



## Bismuth (Bi<sup>+3</sup>)

### Properties

Bismuth is a silvery-white metal with an atomic mass of 209 u. Bi has a density of 9.78 g/cm<sup>3</sup>, a melting point of 271 °C and a resistivity of 129 μOhm cm. It is a soft, brittle and has a Brinell hardness of 70 – 95 MPa. No other metal is verified to be more naturally diamagnetic than bismuth. Of any metals, it has one the lowest values of thermal conductivity of 7.97 W/(m·K) after manganese and the highest Hall effect.

The most common compounds have Bi in the +3 state, while it also exists in other oxidation states such as -3, -2, -1, +1, +2, +4, +5. Its standard electrode potential in respect to Bi<sup>+3</sup> is +0.2V. Bismuth is oxidized in ambient atmosphere forming black film on the surface. It does not dissolve in diluted hydrochloric and sulfuric acid, but dissolves readily in nitric acid. Bi is estimated to be at average concentration of 0.2 parts per million (ppm) in the Earth's crust.

### Plating Solutions

Bismuth can be electrochemically deposited from perchlorate, fluoroborate, phenolsulfonic, nitric, hydrochloric, fluorosilicate, and pyrophosphate aqueous electrolytes. Bi can be electrodeposited at temperatures of 18 – 25 °C from the aqueous solutions, containing in g/l:

- a) Example #1. Sodium bismuthate – 60, hydrochloric acid – 200 ml/l, glue - 2 at current density of 5–27 mA/cm<sup>2</sup> with current efficiency of 97-100%.
- b) Example #2. Bismuth nitrate – 75, glycerol – 125, potassium hydroxide – 65, tartaric acid – 50 at current density of 3 – 5 mA/cm<sup>2</sup> with current efficiency of ~100% or bismuth nitrate – 80, ethylene diamine tetraacetic acid (EDTA) – 90, 5-sulfosalicylic acid – 120, potassium sodium tartrate – 75 and potassium chloride – 75 at pH of 8-9 [1].
- c) Example #3. Bismuth fluoroborate – 75 and fluoroboric acid – 90 at current density of 1-16 mA/cm<sup>2</sup>.
- d) Example #4. Bismuth chloride – 30, potassium pyrophosphate – 210, hydrochloric acid – 95, EDTA – 165, dextrin – 7 at current density of 5-10 mA/cm<sup>2</sup>.

Bismuth and bismuth telluride can be also electrodeposited from choline chloride-oxalic acid ionic liquid at temperature of 60 °C [2].

### Applications

The primary use of bismuth metal is in making alloys. Many bismuth alloys have low melting points. There is increasing interest in using bismuth as a substitute for lead in alloys. Bi has been also used in pharmaceuticals, pigments, cosmetics and other chemicals. Bi films possessed many applications in electrochromic devices, environmental detection, catalysis, superconductivity, thermoelectric, and piezoelectric [1-5].

### References:

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