

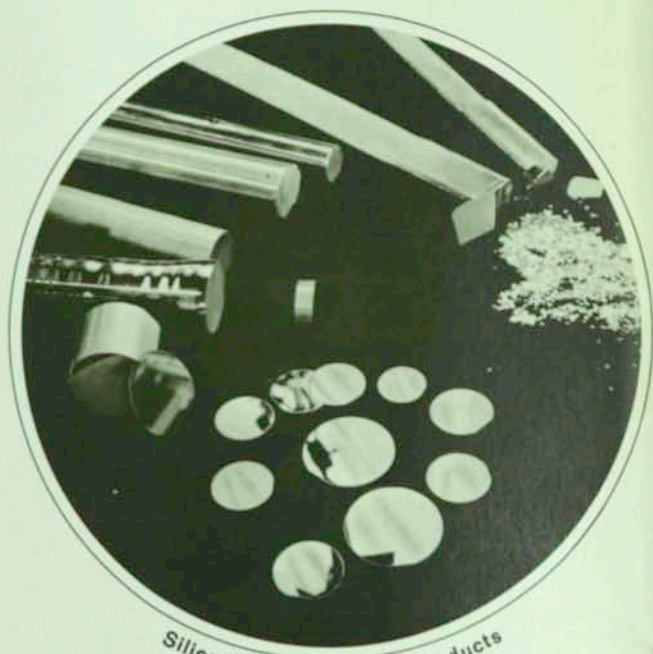
Semimetals, Inc./materials for the semiconductor industry ■ polished silicon slices ■ silicon epitaxial slices ■ buried collector epitaxial ■ single crystal germanium ■ single crystal silicon ■ germanium dice

introduction

For more than a decade, Semimetals, Inc. has been dedicated to the manufacture of germanium and silicon single crystals, polished slices, silicon epitaxial slices, buried collector epitaxial slices, and germanium dice for the semiconductor industry. This singleness of purpose and specialization of product area makes it possible for us to offer the most comprehensive product line available in the industry.

Semimetals' approach to customer service is characterized by a unique manufacturing technique which permits us to match our product to specific individual requirements. To achieve this, each customer is assigned a product specification code. This code identity is then maintained from single crystal to finished product.

Semimetals' stringent materials process control, and its ability to anticipate the ever-changing needs of the industry, ensures rapid, economical manufacture of both prototype and production quantities.



Silicon and germanium products



Surface inspection of silicon products

quality control



Thickness and resistivity measurements of epitaxial layers

Semimetals' product quality is quickly translated by the semiconductor manufacturer in terms of device yield. At Semimetals, human ability to examine and judge is aided by the best laboratory equipment available to evaluate all product parameters, including Laue X-ray equipment, infra-red spectrophotometers, and electronic probes and gauges.

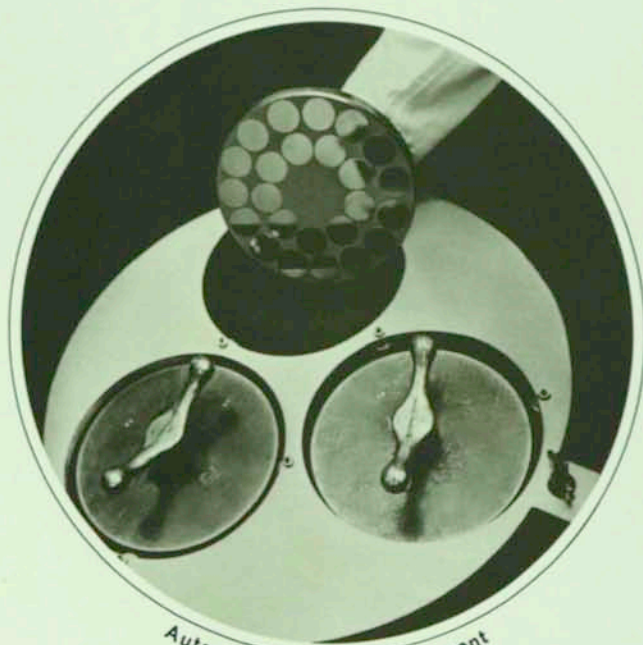
Quality is further enhanced through the use of automated production equipment which removes the possibility of operator error, yielding products of highly reproducible characteristics.

Of paramount importance is the fact that at Semimetals, a large staff of engineers is maintained to keep abreast of the continuous changes taking place within the industry and to evolve the technology required for the successful manufacture of our highly specialized product.

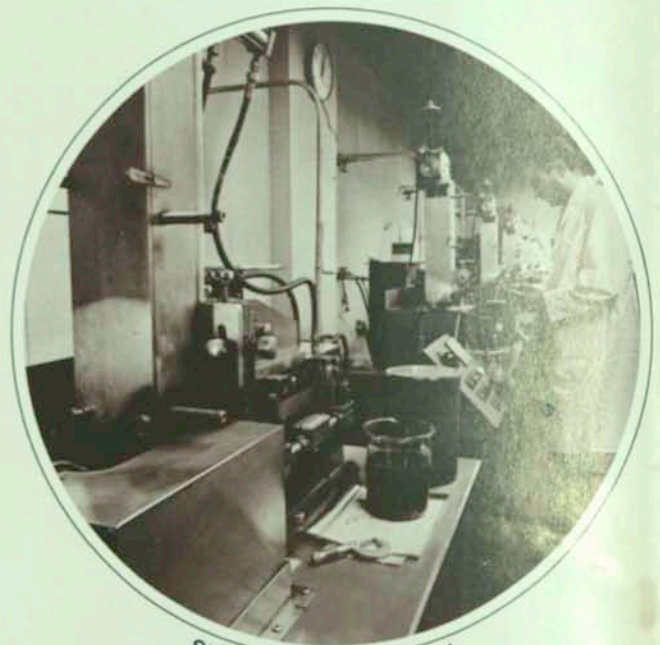


Laue X-ray equipment

polished silicon slices



Automatic polishing equipment



Silicon slicing equipment

Polished silicon slices for microcircuit and epitaxial use demand a surface which is free from scratches, pits, haze, waviness, protrusions, or chips. Modern, highly automated equipment, combined with stringent manufacturing procedures, produces an optically flat polished surface free of superficial or concealed residual defects . . . resulting in a defect-free wafer to increase customer device yield.

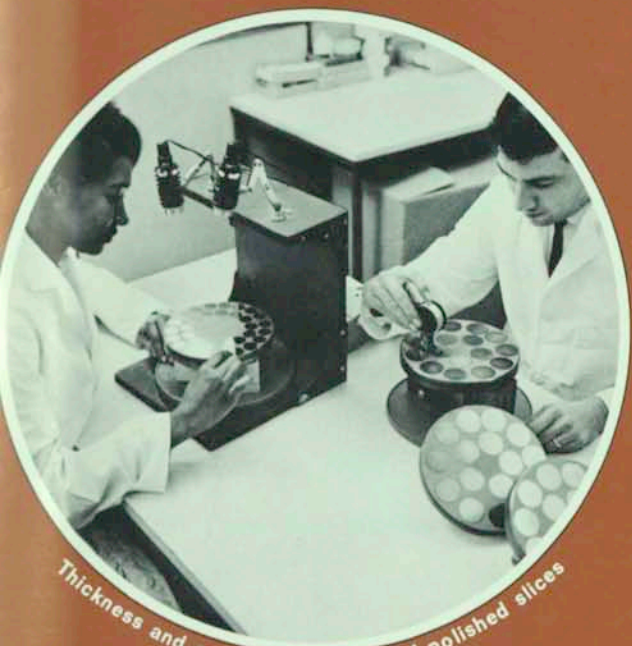
Semimetals, Inc. can guarantee consistent quality and high reproducibility from wafer to wafer and shipment to shipment because of the exclusive procedure of maintaining crystal identity throughout each process—thereby ensuring the tracability of each slice to a particular crystal and eliminating the possibility of material mixing. This is accomplished by giving each customer an individual code which contains the product specifications and by maintaining code identity from single crystal to the finished product.

All wafer orientations are measured by X-ray reflection techniques.

SPECIFICATIONS

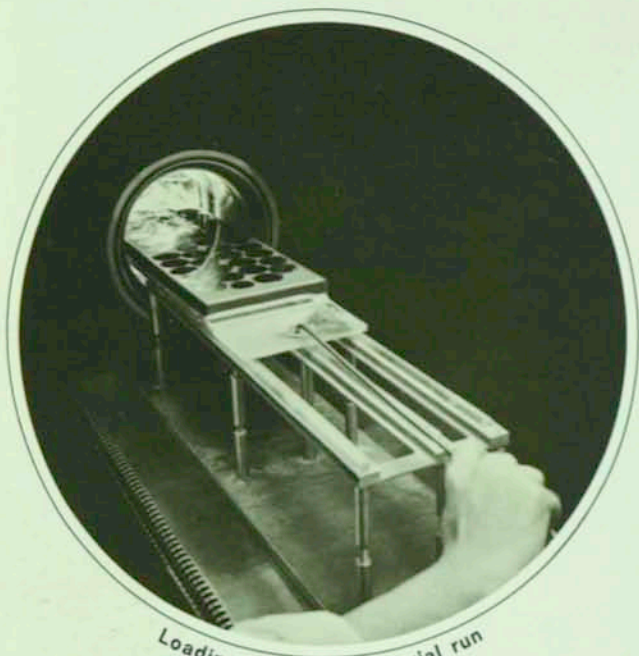
Material:	Czochralski or float zone single crystal silicon.
Orientation:	Surface 111 or 100. Misorientation toward any plane* or randomly to 4° within 30 minutes.
Flat Plane:	211 or 110 for 111 surface. 100 or 110 for 100 surface. Capable of flatting to within 30 minutes of required flat plane, using Laue back reflection techniques.
Type and Dopant:	(P) Boron, (N) Antimony, Phosphorous, or Arsenic.
Resistivity:	P type 0.0007—1000 Ohm/cm. N type 0.001—1000 Ohm/cm.
Thickness:	4 mils or greater.
Taper:	Less than 0.50 mil.
Flat Length:	Any length required.
Slice Diameter:	Any diameter up to 2 1/4 inches.
Diameter Tolerance:	± .005" to ± 1/16"
Back Side Condition:	As cut, etched or lapped.

*Laue photograph or standard projection must be furnished by customer when misorientation towards any plane is required.

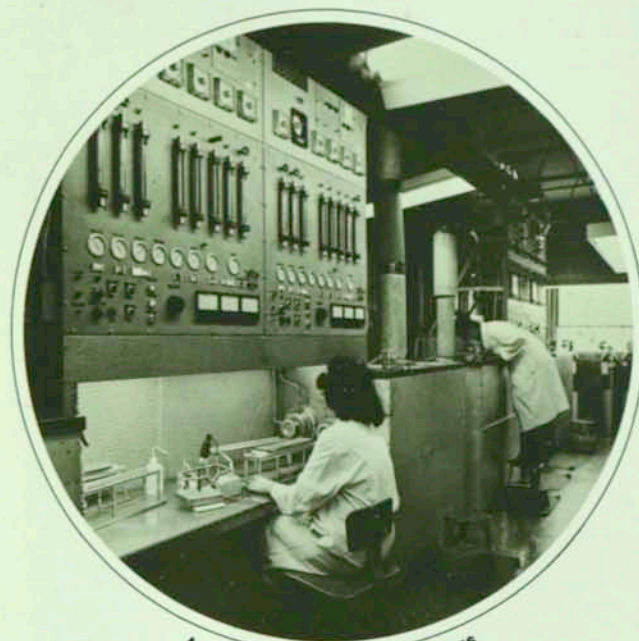


Thickness and surface inspection of polished slices

silicon epitaxial slice



Loading of silicon epitaxial run



Automatic epitaxial reactors

Silicon epitaxial slices—an essential "raw material" in the production of many semiconductor devices—demand exacting attention to detail, and extremely sophisticated quality control procedures. The production process requires that silicon tetrachloride and gas dopants be reacted at high temperatures (induction heating) to deposit a silicon layer on a polished silicon substrate. Prior to deposition, the substrate is vapor etched to ensure a perfect crystallographic surface. Every epitaxial run is immediately evaluated for thickness and resistivity upon completion.

It should be noted that the Semimetals reactor used to grow an epitaxial layer is a completely automated system which totally eliminates operator variables. With this system there is far less chance for error, which means higher device yield.

Partial list of epitaxial combinations

Product	Resistivity Range (ohm/cm)	Thickness Range
N	.01 - >50	.5 μ - 4 mils
P	1 - 1000	>4 mils
P	.001 - 10	.5 μ - 4 mils
N	>.02	>4 mils
N	.01 - >50	.5 μ - 4 mils
N+	.001 - .02	>4 mils
P	.001 - 10	.5 μ - 4 mils
P+	.0007 - 1	>4 mils
N	.01 - 10	.5 μ - 4 mils
P+	.0007 - 1	>4 mils
P	.001 - 10	.5 μ - 4 mils
N+	.001 - 10	>4 mils

Three techniques are used to measure epitaxial layer resistivity: (1) The four-point probe measurement of opposite type control monitors is the most accurate production technique for measuring resistivity. (2) Differential capacitance-voltage technique. Periodic sampling for quality control. (3) The three-point probe which measures the breakdown voltage of the epitaxial layer.

Normal quality control procedures dictate that the results of the three resistivity measuring techniques correlate. Thickness is measured by an infra-red spectrophotometer (Beckman IR-5A with Micro Specular attachment). Resistivity and thickness are calculated by computer from values obtained by four-point probe and spectrophotometer measurements.

An almost infinite number of multi-layer combinations are available. The following is one example:

Partial list of multi-layer combinations

Product	Resistivity Range (ohm/cm)	Thickness Range
P+	<.001	<20 microns
N	.01 - >50	.5 μ - 4 mils
N+	.001 - .02	>4 mils

Graded layers can be supplied which have high resistivity on the substrate and low resistivity above it—or low to high. Epitaxial deposited oxides with thicknesses of 1000 Å to 10,000 Å can be produced.

buried collector epitaxial

Epitaxial material with buried collector (N^+ regions) has become established as a fundamental requirement in the manufacture of conventional integrated circuits.

As a specialist in the manufacture of polished silicon slices and silicon epitaxial slices, Semimetals has developed manufacturing techniques for the production of a product which is free of pattern shifting with minimal stacking fault densities and tripyramid growths at pattern edges. As with all Semimetals products, careful quality control procedures and step-by-step inspection assure high product quality and IC yield.

SPECIFICATIONS

Type: P type substrate material chem-mechanically polished.
Etching: Gas etched to remove a minimum of three microns

from the polished surface to ensure a crystallographically perfect surface.

Oxide: Thermally oxidized to produce 8,000 Å to 10,000 Å of silicon dioxide which acts as a mask against the diffusion of N type impurities into selected areas of the silicon surface.

Masking: Masks provided by customer. Photolithographic techniques used to expose silicon in areas where diffusion is desired.

Diffusion: N^+ impurities diffused into the exposed silicon regions to resistivities of 15-20 ohms/square and depths of approximately four microns. Other sheet resistivities and thicknesses available upon request.

Epitaxial Layer: Epitaxial layer grown to customer's specification after oxides are removed from wafer surface.

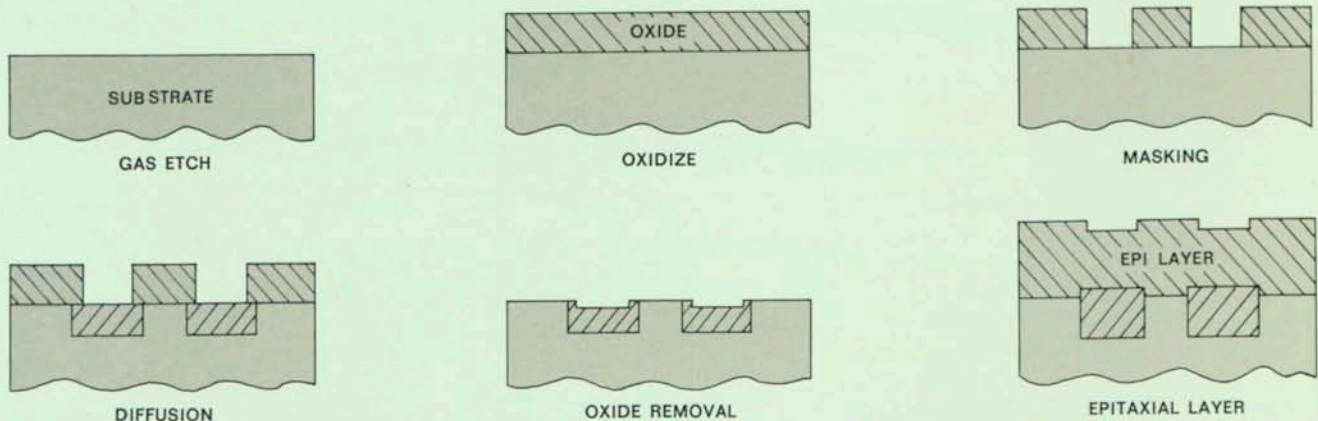


Diffusion furnace for buried collector



X-ray equipment for measuring surface mis-orientation

process flow diagram—buried collector epitaxial



single crystal germanium



Growing single crystal

Semimetals, Inc. produces two sizes of single crystal germanium: MS-11 and MS-12. They are offered in zone levelled trapezoids. Type MS-11 has 60 to 65 grams/in.; type MS-12, 110 grams/in.

SPECIFICATIONS

Resistivity	MS-11	MS-12
P type	0.0007 ohm/cm to intrinsic	.01 ohm/cm to intrinsic
N type	0.001 ohm/cm to intrinsic	.01 ohm/cm to intrinsic

Tolerance N Type, $\pm 20\%$
P Type, $\pm 15\%$

Orientation (211) (110) (100) (111) $\pm 1^\circ$

Dislocation Density Avg. 2-5000/cm²; 4-8000/cm²; or 5-12000/cm²

Lifetime 0.5 - 9.0 ohm/cm - 50 μ sec minimum
Above 9.0 ohm/cm - 200 μ sec minimum

Lineage All material free of lineage

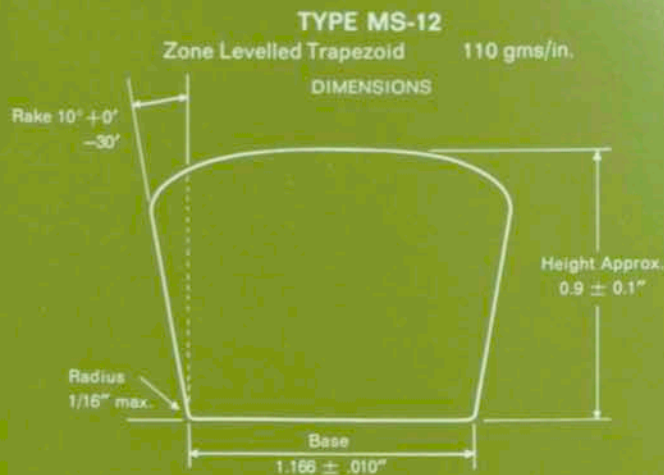
Gold Doped Germanium N type material available from 0.001 to 8 ohm/cm

Gold Doped Germanium P Type material available from 0.001 to 10 ohm/cm



*Base dimension determined by intersection of side rake and base line

**Standard packaging length; lengths available up to 18"



specific material requirements

request for quotation

ITEM #	1	2	3
A. Structure			
B. Substrate			
1. Dopant			
2. Orientation			
3. Flat length			
4. Flat Plane			
5. Diameter (")			
6. Thickness (mils)			
7. Resistivity (ohm/cm)			
8. Radial gradient			
9. Backside Condition			
10. Dislocation Den (/cm ²)			
11. Method of Growth			
12. Type of Surface Finish			
C. Epitaxial Layer(s)			
1. Dopant			
Resistivity (ohm/cm)			
Voltage (volts)			
Thickness (mils)			
Thickness (μ)			
2. Dopant			
Resistivity (ohm/cm)			
Voltage (volts)			
Thickness (mils)			
Thickness (μ)			
D. Overall Thickness (mils)			
E. Total Quantity			
F. Rate of Delivery			
G. Specification Ref:			
H. Special Tolerances:			

name _____

company name _____

address _____ zip _____

telephone _____

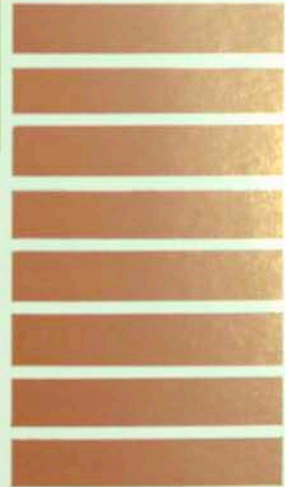
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Westbury, New York 11590



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single crystal silicon



Crystal growing equipment

Semimetals uses the most modern Czochralski-type crystal growing apparatus to produce single crystal silicon of consistently superior quality. Through precise control of the crystal growing operation, low dislocation, uncompensated, and low gradient crystal is produced.

SPECIFICATIONS

Material: Czochralski-type single crystal silicon

Dopants and Resistivities: Antimony—.005—25 ohm/cm. Arsenic—.001—1 ohm/cm. Phosphorus—.0001—50 ohm/cm. Boron—.0007—50 ohm/cm. Other resistivities on request.

Dislocation Density: 2000/cm² std, 1000/cm². 500/cm² available on request.

Orientation: (111), (100)

Orientation of Flat Plane: Within 2° of (110) or (211) on (111) oriented crystal, within 2° of (110) or (100) on (100) oriented crystal. Flats can be supplied within 0.5° on request.

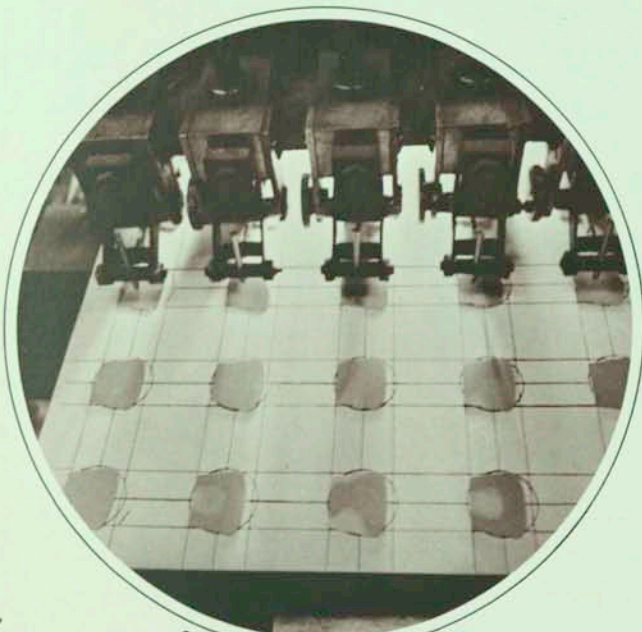
Diameters: 3/4" to 2 1/4", tolerances from 1/16" to .010".

germanium dice

Semimetals, Inc. is the largest commercial manufacturer of germanium dice in the United States. Specialization in this field makes it possible to produce dice in any required quantity on a production basis. Many device manufacturers now producing dice for their own requirements will find it convenient and economical to switch to Semimetals for germanium dice needs.

Germanium Dice Parameters

- Any size from 30 mils to 226 mils.
- ± 2 mil width and length.
- Can scribe from 5 mil to 10 mil in thickness larger and thicker on request.
- Can etch off from 1 mil to 6 mil or more.
- Thickness tolerance ± 0.1 mil.
- Minimum thickness 1.9 mil.



Scriber for germanium dice



SEMIMETALS, INC. 172 Spruce Street, Westbury, New York 11590 516-333-8400 TWX 510-222-8810