



Osmium (Os⁷⁶)

Properties

Osmium is a bluish-white transition metal in the platinum group with an atomic mass of 190.23 u. Os has a density of 22.59 g/cm³, a melting point of 3033 °C and a resistivity of 8.12 μOhm cm. It is hard, brittle with a Brinell hardness of 980 – 1350 MPa and Young's modulus of 462 GPa, which rivals that of diamond (443 GPa). Because of its hardness, brittleness, low vapor pressure (the lowest of the platinum-group metals), and very high melting point (the fourth highest of all elements, after only C, W and Re), solid osmium is difficult to machine, form, or work.

When annealed osmium is the hardest of the platinum group. It is attacked by nitric acid, aqua regia, and chlorine. For comparison, rhenium has a density of 21.2, a melting point of 3,167°C, is described as soft, is attacked by nitric acid but not other acids, and also chlorine, and bromine to a lesser extent. Ruthenium has a density of 12.26 and a melting point of 2,450°C, resists all acids but is soluble in hypochlorite. Iridium has a density of 22.42, a melting point of 2,240°C, and is very resistant to all acids, and to alkalis.

The most common compounds have osmium in the +2, +3, +4 and +8 states, while it also exists in other oxidation states such as -4, -2, -1, 0, +1, +5, +6, +7. Its standard electrode potential in respect to Os⁺² is +0.7V and +0.02V for Os⁺⁸. Os is one of the rarest elements with estimated average concentration of 50 parts per trillions (ppt) in the Earth's crust.

Plating Solutions

Osmium can be electrochemically deposited from both acidic and alkaline aqueous electrolytes, ^[1, 2] containing in g/l:

- Example #1. Osmium as metal – 8, hydrochloric acid – 73, ammonium chloride - 70 at temperature of 50-60 °C and current density of 5-10 mA/cm².
- Example #2. Osmium as metal – 12, potassium hydroxide – 30 at temperature of 30-60 °C and current density of 200 – 400 mA/cm² with plating rate of 0.7-1 μm/min.
- Example #3. Electrolyte for plating Os can be also prepared by reacting sulphamic acid with osmium nitrosyl complexes, in particular K₂[Os(NO)(OH)(NO₂)₄]. Bright osmium deposits are obtained in both acid and alkaline conditions. Below pH 7 the current efficiencies are low (~2%). For maximum current efficiency (8 to 12%), the preferred operating range is pH 12 to 14 when a deposition rate of 2 to 3 μm/hr can be achieved.

Applications

Because of the volatility and extreme toxicity of its oxide, osmium is rarely used in its pure state, but is instead often alloyed with other metals for high-wear applications. Osmium alloys such as osmiridium are very hard and, along with other platinum-group metals, are used in the tips of fountain pens, instrument pivots, and electrical contacts, as they can resist wear from frequent operation.

References:

1. T. Jones. *Metal Finishing* **100**(6), 84-90, 2002.
2. G.B. Kauffman. *Platinum Metal Rev.* **20**(4), 130, 1976.

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PER YOUR REQUIREMENTS***