



Molybdenum (Mo⁴²)

Properties

Molybdenum is a silvery-gray metal with an atomic mass of 95.94 u. Mo has a density of 10.28 g/cm³, a melting point of 2623 °C and a resistivity of 5.34 μOhm cm. Mo has one of the lowest coefficient of thermal expansion (4.8 μm/(m·K)) among metals. It is hard and has a Brinell hardness of 1370 – 2500 MPa.

Molybdenum forms chemical compounds in oxidation states from -2 to +6. Its standard electrode potential in respect to Mo⁺³ is -0.2V and Mo⁺⁶ is 0B. Mo is chemically resistant in ambient atmosphere. Nitric acid and aqua regia (HNO₃:HCl=1:3) dissolve molybdenum. Mo is hardly attacked by hydrochloric and sulfuric acid. Molybdenum abundance in earth's crust is estimated to be about 10 ppb.

Plating Solutions

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

- Example #1. Ammonium molybdate – 10, hydrofluoric acid - 25 at temperature of 15 - 25 °C and current density of 30 mA/cm² and Ammonium molybdate – 100, hydrofluoric acid – 10 at pH ~5, temperature of 40 °C and current density of 50 mA/cm².
- Example #2. Ammonium heptamolybdate – 4, ammonium acetate – 660, potassium acetate – 66 at pH ~ 6.75, temperature of ~ 30 °C and current density in the range of 200 – 350 mA/cm² [1]. Below current density of 200 mA/cm², no coating was observed on the cathode surface since whole current was consumed by the hydrogen evolution reaction.

Molybdenum can be electrodeposited in molten salts, containing in g/l: potassium molybdate – 25, potassium chloride – 37.5, sodium chloride – 37.5, at temperature of 600 °C and current density of 30 mA/cm².

Molybdenum can be successfully deposited with a number of other metals, such as nickel, cobalt and iron, in aqueous solution to form co-deposited alloy coating with up to ~82 wt% of Mo^[2].

Applications

The benefits of molybdenum's high level of hardness, high modulus of elasticity (330 GPa), high thermal conductivity (138 W mK⁻¹), low coefficient of expansion, low specific heat, high electrical conductivity, high wear and corrosion resistance are harnessed through alloying with other metals; engineering and stainless steels, and super alloys, accounts for around 86% of the metal's consumption. The molybdenum-based mixed oxides are also versatile catalysts in the chemical industry.

References:

1. R. Syed et al. *Surface & Coatings Technology* **261**, 15 – 20, 2015.
2. S. Sun and E.J. Podlaha. *J. Electrochem. Soc.* **159** (2), D97-D102, 2012.

CONTACT NANO3D SYSTEMS LLC TO FORMULATE MOLYBDENUM PLATING SOLUTION PER YOUR REQUIREMENTS