Moving Towards Integrated Circuits

History and Fabrication

Transistor History

- First transistors were hybrid devices made from germanium and operated in a vacuum tube (1947).
- The first transistor radio (by Regency Division of IDEA) was made from 4 transistors and required a 22.5 V battery (1954).
- The bipolar junction transistor was developed in the late 1950s (still hybrid).
- The movement to monolithic devices came in the 1960s with the dawn of silicon microfabrication.
- BJTs were the earliest transistors and are current-controlled devices. They can carry larger currents and perform well at high frequencies.
- MOSFETs are voltage controlled devices. They are symmetrical, can operate at low power, can be made smaller, and have near infinite input resistance.

Transistors

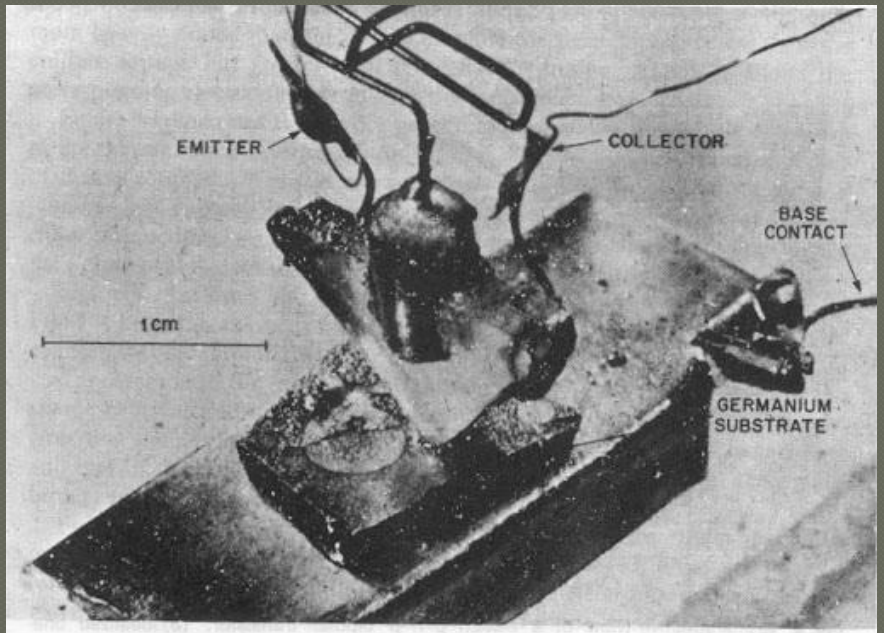


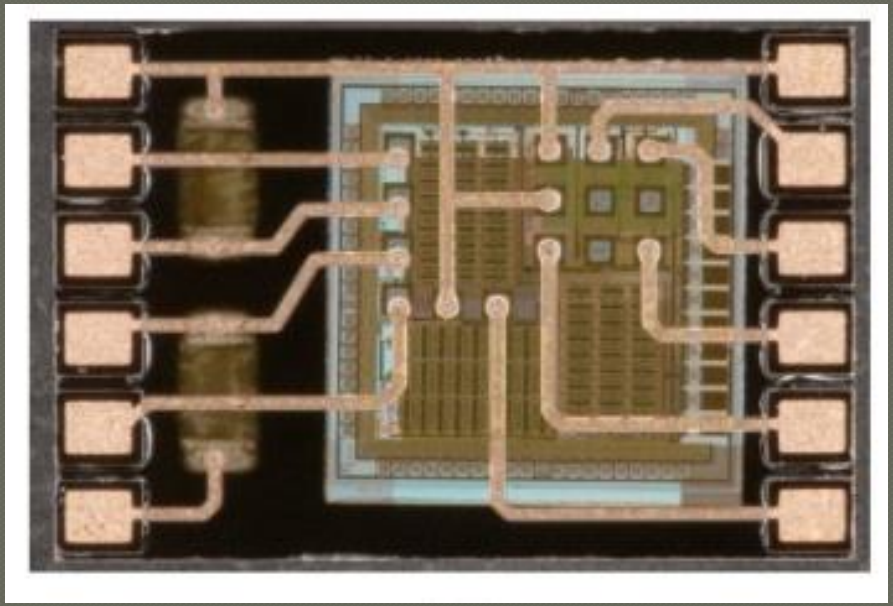
Fig. 1 The first transistor.[1]

Bell Labs Engineers: Shockley, Brattain and Bardeen invented the point-contact transistor in 1947 and the hybrid BJT in 1948

Transistors were originally manufactured from Germanium.

Silicon became the material of the future because of it's high operating temperature, inert material qualities, and cost.

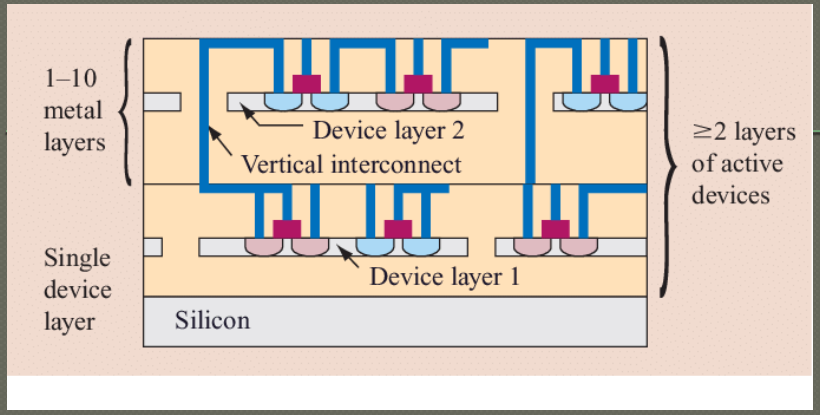
Transistors

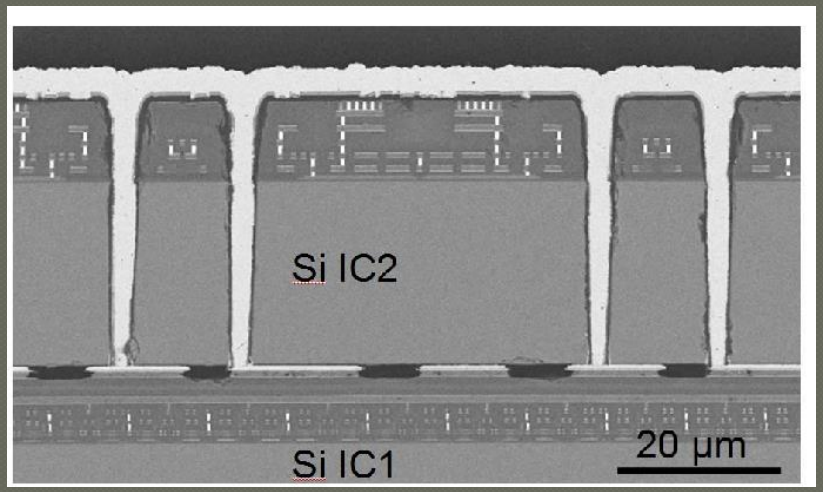


Silicon fabrication processes allowed for smaller feature sizes and increased density of transistors per unit area.

Transistor are small, but contact pads, resistors and capacitors take up a lot of space.

Transistors



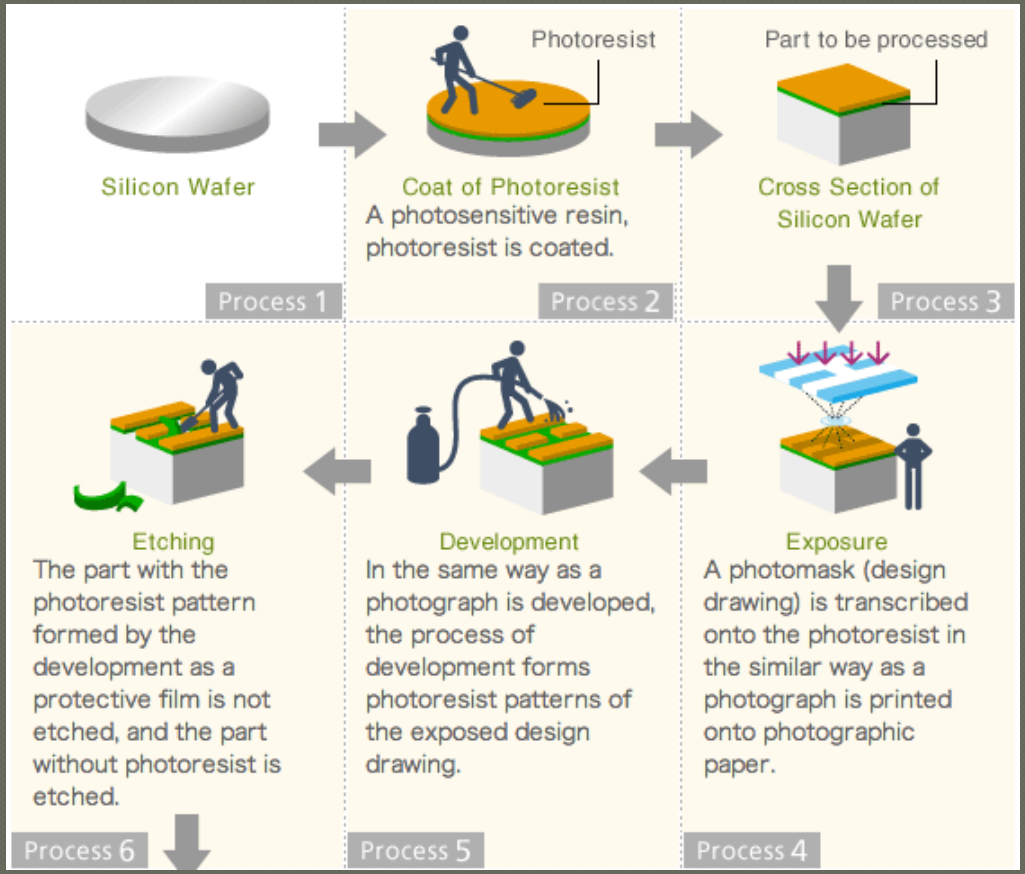


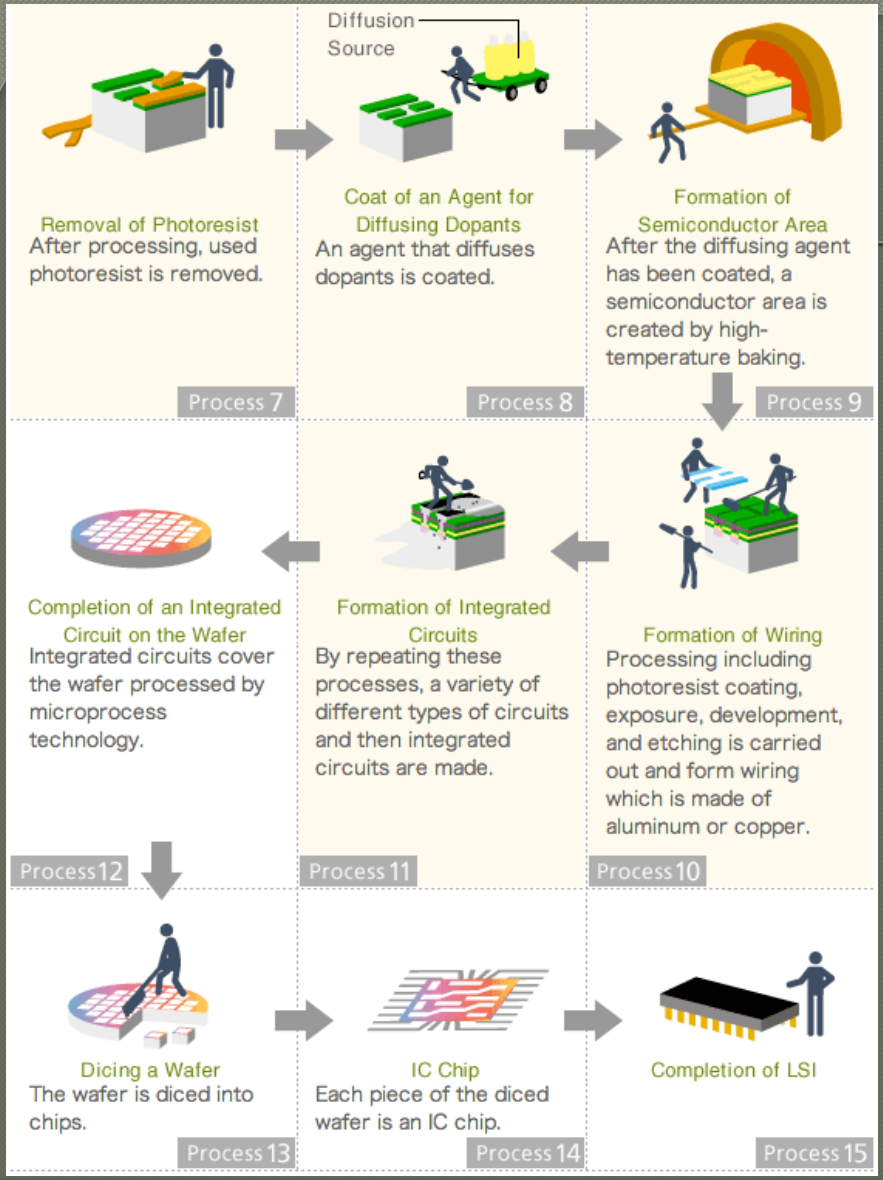
Just like in cities, when we run out of space, we go vertical!

Semiconductor Fabrication

- Fabrication is done in a largely automated process to reduce manufacturing issues related to humans coming in and out of the plant.

General Process





General Process

Health and Environmental Impacts of Manufacturing

- Many chemicals associated with semiconductor fabrication are toxic to humans and to the environment.
- Water usage is a huge factor as well.
- A typical facility uses 240,000 kW-hrs of electricity and over 2 million gallons of water every day. (The average person uses about 100 gallons of water a day).
- Chemicals require disposal mechanisms to protect the water table.
- Not to mention issues with disposal of actual circuits after their useful life ends (arsenic, gallium and heavy metals leach out in the environment)