FUSION TECHNOLOGY DESCRIPTION

EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

Tungsten-based semi-finished products with high toughness, ductility, strength, and thermal conductivity

Scientists at KIT have developed a strong know-how in the production of tungsten laminate semi-finished products for plates, pipes or foils. They are used for W-Cu Laminated cooling Pipes, Helium Cooled High Heat Flux Mock-ups and has found application in fusion under EFDA programme (Tungsten laminate pipes for Innovative High Temperature Energy Conversion Systems or structural divertor applications for example). This expertise offers the possibility to produce ductile/tough tungsten materials with high thermal conductivity and high strength. The innovative approach by laminating tungsten foils to semi-finished products opens a new materials class that enables various applications in cooling, energy conversion technology or structural/functional high-temperature applications in vacuum or inert gas.

Description of the technology

Tungsten has one major drawback which is its low fracture toughness at room temperature (RT) or its high brittle-to-ductile transition temperature (BDTT). However, by cold working, the BDTT can be shifted to lower temperatures. At the extreme, this results in a tungsten foil with a BDTT below -120°C combined with a RT fracture toughness of 70 MPa m1/2 and tensile strength higher than 4 GPa.

By rolling up and joining a tungsten foil, tungsten laminate pipes can be synthesized that can dissipate at least 20 J in a Charpy KLST impact test at RT and survive a burst test at RT at 1000 bar without any residual damage. The technical readiness of these W laminate pipes is approved by high heat flux tests performed at the Plataforma Solar de Almería, Spain, as well as at the Max Planck Institute of Plasma Physics, Garching, Germany.

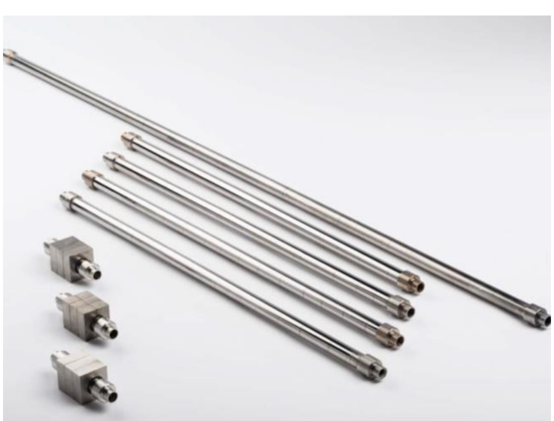

Fig. 1: W-Cu laminated pipes Helium cooled Divertor

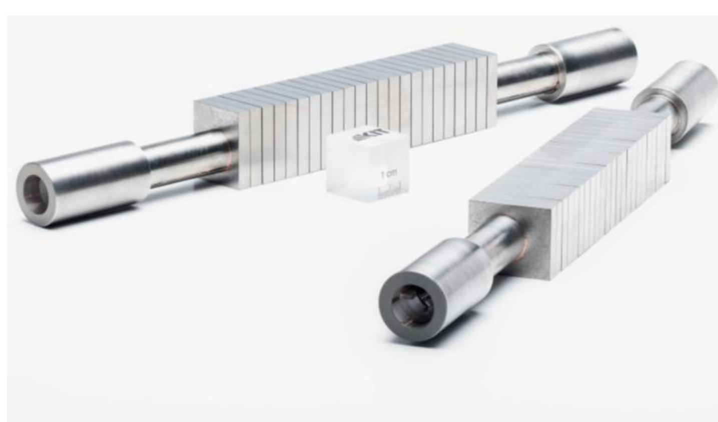

Fig. 2: Helium cooled Divertor

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Innovation and advantages of the offer

This expertise offers the possibility to produce ductile/tough tungsten materials with high thermal conductivity and high strength. Test result gives 8 MW/m2, 1000 cycles (5 min. on, 5 min. off): no failure. Surface temperature (max.): 1200 °C. Helium inlet: 400 °C, 80 bar, 70 g/s

Non-fusion Applications

The innovative approach by laminating tungsten foils to semi-finished products opens a new materials class that enables various applications in cooling, energy conversion technology or structural/functional high-temperature applications in vacuum or inert gas. Further application areas are space, such as for electric propulsion components made of tungsten, as well as (test) facilities outside the fusion domain but subject to high temperature and/or pressure regimes. The technology is also applicable to liquid metal transport e.g. use in new solar farms.

State of the art and outlook

- W-Cu Laminates: plates – pipes – components
- Tungsten sheet with a BDT temperature of -65°C is available
- Example: 50 µm foil, tensile strength 5.6 GPa, fracture toughness 120 MPa m ^0.5
- Future product: heavy cold rolling – stabilizing the microstructure – diffusion bonding
- Applications: Armor & Structure

EUROfusion Heritage

The refractory metal foils was developed at the Karlsruhe Institute of Technology (KIT) to produce Tungsten laminate pipes for example for Innovative High Temperature Energy Conversion Systems or for structural divertor applications. It has been supported by EFDA and was successfully tested and patented. It shows superior performance, i.e. significantly higher ductility and resistance at high temperatures and/or pressure compared to conventional metal tubes.

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