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Germanium (Ge^{32})

Properties

Germanium is a grayish-white metalloid with an atomic mass of 72.59.8 u. Ge has a density of 5.3 g/cm^3 and a melting point of 936 ^oC. It is a lustrous and a hard-brittle semiconductor with an appearance similar to elemental silicon.

The most common compounds have germanium in the +2 and +4 states, while it also exists in other oxidation states such as -4, -3, -2, -1, +1, +3. Its standard electrode potential in respect to Ge^{+2} is +0.0V. Germanium is stable in dry air, acids or alkalis. Ge can be dissolved in mixture of nitric and sulfuric acids. Germanium is estimated to be at average concentration of 1.6 parts per million (ppm) in the Earth's crust.

Plating Solutions

Germanium can be electrochemically deposited from aqueous electrolytes, containing in g/l: germanium dioxide – 2.6, sodium hydroxide – 170 or germanium sulfate – 20, potassium hydroxide – 40, sodium sulfate -12 with pH 7.5-8 at temperature of 30 ^oC and current density of 25 mA/cm^2. However, the plated thickness is very thin due to low hydrogen overpotential.

Germanium can be deposited from non-aqueous solutions, containing 5-7% of germanium tetrachloride in ethylene glycol at temperature of 60 – 100 ^oC and current density of 100 – 200 mA/cm2 with current efficiency of ~2%.

Germanium can be also deposited from ionic liquids, including 1-butyl-3- methylimidazolium hexafluorophosphate using germanium(IV) halides as germanium source [1], 1-butyl-1-methylpyrrolidinium dicyanamide and 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide containing $[GeCl_4(BuIm)_2]$ (where BuIm = 1-butylimidazole) or $GeCl_4$ [2] , other ionic liquids, e.g. 1-butyl-3-methylimidazolium bis- (trifluoromethylsulfonyl)imide, 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide, 1-ethyl-2,3-dimethylimidazolium bis(trifluoromethylsulfonyl)imide [3-5].

Applications

Elemental germanium is used as a semiconductor in transistors and various other electronic devices. Historically, the first decade of semiconductor electronics was based entirely on germanium. Presently, the major end uses are fibre-optic systems, infrared optics, solar cells and light-emitting diodes. Silicon-germanium alloys are very important semiconductor material for high-speed integrated circuits.

References:

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