METALCUTTING
CORPORATION

A Comparative Analysis of the Properties of Tungsten for Medical Device Applications

An analysis of the properties, processes and applications of tungsten as compared to various precious metals to help medtech professionals make informed and cost-conscious materials.

Choosing a sourcing or contract partner can be a daunting task when your requirements include biocompatibility, fatigue resistance and radiopacity.

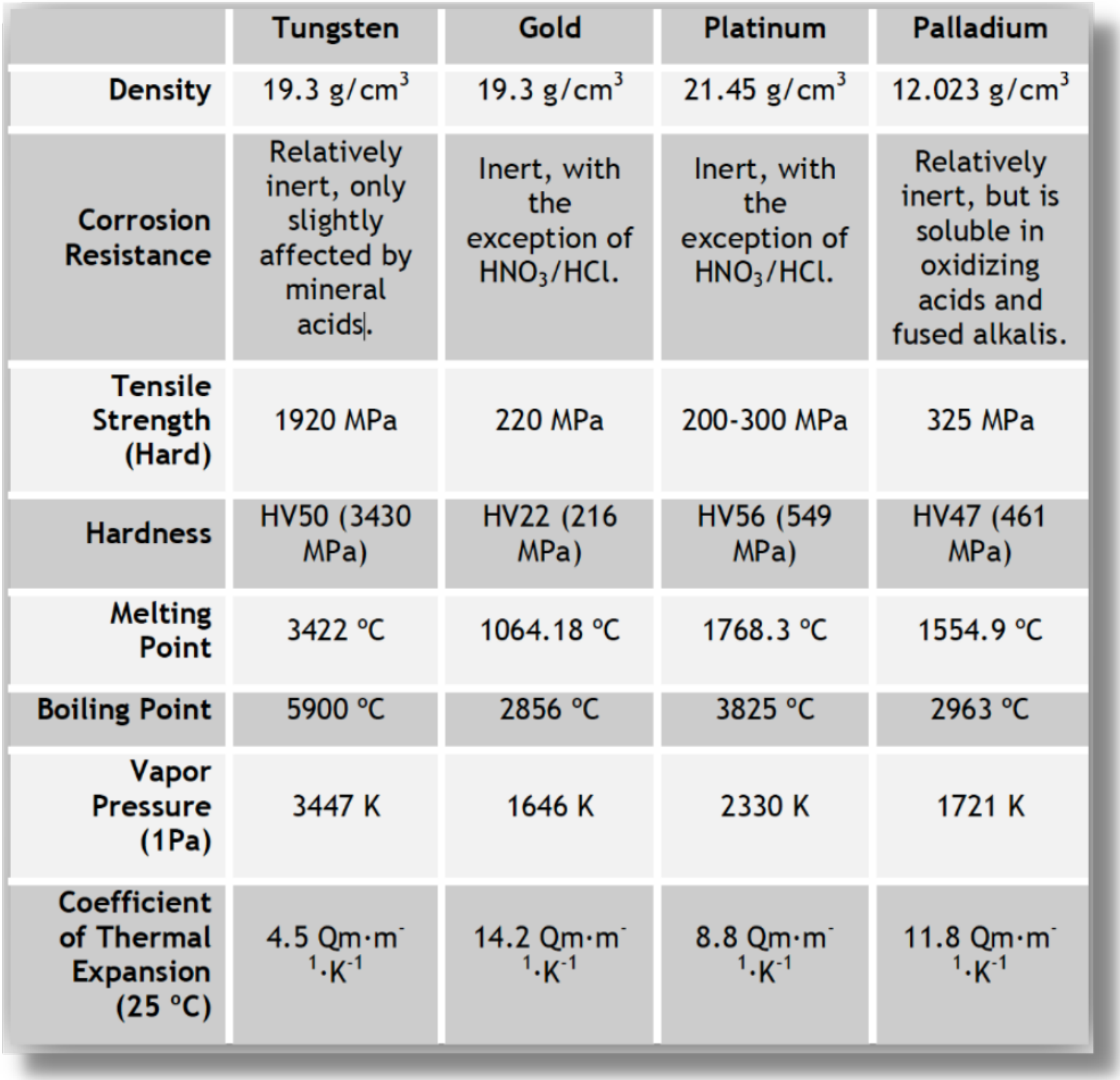
INTRODUCTION

As the medical device community continues to endeavor for safer, longer lasting and less cumbersome devices, so too must the sourcing partners that serve it. Implantable and minimally invasive device applications require materials that, at materials that, at a minimum, possess structural integrity and biocompatibility. But as engineers push the limits of device functionality, sourcing and contract partners must stay ahead of the curve in order to provide materials with secondary characteristics that go beyond mere biocompatibility.

Specialty metals for stent applications should be flexible, yet still hold shape, while orthopedic applications require increased fatigue resistance and load bearing capability. And then there's radiopacity. Guide wires, CRM and deep brain studies necessitate imaging with virtually no margin of error. Often 'specialty metals' for these types of applications is synonymous with precious metals. With the increasing price of gold and similar metals device design teams are forced either to stretch budgets and timelines thin, or make difficult compromises down the supply chain.

UNDERSTANDING THE PROPERTIES OF TUNGSTEN

So, what's a device maker to do? Wait for the price of precious metals to go down? Or compromise critical device functionality, or worse quality? In devices where strength, fatigue resistance and secondary characteristics such as radiopacity are critical there is an alternative.



	Tungsten	**Gold**	**Platinum**	**Palladium**
Density	19.3 g/cm^3	19.3 g/cm^3	21.45 g/cm^3	12.023 g/cm^3
Corrosion Resistance	Relatively inert, only slightly affected by mineral acids.	Inert, with the exception of HNO$_3$/HCl.	Inert, with the exception of HNO$_3$/HCl.	Relatively inert, but is soluble in oxidizing acids and fused alkalis.
Tensile Strength (Hard)	1920 MPa	220 MPa	200-300 MPa	325 MPa
Hardness	HV50 (3430 MPa)	HV22 (216 MPa)	HV56 (549 MPa)	HV47 (461 MPa)
Melting Point	3422 °C	1064.18 °C	1768.3 °C	1554.9 °C
Boiling Point	5900 °C	2856 °C	3825 °C	2963 °C
Vapor Pressure (1Pa)	3447 K	1646 K	2330 K	1721 K
Coefficient of Thermal Expansion (25 °C)	4.5 Qm·m^{-1}·K^{-1}	14.2 Qm·m^{-1}·K^{-1}	8.8 Qm·m^{-1}·K^{-1}	11.8 Qm·m^{-1}·K^{-1}

Because the density of tungsten is equivalent to gold at 19.3 g/cm3 (only slightly less than platinum, and significantly higher than palladium), it has become an attractive alternative at a fraction of the cost. Unlike precious metals, tungsten remains unaffected by speculative pricing and is thus a cost-effective replacement for gold, platinum and palladium alloys.

Tungsten is corrosion resistant, being only slightly affected by most mineral acids. And for some of the added biocompatibility attributes of pure gold, wire can be gold plated with plating thicknesses from 0.3µ to 1.5µ typically available.

In addition, tungsten’s tensile strength is significantly higher than other radiopaque metals, maintaining 2400-3600 N/mm2 at over 1000° C, at diameters as low as 0.0004” (0.01 mm).

Tungsten also has a hardness of HV350 (3430 MPa), while platinum has a hardness of HV56 (549 MPa) and gold just HV22 (216 MPa).

This combination of hardness and tensile strength make for an overall material toughness that results in stiffer coils and more steerable braids, thus it is used extensively for coil tips, guide wires, electrodes and probes.

Tungsten is also largely unaffected by temperature with the highest melting point of any metal, at 3422° C and a boiling point of 5900° C.

And it has the lowest vapor pressure and coefficient of thermal expansion of any pure form metal. The combination of low thermal expansion, high melting point and strength at small diameters makes it ideal for applications where a material’s ability to resist the stresses exerted by bodily process is critical.

CHOOSING A SUPPLIER

Notably, however, standard tungsten machining can cause a deformation of the elongated grain structure (a characteristic of wrought tungsten) known as delamination, ultimately resulting in device failures.

At the performance level, the implications for such could be devastating. As a result it is crucial that device makers choose a sourcing partner with advanced production methods that ensure no delamination occurs during the standard cutting, drawing, rolling, grinding, and machining, in order to maintain the integrity of the material while achieving exceptional quality and accuracy.

And for increased biocompatibility secondary processes can be applied, including passivation (per ASTM A967) and sandblasting.

As quality is imperative in implantable, fluoroscopic and minimally invasive devices, contract manufacturers should be ISO 9001:2008 certified (or higher), offer cleanroom metrology, 100% mechanical inspection and camera vision inspection to ensure all customer specifications and quality standards are achieved.

APPLICATIONS

Tungsten tight tolerance components, including small diameter tubes, pins, probes and wires are currently being used across a variety of medical applications such as minimally invasive neurology, interventional cardiology & radiology and peripheral vascular surgeries, as well as general medical applications like arthroscopy, ophthalmology and dental implants. More specifically, gold plated tungsten wire is commonly used in fluoroscopic and cauterization applications, as guide wires and probes, and in such procedures as endovascular intervention, in electrodes used in deep brain studies, and in some carotid procedures where confident placement is critical.

CONCLUSION

As biomaterials have continued to evolve, OEM’s have come to expect their contract partners to thoroughly understand how standard machining processes will affect a material’s end functionality. As a result, contract manufacturers and engineers must maintain a commitment to education and innovation in order to readily meet the market’s evolving demands. Metal Cutting was a pioneer in serving the minimally invasive device market and today, our advanced materials knowledge, continued dedication to expanding technical acumen, and over 40 years of experience has helped us establish a key position in the changing landscape of medical devices.

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ABOUT METAL CUTTING

Metal Cutting has been providing precision abrasive and EDM cutting, grinding, high finish polishing and lapping, and custom 4-axis CNC machining of all metals to the medical device community for over 30 years. Our processes are suited for virtually any metal, including the more difficult metals such as nitinol, titanium and the full range of stainless steel alloys often required for medical applications. We keep an extensive inventory of these and other commonly used medtech materials, and maintain a significantly large position in tungsten and molybdenum. And for all the rest, we have a network of experienced sourcing partners.

Metal Cutting Corporation
89 Commerce Road
Cedar Grove, NJ 07009
www.metalcutting.com

Phone 973 239 1100
Toll Free 800 783 6382
Fax 973 239 6651