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Heavy metal alloy on tungsten basis

The EU Directive 2011/65/EU (RoHS 2) regulates the use of certain hazardous substances in electrical and electronic equipment. Lead is ranked at the top of the list, even higher than mercury and cadmium. The heavy metal used as radiation shielding or for anti-scatter grids due to its high atomic mass is highly toxic and does not break down easily, which is why a weight proportion of only 0.1% is permitted in new electronic and electric equipment. It also has a low melting point of just 327°C, constituting an additional hazard in case of fire. The Bavarian company Wolfram Industrie offers an innovative, more environmentally friendly alternative with Triamet, a heavy metal alloy on a tungsten basis: thanks to its specific high density and the resulting radiation absorption capacity, the dimensionally stable product that is available in both an iron-nickel and a copper-nickel binder phase even shields against gamma radiation. While tungsten is normally difficult to process, it can be shaped into blanks using a powder-metallurgical process in this form. Subsequently these blanks can be processed further with little effort.

Since tungsten is a very dense and heavy material with a density almost as high as gold, it is particularly well suited for restricting beam inlets in collimators or shielding against high-energy electromagnetic radiation. Dangerous gamma radiation and X-rays in particular can be contained thanks to the very high absorption value of the metal powder mixture.

Due to the high melting point of Triamet at more than 1,000°C, which is much higher compared to lead, there is no risk of melting in case of a fire. However, only powder-metallurgical processing is possible due to this special characteristic: for the production of Triamet, tungsten powder is mixed with iron and nickel or copper and nickel powders. Subsequent shaping is either realised hydraulically with binding agents and a press or isostatically under great pressure of 2,000 to 3,000 bar. The former is suitable for smaller dimensions, the latter for large-scale components. The resulting green parts are sintered into semi-finished products in an electrically heated vacuum oven or in a reduced hydrogen atmosphere.

Wolfram Industrie uses a nickel and iron binder phase for the production of Triamet, added to the tungsten powder at the rate of 3 to 10%. Nickel acts as a catalyst that accelerates diffusion processes on the surface of the tungsten powder and thereby reduces the sintering temperature by about 1,000°C. Subsequently the Triamet green parts are sintered at about 1,500°C – in contrast to the 2,500°C required for pure tungsten – so that a unique microstructure with a spherical tungsten phase encaulded by the binder phase is formed.

"Wolfram Industrie produces Triamet with a very high density," reports Dipl.-Ing. Wolfgang Jung, the metal expert responsible for research and development. It is declared at G19 and is about 18.8 ± 0.2 g/cm³. A maximum density of 19.3 can be achieved with pure tungsten – which in fact is about 8 g/cm³ higher than lead. The lower the proportion of the binder phase the higher the density will be. With the G14 version of the product for example, the minimum density is 13.9 ± 0.2 g/cm³. "Our material developments are based on a good mix of our empirical experience and theoretical insights," Jung explains. "Often the idea for a new material or a new process emerges through cooperation with our customers. As a rule there are clear requirements here. Cooperation with universities is also very valuable to us for implementation."

A mixture of tungsten granulate and epoxy resin is used as a backing material in ultrasound heads (transducers) to minimise interfering acoustic reflections. Here the acoustic impedance of the backing material is increased by adding tungsten. Triamet is used in radiation therapy to shield against hard gamma radiation. "Radioactive seeds that are delivered to a tumour and subsequently removed again during HDR brachytherapy can be stored in containers made of Triamet," Jung explains. Shielding phials for radiopharmaceuticals to reduce the radiation exposure of employees constitute another possible application. It is also suitable for isotope containers thanks to its
dimensional stability that ensures easy cleaning and sterilisation. Tungsten is atoxic and not environmentally hazardous according to its RoHS conformity, so that no coating is required. In addition to shielding elements for medical diagnostics and radiation therapy, Triamet can also be used as a material for microprobes and electron microscopes. Compared to lead frequently used for these applications in the past, space-saving Triamet that meets the requirements according to ASTM B777 also does not need any supporting structure due to its high resistance.

Triamet is available as an S and G-material. The binder phase of the former consists of copper and nickel. It is paramagnetic and only weakly magnetisable, making it suitable for use in the proximity of stronger magnetic fields, for example in magnetic resonance tomographs. The binder phase of the G-material is made of iron-nickel compounds and, in contrast to the S-material, is ferromagnetic.

Aside from medical technology applications, Triamet is often used as a counter-weight or balancing weight in the automobile industry and also in aluminium casting due to its very good durability and extremely low wear. The product is used in mechanical engineering and plant construction as well because Triamet with its high modulus of elasticity and the microstructure typical for sintered materials has excellent damping characteristics, making it capable of considerably reducing vibrations. Compared to steel, the Triamet work pieces with 340-390 GPa have a modulus of elasticity almost twice that of the commonly used V2A steel with 200 GPa. This reduces deflection under the same load by 40%. (According to press information from Gesellschaft für Wolfram Industrie mbH)

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