material. Even if holes and electron mobilities are higher in Ge, the semiconductor bandgap of only 0.67eV of Ge vs 1.12ev in Si, means that at temperature > 75°C Ge stops being a pure semiconductor to become a metal, so Ge can barely accommodate the consumer temperature range of 0°C to 70°C, cannot satisfy the industrial temperature range of -40°C to + 85°C, and certainly not the military with its range of -55°C to + 125°C!

In 1959 Jean A. Hoerni, one of the Fairchild founders made the really fundamental “planar” process discovery. Instead of diffusing the whole silicon surface with dopant and then etch mesa diodes or transistors off the bulk silicon, Jean had the idea to grow oxide on the silicon, open windows in the oxide where you wanted the diffusion to happen, and then diffuse dopants into the silicon only where the windows had been etched, the rest of the oxide on the wafer providing a mask against the dopant. The great advantage being that if the wafer was, say, p-type and the diffusion dopant being n-type, during the diffusion cycle, the dopant would move away from the edge window, and deeper so that the p-n junction would always be below the oxide and hence well passivated and protected from surface impurities and thus have very good electrical leakage characteristics. It was also clear that photolithography combined with oxide window etching and diffusion was a fantastic tool to increase the density of active elements: diode, transistors, resistors per cm2 of the wafer surface.

Jean was born on September 26th, 1924 in Geneva, Switzerland, after a BS in Mathematics at the University of Geneva, he got 2 PhDs in physics, one from the University of Geneva, and one from the University of Cambridge. He then took a postdoc position at Caltech in 1952 where he met William Shockley one of the three people awarded the future 1956 Nobel prize for their invention of the transistor. Shockley then recruited Jean to join the Shockley Labs in Mountain View, California.

Very shortly after they were hired, a bright and ambitious group of scientists left the Shockley Labs, and formed Fairchild in 1957. This must have been something of a shock to the engineering community, imagine these guys having had the luck to be hired as fresh PhDs by a Nobel prize winner to participate in the exciting new field of electronics, deciding to quit, one year after they started, because they thought they had a better idea!! Very unusual at the time, but I am not surprised, knowing the intensity, the independence, the intelligence, fierce dedication to the development of their new industry, of at least four of the eight: Jean, Eugene Kleiner, Jay Last and Gordon Moore, whom I knew.

Creation of new processes and products

Having chosen the new Si material led the path to equipment infrastructure and the revolutionary planar process to be used by all semiconductor technologies, Fairchild then developed the specific semiconductor processes used for its product revenue generators: bipolar digital, bipolar linear, NMOS, NMOS Si gate, CMOS metal gate.
The products started with individual diodes, transistors, and then digital ICs: DTL and RTL logic circuits, and the first linear ICs: Robert Widlar's uA702 (1964), and David Fullagar's uA741, the most popular IC op amp of all time.

Another Swiss engineer played an important role in developing a leading product of Fairchild: the TTL product family: Heinz W. Ruegg. He followed the path several of us took, by first going to Caltech in 1960, he then joined Fairchild in 1961, where he stayed until 1967, when he returned to start Faselec in Zürich which incorporated the already existing transistor fab of Philips (info from Hugo Wyss and Lucien Trüb). I met Heinz in the late 70s as CEO of Eurosil, when Eurosil was dominating the quartz clock business in the Black Forest, and Faselec was a tough competitor for the Swiss quartz watch business.

Problems and explosion of Fairchild, exit of the eight founders

Some of the same causes, which blew up Shockley Labs, eventually produced the same results at Fairchild.
The overall industry had grown from $100M revenue in 1957 to $1B in 1964. The sales of the Fairchild semiconductor division had doubled every year and by the mid-60s accounted for 2/3 of total sales of the parent company.
The 8 founders of Fairchild were obviously aware of the tremendous progress they had made in 10 years, and felt that their contributions were not sufficiently being recognized.
Finally, the semiconductor division, situated in Mountain View and Palo Alto, California, was actually managed by executives from Syosset, NY, who visited California once a year, even though the semiconductor division earned most of the profits of the company!

This time, it is not an exit “en masse”, the most driven Fairchild founders feel they want to control their destiny and start their own company!

Jean Hoerni, Jay Last, and Sheldon Roberts are the first to leave in 1961 to found Amelco (Teledyne), and then Jean founded Union Carbide Electronics in 1964 with John Hall and Robert Freund, and then in 1967 Intersil, with $300k of his own money, $4.5M from Arthur Rock and Fred Adler, the legendary VCs, and from corporations: Olivetti, Omega Watch, Portescap: the Swiss connection! The first Intersil building was on 10900 N. Tantau Avenue, Cupertino.

In 1968, Robert Noyce and Gordon Moore started Intel a year after Jean Hoerni started Intersil with money from Arthur Rock *and what is not well known with $300k from Jean. Jean told me that none of the companies he founded brought him even a small fraction of return compared to what he earned from this seed money in Intel in 1968, he would at the same time easily acknowledge that while Moore, Noyce and Andrew Grove might have been less creative than he was they were much better managers than he had ever been!!*

The last of the eight founders to leave Fairchild in 1969 was Julius Blank.
The additional launch of AMD in 1969, AMI in 1966, NSC in 1959, PMI in 1968, Signetics in 1961, further weakened Fairchild by draining the next tier of experienced managers.

1957 to 1967

This time span covered my university education: accepted at the EPFL-CMS in 1957, then accepted in the EPFL physics dept in 1958, became a diplome engineer in 1963, accepted at Caltech in 1963, MS and PhD in Engineering Science in 1964 and 1968. The only distractions on my blissful ignorance of the electronic world were a 6 months course by Prof R. Dessoulavy on vacuum tubes and a 3 months introduction to transistors in 1962, followed by a solid course at Caltech by Prof Middlebrook on bipolar transistors physics in 1964, nothing on MOS!!. I did dabble in building high power RF amplifiers to light up the gaseous plasma, for microwave plasma diagnostics, the subject of my thesis. Basically until 1968, I was completely unware of the drama and excitement of the start of Silicon Valley! Interesting bit of coincidence, Prof Demetri Psaltis of the EPFL had Prof. Roy W. Gould as his supervisor while at Caltech, who had been my thesis supervisor.

The wild expansion years 1968-1974

This was a pretty unique time in technology development history where a few hundred people mostly in their thirties and early forties spread over a dozen freshly started companies completely controlled a very fast growing industry with almost no competition worldwide, except from each other!

Each of the new companies, including and especially Intersil, had an absolutely bewildering proliferation of technologies usually run in the same fab. At Intersil, from the single FET business of Bruce Kerr, to PMOS and NMOS Si gate, MOS EPROM, CMOS metal gate of Marshall Wilder, linear bipolar, and digital gold doped bipolar of the Intersil Memory division started by Marshall Cox and Joe Rizzi, without mentioning the guys doing exotic process like dielectric isolation, etc.

To speed up sales and increase company valuation the BoDs did not hesitate to bring groups from other companies, who often brought with them note books, process sheets, even mask sets to speed up the product development and sales generated from them. Let us say, IP, for a few years was not a great concern. Everybody felt they had generated ideas by themselves, and were just carrying them in their heads when walking from one company to the next.

Each of these special technologies would constitute individual groups, in the company, who would then all claim for the company resources, leading to chaotic direction and evolution of most companies, except for a few.

There was no incentive to streamline or focus, as there would always be some customers around, if you had anything working that you could deliver in some quantity with a minimum of reliability data.

Obviously the operational production quality and discipline was low in these fabs which were running multiples processes, completely manually: no ERP, no SPC, etc. As a visiting future Eurosil wafer fab manager, residing for 18 months at Intersil, starting in July 72, I was often consulted on strange end test electrical probing results: more often than not, wafers had been started in one technology, say linear bipolar but the top layers were CMOS metal gates, etc!!
There was hope in the chaos, in that you could always have lunch in local restaurants, and quiz your competitors about your most recent problems, he would give you a bit of information if you gave him some too: a huge competitive advantage of the Silicon Valley in the beginning years.

<u>The other real heroes of the time were the visionary customers</u> who would flock around the various companies from the US, Europe, and Asia, trying to convince managers and engineers to work on their products, to propose new contracts for new and old designs. They were often instrumental in teaching the basic requirements a semiconductor device would need in their industry, to the silicon guys who had more technology processing skills than real product engineering skills which would develop much later.

The customers had to be patient: the delivery dates were often not respected, the specs rewritten to fit what we could make, etc, etc. But the customers had no choice, California was completely dominating the new semiconductor technology area.

All markets were attacked by most companies: military, industrial and consumer. In the beginning of the ‘70s many attempted to make complete consumer products like digital LCD or LED watches. Even the most disciplined and well run of them all: Intel, also yielded to the fad and bought a LCD watch company Microma in 1972, to close it down in 1974, recognizing that Intel had no business and no skills in the consumer space, at least at that time, as Andrew Grove told me when he visited the Eurosil fab in 1974, in Munich.

<u>Human experience</u>: It was the exhilarating experience to be part of something growing fast and big, to report to legends, figures bigger than life, who were willing to give you much more responsibility than you ever had before, who could yell at you for any mistake, but would also show you the way, they taught you to be like them demanding on themselves and others. The hours were long, but parties frequent, relationships between men and women employees extremely relaxed. Life was fun!! When you woke-up in the morning you rushed to discover the new exciting day! The only cloud on this ideal picture for the young participants of this new industry was the severe society disruptions caused by the Vietnam war!

1968 to 1974
Hughes Research Labs
Newport Beach, California

Robert W. Bower, a researcher at the Hughes Research Lab (HRL) was named department manager in the Newport Beach Research Labs facility and was mandated, together with section head Hans G. Dill, to create an engineering group. Their task was to evaluate the possibility of using ion implantation as a semiconductor doping tool in the rapidly expanding MOS processes, in particular CMOS. I was one of six freshly graduated PhDs hired by Bob. The interview process for me was 2 hours of grilling on the subject of my thesis in plasma physics at the beautiful Malibu HRL facility, followed by a character and stamina test of sailing for 3 hrs on his Cal 25’ sailboat in really rough winds around the Long Beach Harbor, so I passed!

The six of us, all starting around Sept 1st, 1968, got as our first assignment reading A.S Grove's famous "Physics and Technology of Semiconductor Devices, Wiley, Feb 67, book, first and foremost. We were coming from various great schools, but none of them had taught anything substantial on semiconductors, at least fitting the state of the art of industry. So we spent a month of book learning before going into the lab and getting paid for it!

Bob was 32 when he hired us, a super dynamic, wild personality. The high point of his career was the work with Hans G. Dill leading to the paper by Dill and Bower at the 1966 IEDM conference in Washington DC and his patent # 3,472,712 covering the principle of using the gate (metal or Si) as a mask, to create self-aligned MOS transistors whose source and drain regions by created via ion implantation.

Because of my specific plasma knowledge, I was put in charge of the primitive ion implantation system, just a basic 200kV accelerator with a magnet driven mass separator and wafer loading target system. The task was to find appropriate gases to generate plasma in the ion source from which we could extract high enough current density for the doping species of interest: Boron, Phosphorous, Arsenic, etc.

Using Hughes CMOS "production" wafers (1.25" diameter, and 0.4mil" or 10um min CD!!) we could quickly show that all ion implantation processes such as threshold shifts and p-well doping were very accurate, for the simple reason that we were measuring the current generated by the desired implant species, and assuming the ions were singly charged, after a time x of implantation, you knew that the z amount of doping was going to be embedded in the silicon with the few % accuracy, precision needed to achieve the CMOS threshold values and reproducibility needed by the quartz watch and clock applications.

There were a few ancillary questions on the damage caused by the ion implantation to the silicon, and the anneal temperature required to activate 100% of the ions implanted but these questions were rapidly solved, and the Hughes Aircraft Company production organization started to produce a large number of watch ICs for many watch producers, but specially Timex.
In parallel the people in what had become my group started to publish papers on our progress. This quickly had an unanticipated consequence for the Hughes Research Labs organization, in that we quickly lost several ion implantation CMOS specialists to Silicon Valley companies.

Bob was my first mentor, not only in ion implantation but also in how to body surf at the Wedge on Newport Beach pier, and how to sail to Catalina island for a week-end from Newport Beach, when on the way we would often cross the path of whales migrating to Baja California. He decided to leave the HRL because of a power struggle at the division head level, and went back to Caltech to get his PhD. It was a big let-down, and Hans Dill, my new boss while a great person, was not as much fun!

Intersil/Eurosil
Cupertino California
By early 1972, I clearly realized the action was in Silicon Valley and so I started to think about how to get there. At the same time Jean A. Hoerni, always in search of new capital, probably met my father who was head of the Swiss Watch Federation -- a quality, marketing organization of the largest Swiss watch companies -- and Jean discovered that there was this young Swiss ion implantation CMOS specialist at HRL. Since nobody in Silicon Valley knew anything about ion implantation, I was quickly contacted by Jean.

Since the beginning of 1970, Jean had been very busy in strengthening Intersil, in Operations by bringing Roger Smullen and Ken Moyle from National Semiconductor; in Products by bringing in Marshall Cox and Joe Rizzi to launch Intersil Memory ; in General Management by bringing in James Riley from Signetics to succeed himself as president of Intersil. So feeling he had achieved his most important Intersil goals, Jean turned to his Eurosil project, financed in great part by Swiss watch companies which saw with interest the project to build a fab in Europe, in Munich, not far from the Swiss watch manufacturing centers.

In our first meeting, after a few hours of discussion, Jean proposed to me to become the Eurosil fab manager. The fab construction was being planned already, and I received a budget of $1.5M to buy equipment for a 5,000 wafers start per month (2" diameter, 0.3mil" or 7.5um min CD). I was also responsible to define and specify the CMOS metal gate processes to make watch and clock circuits for our potential European customers. I received a 50% increase in salary and a stock option grant, I had no idea how to evaluate, so I did not know how to negotiate it. (It did turn out to become about 3 years salary worth, so Jean did not take too much advantage of my inexperience!!) The trust shown and responsibility which were becoming mine, the fact I already liked Munich, made my decision to accept very easy, and so it started my relationship with Jean for more than 12 years.

My first day at Intersil, 10,900 N. Tantau Avenue, Cupertino, departed markedly from the conservative environment of HRL (except for R.W. Bower). A young lady from HR in a very short miniskirt introduced me to my office and desk, and then proceeded to jump on top of the desk, and following a little impromptu dance on my future desk, asked me if I liked her!!?? I could see things were going to be different!!

The 18 months stay at Intersil went quickly, visiting fab equipment vendors, talking to experienced Intersil fab managers about their equipment and process experience, writing up process specifications for the future Eurosil fab, combining Intersil processes and some of what I had learned at HRL, I was helped in this task by the senior ex-NSC fab supervisor Thelma Kamuchey, and a senior operator also coming from NSC who joined the Eurosil group. We were also in charge of processing the new Eurosil designs for European customers made by the Eurosil design group already located in Munich.

Since our small group depended on the good will of Intersil fab managers and engineers, we went out of our way to help them solve their engineering problems whenever we could.
We could already see that having only two basic CMOS metal gate processes, one for low power 32 kHz IC for watches, and one for 4 Mhz IC for clocks, our process development efforts for higher product performance and yield would be so much simpler, than the more or less controlled chaos of Intersil fabs with its multiple technologies. In mid '73, the Eurosil group arrived in Munich to start its work.

1974-1984
The rise of worldwide competition- Product engineers, products marketers, strategic marketing take over key management positions from technologists

The euphoric years of the previous period faded away pretty quickly as investments in wafer fabs to stay competitive increased rapidly and the sales volumes increased dramatically. Financial controls and reporting regained critical importance.

The first action taken by the well-run US companies, Intel, AMD, NSC concerned production costs and came quickly, reducing the number of technologies run in their fabs and tightening up the production discipline and cost. They specialized by area: diffusion, masking, thin films, etc. production sustaining engineers, replaced the star process engineers doing everything. By focusing on a few technologies, yield breakthroughs became routine and reproducible, weekly engineering yield meetings attended by most of the top managers became the norm and the crucible in which engineers were held to the highest standard of data and statistical significance for the improvements they were proposing, not just gut feeling. They were also the years where Turn Around Cycle/Time (TAT) became a key measure, WIP (Work-In-Progress) were thinned down, activities in all areas of a fab were measured, posted, and used to determine the productivity of each shift and associated engineers.

Obviously the better US manufacturers were not alone in taking these steps. The original overseas customers of US semiconductor products who had observed the dramatic California events launched their own semiconductor developments, first under license, and then on their own. They carefully picked a limited number of technologies and products, and by the end of the '70s, Japan, in particular, had become a formidable competitor in a product area where the product evolution was easy to foresee, like the density increases of DRAM going up by a factor of at least 2 every 2 years (Moore's law).

The second action, which was more significant in the long run, was to ensure steady growth of the top line, the development of rigorous product development management systems, and the associated management structures compensated on the basis of profitability of the individual product families. The addition of application groups for each product family helped develop a symbiotic relationship with customers in target industries and diminished the impact of competition based purely on price. These systems were instrumental in ensuring a steady flow of profitable products closely tied to general market requirements and specific customers, at least for the companies who had invested intensely in upgrading their management in these critical business skills, largely forgotten in the excitement of the wild years!

Transition case in point: Intel move from DRAMs to Microprocessors.

This was probably the most traumatic decision in the history of Intel and took place over the whole year of 1984, driven mostly by Andrew Grove. The problem was while Intel had tried to maintain a competitive advantage and introduced several innovative design efforts with its DRAMs offerings, it still steadily lost its strategic position in the DRAM market over time. Intel declined from 82.9% market share in 1974 to 1.3% share in 1984.

In parallel, the microprocessor business, resulting from the Busicom design, which was bought back by Ted Hoff for uses on non-calculator devices, was quickly growing. Andrew Grove would tell his direct reports to "make data-based decisions and not to fear emotional opposition". Andrew is quoted as saying: "The fact is that we had become a non-factor in DRAMs, with a 2-3% market share. The DRAM business just passed us by! Yet, many people were still holding to the "self-evident truth" that Intel was a memory company. One of the toughest challenges is to make people see that these self-evident truths are no longer true".

I remember distinctly the time when Intel made this decision public, resulting in a huge layoff: "Intel lays off hundreds of people" -- that was big news and the beginning of the big battle by all US semiconductors companies to regain their # 1 position after losing it in 1984. A few years earlier in September 1982, IBM had infused $250M in Intel through a large purchase of its stock. This support definitely helped Intel made its dramatic decision to exit the DRAM business, and in August 1987, IBM sold the stock of Intel at a nice profit, as Intel had grown significantly past its momentous and correct decision.

1974 to 1984
Eurosil
Munich, Germany

Arriving in Munich in mid-73, the first tasks were to install the production equipment flying into Munich airport, into the just-completed wafer fab facility, built out of an apple cider factory. The installation of equipment went pretty easily, as we could recruit well trained technicians: products of the excellent German trade school system but also from Texas Instruments Freysing which a had a large facility there. A number of supervisors and young engineers could be enticed to work for the new Eurosil company, a rare occurrence in this established conservative work force. We had much more difficulty hiring and retaining manual labor: afraid to work in this clean environment with what appeared as exceedingly complicated machines!! Once we found some who finally accepted some operator positions, they co-opted others and all of them stayed with Eurosil through most of its history: almost no direct labor turn-over: a big change compared to Silicon Valley.

By early 1974 we were processing the first 2” wafers (on equipment that was 2” & 3” compatible). Test vehicles were 4 MHz clock ICs and 32 kHz watch ICs. We had expected easy sales in the Swiss watch market, but Faselec in Zürich had started delivery of samples to the main watch makers, and Marin Electronic headed by Kurt Hübner who had hired Hans G. Dill from HRL, together with a license of the HRL process, had started its own production of its own watch IC designs, somewhat pre-empted our marketing effort there, to the great irritation of Jean Hoerni!

However the Black Forest clock market, opened by our legendary sales manager Bob Dugan, accepted us with open arms: the local manufacturers had been flooded by cheap mechanical imports from East Germany wanting hard currency: DM. The quartz movements made possible by Eurosil ICs, compatible with their production processes, allowed them instant differentiation and with our help recuperated 100% of their markets ... but it would take a couple years to really take-off.

This delay in what was supposed to be the main Eurosil market, the Swiss watch market, generated some quick reactions and decisions from the Board of Directors of Intersil and Eurosil, and Jean was not a man to hesitate to make drastic decisions when he felt it was needed. It was decided sometimes in mid-'74, that I would give up half of the equipment and facilities I had just finished building, qualified to build CMOS metal gate wafers, to a new memory group headed by a very talented and efficient Maurice Chidlow (who became my good friend) coming from Intersil by the way of AMD: they were going to run a 256-bit and 1024 bit NMOS Si gate memory process/product that was in high demand in California. Maurice managed to quickly get his products in the Eurosil wafer fab, and managed to reach yields which were double those that were the norms in the Cupertino fab. However the Intersil design had a fatal flaw: electrical migration in a power supply aluminum line that would shut down the part after about 1 year of operation, additionally, while the Intersil part was first on the market in beginning of 1974, by the end of the year there were seven suppliers and the price dropped from around $10 to $2 a piece.

Following this bad news, another memorable Eurosil board meeting was convened with Jean, Fred Adler, Marshall Cox, Joe Rizzi, and Eftim Pandeff of a Rothschild NY fund, at the beginning of 1975, I think. It was decided that the Maurice Chidlow memory group would return to Intersil, that I would recuperate the whole fab and that it would be focused exclusively on CMOS watch and clock IC products.

Intersil itself was going through some difficult times, the board pushed Jean to find a local buyer to help Eurosil through its own difficult transition. It was during this board meeting that, as described to me recently by Joe Rizzi, Eftim Pandeff punched Jean on the nose, in the middle of the board meeting, because he did not want to consider selling Eurosil. Jean then rushed downstairs to my office *and told me: "you are a witness, you are a witness, that Eftim punched me!", I told him I saw he had a bloody nose, but that I did not see who punched him!!*

Jean got Bob Freund who had taken over the Union Carbide semiconductor operation from him, and eventually had rejoined Intersil, to lead Eurosil while looking for an eventual buyer. When Eurosil was eventually sold to Diehl Gmbh & Co, in late 1975, Bob committed to stay for a few more years. Aloys Treppesch, from Diehl took care of the finances, Jim Portlock, first and then Hubert Meier took marketing, and I became VP operations.

In this new calmer setting, Eurosil had a good run at least until 1980. As expected the clock IC market boomed from 1975 on with our standard products "e1114" and "e1115," we were the sole suppliers of all German Black Forest clock makers. With Faselec as a small 2nd source with <10% market share, this meant we were shipping millions of these chips per month. We recuperated some of the Swiss watch market and even some of the Japanese watch market (in particular Citizen watch) when our star linear designer Ernst Lingstedt invented a voltage regulator that would shut down the 32 kHz oscillator as soon as it had started, so that our Si gate CMOS analog watch circuits were consuming 200 nA on average with 1.5V supply, a factor 3x - 4x better than the competition. On the digital watch side we also had excellent designers with Gerd Moegen and Paul Nance, who came up with a new programmable digital watch IC with a PLA structure that allowed them to come up with a new design of complex features in six to eight weeks with just a ROM mask change, at little cost to the customer. This relatively large IC was also made in hundreds of thousands per month mostly for the Asian markets.

On the production side, with the help of our excellent German maintenance engineers and process sustaining engineers, our yields surpassed easily those of Intersil for the same products, and packaging costs started becoming a significant fraction of our costs requiring constant monitoring and work with our Asian suppliers.

In the beginning of the transition to Diehl ownership, or just before it, Jean had stayed to help us with the development of our newest technologies, CMOS Si gate on sapphire substrates, to make high frequency, very accurate watch ICs possible, a project for Omega. I then learned to appreciate not only his super bright intellect but also his uncanny ability to admit to technical mistakes, and ability to listen and to take advice from less experienced engineers, including me!

We also made the rounds of the Munich Schwabing night spots together and he was delighted to compete with me, 14 years younger, to attract the attention of young ladies. It was clear that Jean always had a weak spot concerning "le beau sexe". When I knew him, he had divorced from his first wife Anne-Marie, was seeing Ruth Carmona he married later, but he clearly kept his relationship with his first wife, and with Ruth when he divorced her in his later years, until he died, because he was always, kind, generous, and respectful of them. He would also often talk about his parents that he would regularly visit in Geneva. Despite the quirks of his personality, Jean was really a kind and warm human being.

A year after the transition of ownership, Bob Freund who had his main residence in the US, showed up less frequently in Munich and with the agreements of Diehl management he stopped coming, resigned, and I became president of Eurosil in 1978, at 40. The business continued to expand and by 1980, Eurosil had a few hundred employees, sales of the order of $10-20M, but more importantly it was nicely profitable, probably 20% EBITDA at least.

This was good news in that the Diehl group agreed to build a 2nd fab in Eching, north of Munich, but bad news in the sense that as soon as the Diehl headquarters management saw we had become an actual cash generator they sent teams of people to show us how we could make even more money, so we lost our relative independence and motivation.

Telmos
Sunnvale, California

While I was getting bored, and starting to listen to calls from California friends, Jean felt and heard that many management teams in several companies were openly discussing new start-ups and the VC money seemed available. Jean re-contacted me and I was quickly convinced to do a new semiconductor start-up with him as chairman and I as president. I resigned from Eurosil in 1980 and we formed Telmos.

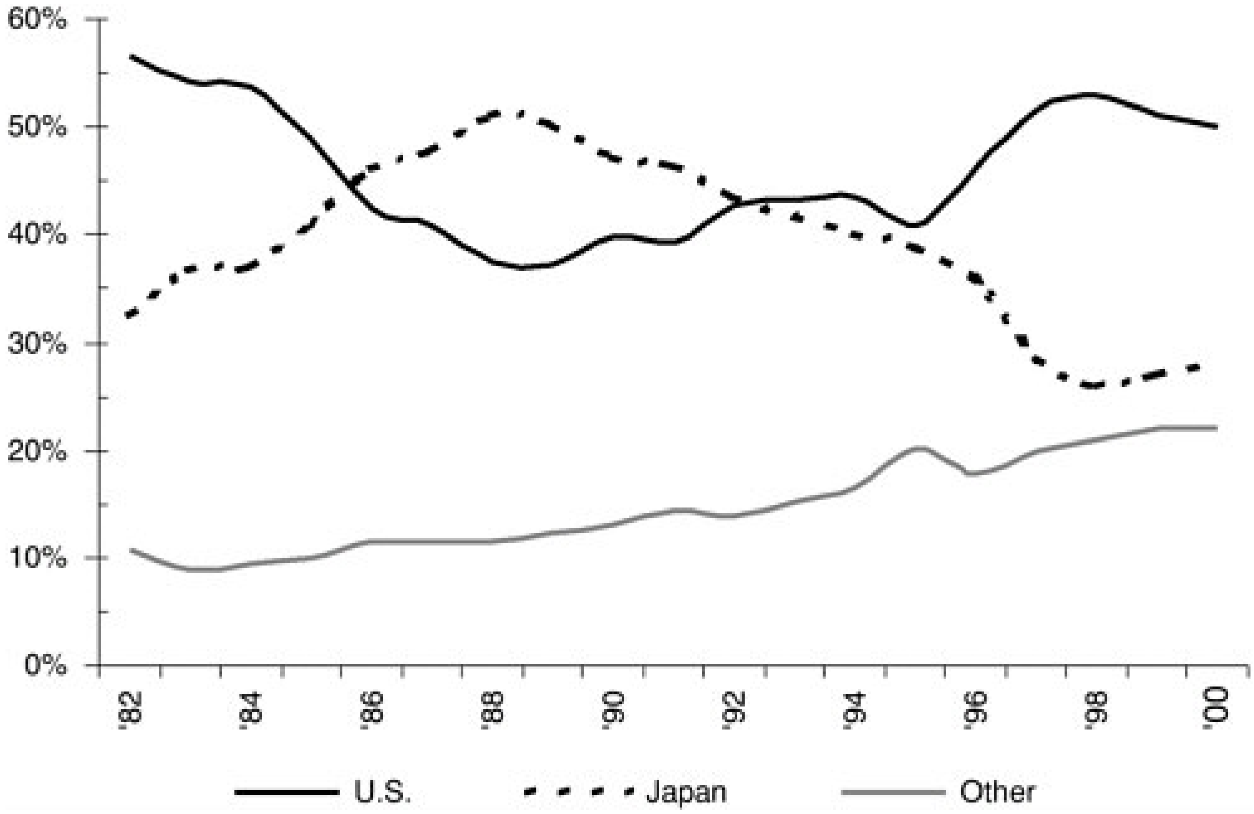
The goal of the company was to produce specialized interface semicustom products covering the linear interface between sensors to the microprocessor/digital logic core and the high voltage/high current actuation response driver products coming out of the microprocessor/digital logic core. I hired a few people out of Eurosil, stayed in Munich until 1982, generated quickly some sales of commercial semicustom linear: about $1M in 1982. The design was mostly made by hand. Main customers were a couple modem chips for SAT-SAGEM, in France and a new start-stop design for VW, Wolfsburg, Germany.

Jean started fund raising, set-up the admin, and located a suitable wafer fab on Kifer road, in Sunnyvale, and hired a few process engineers. It was in 1981 that Bob Dobkin and Bob Swanson, who were in the process of starting Linear Technology, realizing we had started a year earlier, had some sales, and that we were interested in linear products. We had a fab and a functioning admininstration and they proposed to merge Telmos and Linear Technology on a 50/50 basis. We would continue our semicustom linear European business, and they would concentrate on standard linear products. Jean and I share the very costly responsibility to have said no to this fantastic opportunity, because Jean did not want to give up 50% of Telmos, and I would have lost my position of president to Bob Swanson!!! A very painful lesson that business and egos are a bad mix!!!

I came back to California in the summer of 82, with my wife and 2 kids, rented the house of Jean in Hillsborough. For a while Telmos made quick progress, raised money, shipped products. However, in my interactions with peers and competitors, ex-Intersil friends, I understood, after my eight years in Munich, how much behind I was in the latest management skills, mostly in product engineering, product marketing, and the general ability to drive a new generation of successful products in close contact with customers. That was not a strength of Jean either, and we quickly came in conflict as to the focus of the company: linear products for me, and high voltage interface products for Jean. I resigned from Telmos in late 1984, and after contacting Maurice Chidlow who had joined IDT, a high speed SRAM and logic products manufacturer as COO, a few years after leaving Eurosil, I joined IDT as VP and division manager in January 1985.

The onset of maturity-The return of US semiconductor industry to # 1 position: 1985-1992
These were years of intense work, with a sense that our industry was under siege by Asian competitors, especially from Japan. The Intel decision to abandon what had been their main business was fresh on our minds. But the feeling was from the beginning, we will fight, and we will win this battle!! At first the news were not good. As reported by the SIA and pointed out by Andy Grove and Gordon Moore, in discussions at Sematech, the government-industry collaboration to promote certain key technologies in the US semiconductor industry was experiencing what Andy Grove and Gordon Moore dubbed “X-Curves”. It

referred to the US curves for market share going down and Japanese curves going up for a variety of manufacturing industries, including the semiconductor industry. “For the US semiconductor industry, Gordon Moore said, this was disconcerting to say the least”.



Semiconductor market shares 1982-2000: “The X Curve”
Source: Semiconductor Industry

In most US semiconductor companies, and certainly at IDT, we were working easily from 60 to 70 hrs per week. Families did not see us often, our life was totally absorbed in our work.

At IDT, and many companies, the skills of management had gone through marked improvement, from the early '70s, both in terms of adopting the best Japanese manufacturing techniques, but as often reported here already, in the ability to systematically introduce profitable new products, in close contact with key customers, techniques which I absorbed with great excitement and helped me greatly in the further development of my career.

The results started to show after a few years. IDT’s sales grew from $40M/yr in 1985 to $400M in 1989, Intel, despite dropping the DRAM business went from $1.6B, in 1984, to $3.1B in 1989.
Cypress Semiconductors, a competitor of IDT started in 1983, went public in 1986, the linear stars: Linear Technology started in 1981, went public in 1986, Maxim Integrated Products started in 1983, went public in 1988. There was also a flurry of successful digitally programmable array, or field programmable array companies such as Actel and Altera.

Starting in 1992, the X-Curve had inverted again with the US semiconductor business again on top in terms of revenues, but more importantly with highly differentiated products with gross margins mostly higher than 50%, while Japan was struggling to keep its low margin DRAM business from encroachments from the big Korean companies!

Lessons for investing in new technical break-through markets and technologies

There are constantly new fields that will solicit investments from investors and Venture Capitalists, all promising phenomenal growth and profit. To name a few we are looking at, today: autonomous vehicle driving, electrical propulsion for car and planes, environment friendly smart grid technologies, new immune therapy cancer drugs, etc. As in the past there are plenty of candidate pioneer industries!

Some of the companies who are the original drivers of these new technologies assemble very clever, talented and previously successful scientists, like at Fairchild or Intersil. Just because they are first in their domain, they will experience some initial success, mainly because of the temporary lack of organized competition: this can be deceiving! These companies are often driven more by technical prowess competition among the co-founders than by financial results, and their preliminary good results are not lasting. The returns for investors from this kind of technology driven companies in the semiconductor field, like Fairchild and Intersil were meager, the real great returns came to those who waited for the 2^{nd} or 3^{rd} generation teams who were driven by top management, real business motivations, with market driven products, credible business models, and easy to check high manufacturing gross margins.

The temptation could be high to invest too early, there would be constant PR by the initial tech leaders telling you, you missed the boat. <u>But If you insisted on a 10X return on your investment in the semiconductor field, you really needed to wait more than 10 years after the creation of Fairchild</u>, for the 2^{nd} generation: Intel 1968, AMD 1969, or more than 20 years for the 3^{rd} generation: IDT 1980, LSI Logic 1981, Cypress 1982, Linear Technology 1981, Maxim Integrated Products 1983! In other words, whether this is an exciting field or not, if you do not understand clearly the business model, the source of revenue and profit, wait until you get all the facts in hand, don't compromise on your principles, just because there is new fad or excitement, and never never compromise on the quality of your top management!

Swiss engineers in the Early Silicon Valley

Already mentioned in this text:

- Jean A. Hoerni, Hans G. Dill, Heinz W. Ruegg. Luc O. Bauer.

In addition Hugo Wyss and Lucien Trüb brought to my attention the names of:

- Roger Wellinger (1918-2014), after a career at GE Schenectady, came back to Neuchâtel to start the Centre Electronique Horloger (CEH) in 1962.
- Kurt Huebner, who spent time at Shockley Labs. He knew very well the founders of Fairchild, he built the CEH wafer fab from scratch and then started the EEM/MEM semiconductor fab of Ebauches. He hired Hans G. Dill to come to EEM/MEM including a license of HRL CMOS technologies.

