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Titanium (Ti^{22})

Properties

Titanium is a silvery-gray metal with an atomic mass of 47.9 u. Ti has a density of 4.5 g/cm^3, a melting point of 1668 ^{o}C and a resistivity of ~42 μOhm cm. Ti has high ultimate tensile strength of ~ 434 MPa. Titanium is 60% denser than aluminum, but more than twice as strong. It is hard and has a Brinell hardness of 716 – 2770 MPa.

Titanium forms chemical compounds in oxidation states +2, +3, and +4. Its standard electrode potential in respect to Ti^{+2} is -1.63V, Ti^{+3} is -1.2B and Ti^{+4} is -1.9B. Atmospheric passivation gives titanium excellent corrosion resistance, almost equivalent to platinum. Ti is withstanding attack by dilute sulfuric and hydrochloric acids, alkaline bases, chloride solutions, and most organic acids. However, it is corroded by concentrated acids. Titanium is the seventh-most abundant metal (~0.63% by mass in Earth's crust).

Plating Solutions

Titanium can be electrodeposited in aqueous solutions, containing in g/l:

a) Example #1. Titanium hydroxide – 100, hydrofluoric acid – 250, boric acid – 100, ammonium fluoride - 50 at pH 3 - 3.4, temperature of 20 - 50 ^{o}C and current density of 20 - 30 mA/cm^2.
b) Example #2. Titanium hydroxide – 100, hydrochloric acid – 45, ammonium chloride - 110 at pH 4 - 4.5, temperature of 30 - 50 ^{o}C and current density of 30 - 40 mA/cm^2.
c) Example #2. Sodium metatitanate – 70, sodium acetate – 30, sodium hydroxide - 30 at temperature of 30 - 70 ^{o}C and current density of 10 - 50 mA/cm^2.

Titanium can be also deposited from molten salt of sodium chloride containing 15 – 17% of potassium titan fluoride at temperature of 800 – 900 ^{o}C and current density of 500 – 5000 mA/cm^2. Electrodeposition of titanium-alluminum alloys can be performed Lewis acidic AlCl3-1-ethyl-3-methylimidazolium chloride (AlCl3-EtMeImCl) molten salt at ~ 80 ^{o}C (353.2 K) [1].

Room temperature ionic liquids have wide electrochemical windows of up to ±3 V vs. NHE and good ionic conductivity combined with extremely low vapour pressures. Room temperature ionic liquids such as 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)amide ([EMIm]Tf_2N), 1-butyl- 1-methylpyrrolidinium bis(trifluoromethyl-sulfonyl)amide ([BMP]Tf_2N), and trihexyltetradecyl-phosphonium bis(trifluoromethylsulfonyl) amide ([$P_{14,6,6,6}$]Tf_2N) were used to electrodeposit titanium from its halides ($TiCl_4$, TiF_4, TiI_4) [2].

Applications

Titanium found applications in industrial, aerospace, automobile, recreational, medical and other industries. Titanium is used in steel as an alloying element to reduce grain size and as a deoxidizer, and in stainless steel to reduce carbon content. Ti is often alloyed with Al (to refine grain size), V, Cu (to harden), Fe, Mn, Mo and other metals. About 95% of all titanium ore is destined for refinement into titanium dioxide (TiO_2), an intensely white permanent pigment used in paints, paper, toothpaste, and plastic. Titanium nitride (TiN) has a hardness equivalent to sapphire and is often used to coat cutting tools. It is also used as a gold-colored decorative finish and as a barrier layer in semiconductor technology. Titanium carbide, which is also very hard, is found in cutting tools and coatings.

References:

1. T. Tsuda, C.L. Hussey, G.R. Stafford, and J.E. Bonevich. *J. Electrochem. Soc.* **150** (4), C234 – C243, 2003.
2. F. Endres et al. *Phys. Chem. Chem. Phys.* **10**, 2189-2199, 2008.

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