EEE-4227: Processing & Fabrication

Fabrication Technology

Chapter-1: Crystal Growth and Wafer Preparation

Text book: Microchip Fabrication: A Practical Guide to Semiconductor Processing
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Capter-3: Crystal Growth and Silicon Wafer Preparation

Electronics industry

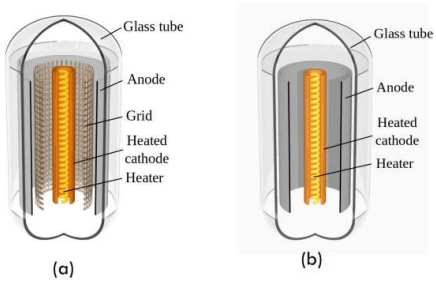
The electronics industry is divided into two major segments:

- semiconductors and
- systems (or products).

"Semiconductors" encompasses the material suppliers, circuit design, chip manufacturers, and all of the equipment and chemical suppliers to the industry.

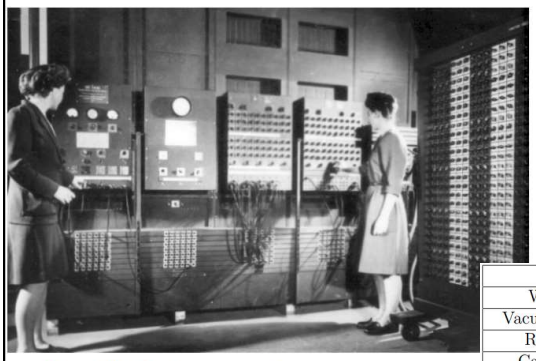
The systems segment encompasses the industry that designs and produces the vast number of semiconductor device based products, from consumer electronics to space shuttles. The electronics industry includes the manufacturers of printed circuit boards.

Down memory lane……
Vacuum Tube



Schematic of the vacuum tube (a) triode and (b) diode.

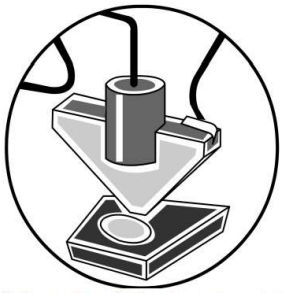
Down memory lane……
Vacuum Tube Computer



World's first computer: ENIAC.

Size, ft	30 × 50
Weight, tons	30
Vacuum tubes, nos.	18,000
Resistors, nos	70,000
Capacitors, nos	10,000
Switches, nos	6000
Power requirement, W	150,000
Cost (in 1940)	$ 400,000

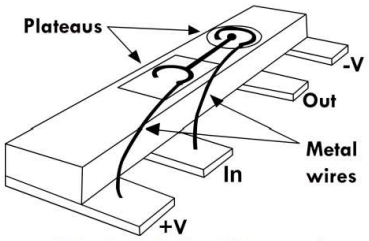
Down memory lane……
First transistor: *point-contact transistor*



Schematic of the first transistor developed in Bell labs

John Bardeen,
William Shockley, and
Walter Brattain
at Bell Laboratories
in December, 1947

Down memory lane……
First Integrated Circuit (IC)



The design of the Jack Kilby IC.Except for the metal wires, the rest of the IC was fabricated on a single wafer of Ge.

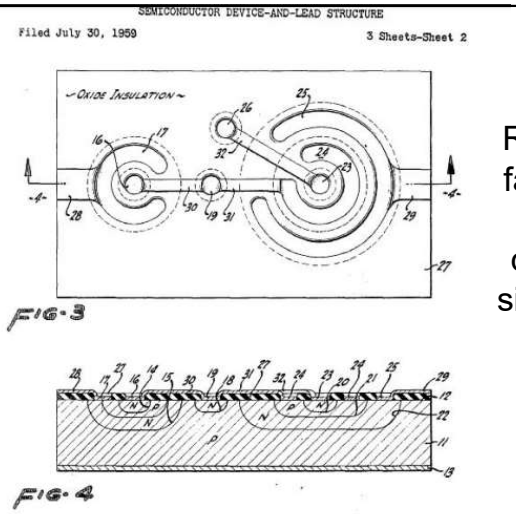


Figure 8: The patent application of the Robert Noyce IC showing the circuit design. A top-down and side view are included.

Robert Noyce fabricated the iindividual devices on a single wafer of Si: the first monolith IC.

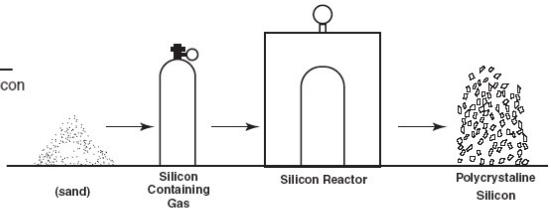
Stages of Manufacturing

Solid-state devices are manufactured in the following five distinct stages (Fig. 1.20):

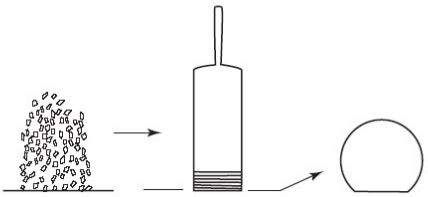
a. Material preparation
b. Crystal growth and wafer preparation
c. Wafer fabrication and sort
d. Packaging
e. Final and electrical test

Stages of Manufacturing……

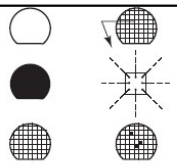
a. Material Preparation
Sand to polycrystaline silicon



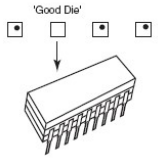
b. Crystal Growth and Wafer Preparation
Polycrystaline silicon to wafers



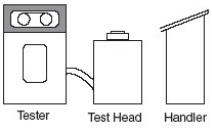
c. Wafer Fabrication and Wafer Sort
Circuit/Devices formed in and on wafer surface. Individual chips electronically tested (wafer sort)



d. Packaging
Functioning die placed in a protective package.



e. Final and Electrical Test



Stages of Manufacturing…….

Semiconductor Silicon Preparation

Book Chapter-3

Semiconductor devices and circuits are formed in and on the surface of wafers of a semiconductor material, usually silicon. Those **wafers must** have

- very low levels of contaminants,
- be doped to a specified resistivity level,
- have a specific crystal structure,
- be optically flat, and
- meet a host of other mechanical and cleanliness specifications.

Semiconductor Silicon Preparation..

Silicon wafer preparation stages

Manufacture of IC grade silicon wafers proceeds in four stages.

- Conversion of ore to a high-purity gas
- Conversion of gas to polysilicon silicon
- Conversion of polysilicon silicon to a single crystalline, doped crystal ingot
- Preparation of wafers from the crystal ingot

Conversion of ore to Metallargical Grade of Silicon

First, metallurgical-grade silicon (MGS) with purity up to 99% is produced in a furnace. The furnace is charged with quartzite, a relatively pure form of sand, and carbon in the form of coal, coke, and wood chips.

Heat (2000°C)

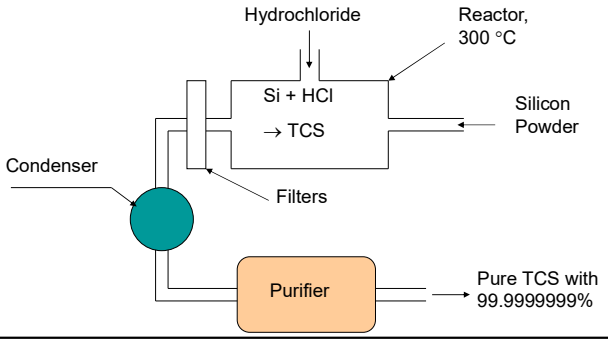
SiO_2 + C → Si + CO_2

Sand Carbon MGS Carbon Dioxide

Conversion of MGS to a High-purity Gas

The next process step is to pulverize the MGS mechanically and react it with anhydrous hydrogen chloride to form trichlorosilane ($SiHCl_3$) according to the reaction:

$Si(solid) + 3HCl(gas) \rightarrow SiHCl_3\ (gas) + H_2\ (gas) + heat$



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Conversion of Gas to Polysilicon Silicon

EGS is prepared from the purified $SiHCl_3$. The chemical reaction is a hydrogen reduction of trichlorosilane(TCS).

$2SiHCl_3(gas) + 2H_2(gas) \rightarrow 2Si(solid) + 6HCl(gas)$