Materials

Tungsten

Tungsten, from the Swedish word meaning heavy stone, is provided in four basic forms, undoped and doped for filaments, high density and porous for chamber and electrode components. It has the highest melting point of all metals at 3410 degrees C and is a copious emitter of electrons at temperatures above 2300 degrees K.

The terms undoped and doped are generic designations for what raw material suppliers may refer to as sag or non-sag, pure or VM, WUX or WK tungsten. In each of these cases, the second term refers to industry standard doping of commercially pure tungsten wire with small amounts of aluminum-potassium silicate. Potassium provided in this form protects against excessive crystallized grain growth across the diameter of the wire. Filaments doped in this way have added strength to counteract operational stresses in unsupported applications such as in the Freeman ion source. Due to their larger size, lower operating temperature, and strength, arc chamber components and electrodes have little need for this type of doping. The following table lists typical chemistry of undoped and doped tungsten wire.

Material	Potassium	Aluminum	Silicon	Tungsten .
undoped	20ppm max	25ppm max	40ppm max	99.95% min
doped	100ppm max	60ppm max	60ppm max	99.95% min

Useful in many applications outside of the semiconductor industry, admixing pure tungsten with rhenium and thorium can effectively increase electron emission. These alternative doping methods are typically discounted in semiconductor applications due in large part to the undesirable nature of the dopant itself.

High-density, commercially pure tungsten has a density ~19.2g/cc and is used in most arc chamber and electrode configurations. Through engineered rolling and annealing processes, high grain aspect ratios can be formed within the high-density material to produce the greatest tensile properties. Porous tungsten, with a density ~16.4g/cc and limited grain structure, can be machined to complex forms with a high finish. Porous tungsten is typically used only where use of the higher strength, high-density, material is prohibitive due to machining considerations. Generally, both materials conform to the tungsten chemistries listed below. Although the AMS specifications for tungsten chemistries (7897 and 7898) are generally met, each raw material supplier may have slightly different conformance rules and quality level. Contact the Electro-Graph Engineering Department for a more detailed review of individual needs.

Aluminum	20ppm max	Calcium	30ppm max
Chromium	20ppm max	Copper	20ppm max
Iron	30ppm max	Lead	20ppm max
Magnesium	20ppm max	Manganese	20ppm max
Nickel	30ppm max	Silicon	20ppm max
Tin	20ppm max	Titanium	20ppm max
Carbon	50ppm max	Tungsten	99.95 min

Typical applications: Undoped – Plasma Flood Systems, Limited Application to Bernas Source and IHC Ion Sources; Doped – Freeman Ion Source, Bernas Ion Source, IHC (ELS) Ion Source; High-Density: Arc Chamber Components, Reflector Plates, Electrodes; Porous: Highly Machined Components.

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