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High energy synchrotron radiation for the development of tungsten fibre-reinforced tungsten composites

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Due to its unique property combination, tungsten would be the ideal material for the highly loaded areas in a future fusion power plant. However, tungsten is brittle up to very high temperatures and prone to operational embrittlement. Tungsten fibre-reinforced tungsten composites utilize extrinsic toughening mechanisms similar to ceramic fibre-reinforced ceramics and therefore can overcome the brittleness problem of tungsten. The proof that this principle can solve the mentioned problems was conducted in the past years.
In this contribution, we present the use of high energy synchrotron radiation in this process. The mechanisms leading to improved toughness have been characterized during mechanical tests in combination with high resolution high energy synchrotron tomography at the ESRF in Grenoble. Both tension and bending tests have been performed for the case of ductile (as-fabricated) as well as the brittle (heat treated) W fibres on model systems containing a single fibre surrounded by a tungsten matrix. A spatial resolution down to 3 µm allowed a clear identification of active toughening mechanisms and their evolution during the test. The tomographic study in combination with a detailed comparison to analytical methods allowed a correlation of macroscopic material behaviour to microscopic mechanisms. Furthermore, we will present the first results of the analysis of residual stress present in the material after fabrication by synchrotron diffraction studies.

Primary author: Mr RIESCH, Johann (Max-Planck-Institut für Plasmaphysik)

Co-authors: Mr BUFFIERE, Jean-Yves (GEMPPM INSA Lyon 20 Av. A); Mr COENEN, Jan (Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung –Plasmaphysik); Mr ELGETI, Stefan (Max-Planck--Institut für Plasmaphysik); Mr HÖSCHEN, Till (Max-Planck-Institut für Plasmaphysik); Mr JASPER, Bruno (Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung –Plasmaphysik); Mr LE BOURLOT, Christophe (GEMPPM INSA Lyon); Mr LINSMEIER, Christian (Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung –Plasmaphysik); LUDWIG, Wolfgang (GEMPPM INSA Lyon); DI MICHIEL, Marco (European Synchrotron Radiation Facility); Mr SCHEEL, Mario (Synchrotron Soleil); Mr YOU, Jeong-Ha (Max--Planck-Institut für Plasmaphysik); Mr NEU, Rudolf (Max-Planck-Institut für Plasmaphysik)

Presenter: Mr RIESCH, Johann (Max-Planck-Institut für Plasmaphysik)

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