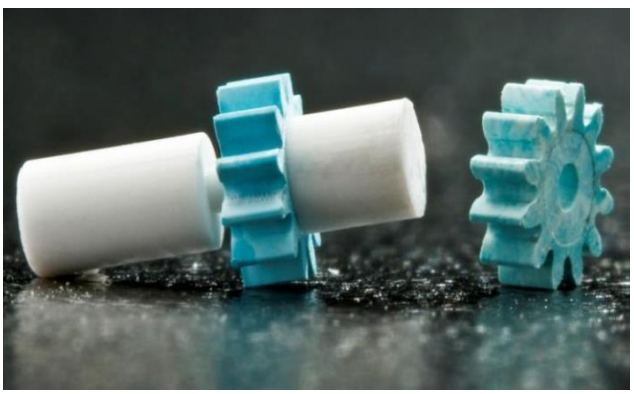
Powder Injection Molding for large scale tungsten alloys parts

Developed at KIT IAM-WK, this technology and know-how consist in metal or ceramic parts manufacturing via Powder Injection Molding and include the whole process chain (development, design and fabrication of a PIM tool, filling simulation, tailored feedstock preparation, injection molding, debinding and sintering. Manufacturing materials with high melting points, such as tungsten or doped (with oxides or carbides) tungsten materials with near-net shape precision and in medium to high volumes is a technology of interest for fusion, especially for plasma-facing material (for example Langmuir probes for the WEST project have been produced via PIM). Besides, this technology could find promising applications in solar ovens, power units but also for cost effective mass production of Carbide tools, electrodes, jewellery, turbine blades or in sports accessories: e.g. arrowheads (archery, darts)

Description of the technology

Powder Injection Molding (PIM) is a manufacturing process in powder metallurgy (PM) for shaping metals (Metal Injection Molding: MIM) and ceramics (Ceramic Injection Molding: CIM) to near-net-shapes with reasonably tight tolerance and a good surface finish. The combination of an inorganic metal or ceramic powder with a small quantity of a polymer - a so-called feedstock - can be molded. After shaping the green part (consisting of powder and binder), the polymeric binder must be extracted and the powder sintered to the near-theoretical density. Materials with high melting points, such as tungsten or doped (with oxides or carbides) tungsten materials, could be effectively fabricated using this process.

Fig. 1: Langmuir probes for the WEST project produced via PIM @ KIT



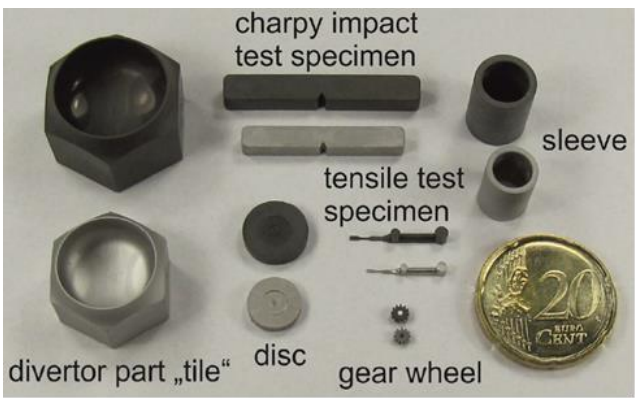


Fig. 2: Smallest ZrO2 gear wheel of the world: outer-Ø 275 µm

EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

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Innovation and advantages of the offer

The properties of such manufactured pure tungsten parts are high density >98% theoretical density (T.D.), high hardness and a microstructure without cracks or pores. This process is very effective and has several advantages such as : near-net shape precision, cost saving compared to conventional machining, large scale production in medium to high volumes (10,000 to over 2,000,000 parts annually), creation of prototype material and tailoring of new composition

Non-fusion Applications

Powder Injection Molding is suitable where cost effective mass production of tungsten parts or parts made of tungsten alloys is desired. Examples of this are Carbide tools, Electrodes, Jewelry, Turbine blades and Sports accessories: arrowheads (archery, darts)

EUROfusion Heritage

In the framework of the European material development programme, for fusion power plants beyond the international thermonuclear experimental reactor (ITER), tungsten is being considered as a potential plasma-facing material. This has favourable properties such as a high melting point of 3,422 °C (3,695 K), high strength and high thermal conductivity (173 Wm-1K-1 at room temperature), low tritium inventory, low thermal expansion, low activation, low erosion rate and high heat resistance. But the use of tungsten and tungsten alloys are limited by recrystallization and ductile to brittle transition. Also an interesting point is the time and cost aspect for manufacturing. Because the production of tungsten parts with conventional technologies is extremely time and cost intensive. A promising fabrication method in view of large-scale production of tungsten parts is Powder Injection Molding (PIM). With its high near-net-shape precision its offers the advantage of cost-saving compared to conventional machining. PIM as special process allows the mass production of components, the joining of different materials without brazing and the creation of composite and prototype materials, and is an ideal tool for scientific investigations. Like for example, the addition of oxide or carbide particles into the tungsten matrix enhanced the mechanical properties such as ductility and strength in comparison to pure tungsten. One of the possibilities for manufacturing of parts is shown by the latest produced samples for diagnostics for the French tokamak WEST.

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