

Functionally graded tungsten/EUROFER97 interlayers for joints in helium-cooled divertor components

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Tungsten and tungsten alloys are promising candidates for plasma facing components, and are therefore used in the current helium cooled divertor design, which is developed at KIT. However, a joint to other ductile materials, such as the ferritic-martensitic steel EUROFER97 or ODS-EUROFER, is necessary. One of the most difficult problems when joining materials with different thermal expansion coefficients are thermal induced stresses that lead to the failure of the joint. The approach taken for the reduction of thermal induced stresses is the placement of a functionally graded layer between the materials to be joined.

The potential of such a graded tungsten/EUROFER97 joint has been examined by FEM [1], where elasto-viscoplastic simulations have been performed by varying the layer thickness, layer orientation and shape. The resulting stresses and strains were used as basis for lifetime estimation and for optimization of joining parameters.

Three production methods (magnetron sputtering, vacuum plasma spraying and resistance sintering under ultrahigh pressure) have been investigated for their capability in producing functionally graded tungsten/EUROFER97 layers [2,3]. In a first step, non-graded samples with different mixing ratios were produced and characterized by nanoindentation, macroindentation, X-ray diffraction and scanning electron microscopy. In a second step, the produced functionally graded layers were joined to EUROFER97 and, if necessary, to tungsten bulk-material by diffusion bonding. The bonding and the graded joints were microscopically characterized and exposed to thermal cycles between 20 °C and 650 °C. Results from this study show that these technologies are ideal for the synthesis of functionally graded tungsten/EUROFER97 interlayers.

[1] T. Weber, J. Aktaa, Numerical Assessment of Functionally Graded Tungsten/Steel Joints for Divertor Applications, *Fusion Engineering and Design* 86 (2011) 220-226.

[2] T. Weber, M. Stüber, S. Ulrich, R. Vaßen, W. W. Basuki, J. Lohmiller, W. Sittel, J. Aktaa, Functionally graded vacuum plasma sprayed and magnetron sputtered tungsten/EUROFER97 interlayers for joints in helium-cooled divertor components, *Journal of Nuclear Materials*, accepted manuscript.

[3] T. Weber, Z. Zhou, D. Qu, J. Aktaa, Resistance sintering under ultra high pressure of tungsten/EUROFER97 composites, *Journal of Nuclear Materials* 414 (2011) 19-22.

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