RHENIUM

Rhenium is one of the refractory metals, but differs considerably in that it's crystal structure is close-packed hexagonal, as opposed to body-centered cubic for niobium, tantalum, molybdenum and tungsten. The ultimate tensile strength of rhenium is much higher at low temperatures than the other refractory metals and it is does not form a carbide but its vulnerability to oxidation at temperatures above approximately 600 °C limit its uses in its pure form. Rhenium is used for catalysts, thermocouples, x-ray tubes and targets, electrical contacts, filaments, and aerospace and nuclear applications. Rhenium is also used to increase ductility in tungsten and molybdenum alloys.

TYPICAL PROPERTIES:

Structure:

Crystal Structure: Close-packed hexagonal; a = 0.2761 nm; c = 0.4458 nm; c/a = 1.615
Minimum Interatomic Distance: 0.2746 nm

Mass:

Atomic Weight: 186.2
Density: 21.02 g/cm^3 at 20 °C

Thermal Properties:

Melting Point: 3180 °C
Boiling Point: 5627 °C
Coefficient of Linear Thermal Expansion: 6.6 *u*m/m · K from 20 to 100 °C; 6.8 *u*m/m · K from 20 to 1000 °C.
Specific Heat: 25.7 kJ/kg · K at 25 °C
Thermal Conductivity: 71.2 W/m · K at 20 °C

Latent Heat of Fusion: 178 kJ/kg
Latent Heat of Vaporization: 3417 kJ/kg
Recrystallization Temperature: 1200 to 1500 °C for 1 hour, depending on the purity of the metal and the amount of cold work.
Vapor Pressure: 1 x 10^{-6} mPa at 1525 °C

Electrical Properties:

Electrical Conductivity: 9.3% IACS
Electrical Resistivity: 193 n · m at 20 °C
Thermoelectric Potential versus Platinum: 2.31 mV at 500 °C
Work Function: 4.8 eV (as high as 5.5 eV on the 0001 orientation)

Magnetic Susceptibility: Volume, 863 x 10^{-6} mks

Thermal Neutron Absorption Cross Section: 85 b
Stable Isotopes: ^{185}Re, atomic weight 184.953, 37.4% abundant; ^{187}Re, atomic weight 186.956, 62.6% abundant.
Spectral Hemispherical Emittance: 42% for = nm from 0 to 2000 °C

Mechanical Properties:

True Stress at Unit Strain: 2.53 GPa at 20 °C
Tensile Strength: 1130 MPa at 20 °C
Yield Strength at 0.2% Offset: 317 MPa at 20 °C
Elongation: 24%

Hardness: Arc melted button, 135 HK; annealed rod, 270 HK; rod swaged 40% in cross-sectional area, 825 HK.
Strain-Hardening Exponent: 0.353

Shear Modulus: 155 GPa at 20 °C
Elastic Modulus: Tension, 460 GPa at 20 °C

Proportional Limit: 181 GPa
Poisson's Ratio: 0.49
Creep Strength (2200 °C): 10-h rupture stress, 20 MPa; 100-h rupture stress, 10 MPa

Chemical Properties:

General Resistance to Corrosion: Oxidation in air is catastrophic above approximately 600 °C due to the formation of rhenium heptoxide (Re_2O_7), which has a melting point of 363 °C. Rhenium is resistant to carburization (it does not form a carbide); it withstands arc corrosion well and has good wear resistance.

Resistance to Specific Agents: Rhenium is resistant to water cycle corrosion to high-temperature filaments in vacuum; to sulfuric acid and hydrochloric acid (but can be dissolved by nitric acid); to aqua regia at room temperature; to liquid alkali metal corrosion; and to attack by molten zinc, silver, copper, and aluminum.

Fabrication Characteristics:

Consolidation: Rhenium can be consolidated by powder metallurgy techniques, inter-atmosphere arc melting, and thermal decomposition of volatile halides. The powder metallurgy product is usually made by pressing bars at 2000 MPa, followed by vacuum presintering at 1200 °C and hydrogen sintering at 2700 °C.

Hot Fabrication: Rhenium cannot be hot worked in air due to penetration of Re_2O_7 into the grain boundaries, which causes hot shortness.

Cold Fabrication: Rhenium has excellent room-temperature ductility; however, because of its high work-hardening coefficient, it must be annealed frequently in hydrogen for 1 to 2 hours at 1700 °C between cold-working reduction steps. Primary working is by rolling, swaging, or forging. Wire drawing has been done. Strip and wire as thin as 2 mils are possible.

Welding: Rhenium can be welded, soldered, or brazed by conventional means. Welds made by inert-gas or electron beam methods are extremely ductile and can be formed further at room temperature.