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Silicon (Si^{14})

Properties

Silicon is a blue-gray metallic solid. It is a tetravalent metalloid and has an average mass of 28.085 amu. Silicon has a density of 2.33 g/cm^3, a melting point of 1414 ^oC, which is the second-highest among all the metalloids and nonmetals. It has low thermal expansion (2.6 μm/(m·K)), good thermal conductivity (149 W/(m·K)) and low electrical conductivity (2.3×10^3 Ω·m). Si is brittle and hard with Mohs hardness of 6.5.

Silicon has a low reactivity but high chemical affinity for oxygen. The most common oxidation states for Silicon are −4, −3, −2, −1, 0, +1, +2, +3, +4 [1]. The standard reduction potential for the SiO_2/Si couple is −0.909 volts. Silicon makes up 27.2% of the Earth's crust by weight, second only to oxygen at 45.5%, with which it always is associated in nature.

Plating Solutions

Silicon as the pure element is difficult to deposit electrochemically and usually requires high temperatures. However, it can be deposited from organic solvents (propylene carbonate, tetrahydrofuran et al) with SiX_4 and $SiHX_3$ (X=Cl, Br) as precursors and ionic liquids at room temperature:

a. Example 1: 0.3M $SiCl_4$, 0.1M TBACl and CH_3CN in controlled potential mode (deposition potential: −2.4V vs. Pt QRE) [2].
b. Example 2: 1 M solution of $SiCl_4$ in 1-butyl-1-methyl-pyrrolidinium bis (trifluoro methylsulfonyl) imide ([BMP]Tf_2N) with −2 to −3 volts [3].

Electrodeposition of Si in organic solvents must be performed in inert atmosphere since the precursors react with moisture to form oxides and Si is deposited at negative potential beyond the background reduction of water.

Applications

Silicon is one of the most important semiconductors as it is the basis of any computer chip. It's been used for transistors, solar cells, semiconductor detectors, and other semiconductor devices. It is also demanding for applications in fabrication of thin film for Si solar cells replace the bulk solar cells made from expensive single crystal Si wafers. It also has applications in waterproofing treatments, molding compounds, mechanical seals, and waxes, and caulking compounds [4].

References:

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[2] T. Munisamy and A. J. Bard. *Electrochim. Acta* **55**, 3797-3803, 2010.
[3] S. Zein El Abedin, N. Borissenko, and F. Endres. *Electrochem. commun.* **6**(5), 510-514, 2004.
[4] H. Chang and S. Q. Sun. *Chinese Physics B* **23**(8), 2014.

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