

A Background to Silicon and its Applications

Jul 20 2001



ChWeiss / Shutterstock

The discovery of (amorphous) silicon in 1824 is credited to Berzelius. It was created by heating potassium with silicon tetrafluoride and repetitively washing the product to eliminate fluorosilicate impurities. Then, in 1854, Deville became the first person to prepare crystalline silicon—the second allotropic form of the element.

Occurrence

Silicon (Si) occurs in the sun and the stars, and is a key component of a group of meteorites called “aerolites.”

Constituting 25.7% of the earth’s crust by weight (oxygen being the first), silicon is the second most abundant element. It does not occur freely in nature, and is mostly found as its oxide and as silicates. Quartz, jasper, rock crystal, sand, agate, flint, amethyst, and opal are examples of the oxide form. Granite, asbestos, clay, feldspar, hornblende, and mica are examples of its silicate minerals.

Synthesis

Silicon is synthesized commercially by heating carbon and silica in an electric furnace, using carbon electrodes. The Czochralski technique is typically used to create single crystals of silicon used in semiconductor or solid-state devices. Hyperpure silicon can be synthesized by thermally decomposing ultra-pure trichlorosilane in the presence of hydrogen, and by using a vacuum float zone process.

Properties

Although silicon is a comparatively inert metallic element, it reacts with dilute alkali and halogens. Except for hydrofluoric acids, a majority of the acids do not have any effect on silicon.

Silicon is a semiconductor, and is better than germanium for transistors, because of its ability to endure a temperature of 149 °C (300 °F) and convey more power. Elemental silicon conveys over 95% of all wavelengths of infrared, from 1.3 to 6.7 μm.

Silicon does not have a metallic-type lattice structure. There is no plasticity and it is more similar to the diamond structure. Silicon exhibits a greater inclination to form compounds with non-metals than with metals, due to its weak electronegative form.

The element forms silicon hybrids of general formula $\text{Si}_x\text{H}_{2x+2}$, which are like paraffin hydrocarbons. However, these are highly unstable and ignite in air.

Applications

Hyperpure silicon metal and doped hyperpure silicon (doping with boron, phosphorous, gallium, or arsenic) are used in:

- Solar cells
- Transistors
- Semiconductors
- Rectifiers and other solid-state devices that are used widely in the electronics and space sectors.

Float-zoned single-crystal silicon (which is 100 times purer than hyperpure silicon) is used in wafer form for infrared and laser detectors, in guided bomb missiles and for high-power

switching devices, such as thyristors.

Hydrogenated amorphous silicon may be used to manufacture photovoltaic cells for transforming solar energy into electricity.

Silicon can also be found in the following:

- Silicon is a vital ingredient in aluminum, steel, and iron alloys. It is added as a fluxing agent for copper alloys.
- Silicones, varying from liquids to hard glass-like solids.
- In the form of clay and sand, it is used to manufacture bricks and concrete; it is a valuable refractory material for high-temperature work, for example, molding sands for castings in foundry applications.
- Silica is used as a raw material for making glass, which is used to make several products like containers, insulators, and windows.
- As silicates, it is added for manufacturing pottery, enamels, and other similar items.
- Silicon carbide is one of the most significant abrasives, and has been incorporated into lasers to create coherent light of 4560 Å.