Interfacial optimization of tungsten fibre reinforced copper for high-temperature heat sink material for fusion application

A. Herrmann\textsuperscript{a}, K. Schmid\textsuperscript{a}, M. Balden\textsuperscript{b} and H. Bolt\textsuperscript{b}

\textsuperscript{a}IPP Garching, Max-Planck-Institut für Plasmaphysik, Boltzmannstrasse, 2, D-85748 GARCHING, Germany
\textsuperscript{b}Max-Planck Institut für Plasmaphysik, Boltzmannstrasse 2, D-85748 Garching, Germany

aurelia.herrmann@ipp.mpg.de

In a fusion reactor the fusion plasma leads to a heat flux of up to 20 MW/m\textsuperscript{2} in the divertor region. The heat has to be removed efficiently from the plasma facing material (PFM) through the copper based heat sink to the cooling channels. Depending on the divertor design, this will lead to temperatures of up to 550\textdegree C at the interface between PFM (W, C) and heat sink material (CuCrZr). Due to the temperature gradient and different coefficients of thermal expansion, high stresses occur at the interface of PFM and CuCrZr. Metal Matrix Composites (MMC), like tungsten fibre reinforced copper, has the potential to strengthen this zone without dramatic loss of the thermal conductivity and thereby serve as a material for the interlayer of the heat sinks in future fusion reactors.

The synthesis of the metal matrix composite is performed applying the Matrix-Coated- Fibre (MCF) procedure. A stable interface between the tungsten fibre and the copper matrix is a basic requirement. The interfacial properties were investigated through pull-out measurements of single coated fibres for three different interfacial concepts: a) pure tungsten fibres directly bonded to the electroplated copper matrix; b) tungsten fibres deposited with a thin copper interlayer by magnetron sputtered and then connected to the matrix; and c) tungsten fibre deposited with a graded transition to the copper matrix by magnetron sputtering. From the pull out experiments the following interfacial shear strengths are determined: a) 26 MPa, b) 69 MPa and c) 21 MPa. Additionally, microstructing of the tungsten fibre is performed to achieve the optimum mechanical gearing. To understand the reactions between W and Cu at the interface during the synthesis process of the MMC, dedicated interdiffusion and segregation experiments are performed. Utilizing Rutherford Backscattering Spectrometry (RBS), concentration profiles of W and Cu at 500\textdegree C, 650\textdegree C, 800\textdegree C and 900\textdegree C are measured.

Number of words in abstract: 303
Keywords:
Technical area: 31. Developing fusion materials Ferritic/martensitic and ODS steels
Special session: Not specified
Presentation: No preference
Special equipment: No special equipment