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Tantalum (Ta^{73})

Properties

Tantalum is a blue-gray, lustrous transition metal with an atomic mass of 180.95 u. Tantalum has a density of 16.69 g/cm^3, a melting point of 3017 ^{o}C and a resistivity of 13.1 μOhm cm. It is hard and has a Brinell hardness of 440 – 3430 MPa.

Tantalum forms compounds in oxidation states -III to +V. Most commonly encountered are oxides of Ta(V), which includes all minerals. Its standard electrode potential in respect to Ta^{+3} is -0.6V. Tantalum is highly corrosion-resistant. At temperatures below 150 °C tantalum is almost completely immune to attack by the normally aggressive aqua regia. It can be dissolved with hydrofluoric acid or acidic solutions containing the fluoride ion and sulfur trioxide, as well as with a solution of potassium hydroxide. Its abundance has been estimated to be ~ 2 parts per million (ppm) of the Earth's crust.

Plating Solutions

The electrodeposition of reactive metals such as aluminum (Al), magnesium (Mg) and tantalum (Ta) from aqueous solutions is impossible causing hydrogen evolution to occur at the cathode, due to the narrow potential window in aqueous solutions.

Electrodeposition from fused salt electrolytes is a general plating technique for the majority of electronegative refractory metals (Ta, Nb, Mo, W, Zr, Hf, Ti, V et al) [1]. It is the most practical method, which can yield thick, high purity, coherent and dense coatings. The process consists essentially of electroplating from a bath composed of fluoride compound of the refractory metal dissolved in a fused eutectic mixture of LiF, KF and NaF in the temperature range of 600-850 ^{o}C and current density range of 5-125 ma/cm^2. For examples, Ta can be deposited in a 61 mol% LiF–39 mol% NaF melt containing 1 mol% K_2TaF_7 at temperature of 800 °C and current density of 5 mA/cm^2 [2].

Tantalum can be also electroplated from ionic liquids, for example, 1-butyl-1-methyl-pyrrolidinium bis(trifluoromethylsulfonyl)imide ([BMP]Tf_2N) containing TaF_5 as a source of tantalum at temperature of 200 ^{o}C [3]. Tantalum nano-clusters can be electrodeposited in non-aqueous solutions, for example, acetonitrile at room temperature [4].

Applications

Its main use today is in tantalum capacitors in electronic equipment such as mobile phones, DVD players, video game systems and computers. Tantalum is also used to produce a variety of alloys that have high melting points, strength, and ductility. Alloyed with other metals, it is used in making carbide tools for metalworking equipment and in the production of super alloys for jet engine components, chemical process equipment, nuclear reactors, missile parts, heat exchangers, tanks, and vessels. The high melting point and oxidation resistance lead to the use of the metal in the production of vacuum furnace parts. Tantalum and tantalum nitride are widely used in semiconductor technology as a barrier layers for copper interconnects.

References:

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4. A. Jo, Y. Lee, and C. Lee. *Analytica Chimica Acta* **933**, 59-65, 2016.

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