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Plasma-facing components based on tungsten fiber-reinforced tungsten composites

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For the first wall of the future fusion reactor, unique challenges on materials in extreme environments require advanced mechanical and thermal properties. Tungsten (W) is the main candidate material for the first wall of a fusion reactor, as it is resilient against erosion, has high melting point and thermal conductivity, and shows rather benign behavior under neutron irradiation. However, the intrinsic brittleness of tungsten is a concern with respect to the fusion environment with high transient heat loads. Additionally, neutron induced effects e.g. transmutation add to embrittlement and are crucial to material performance. To overcome the brittle issue of tungsten, tungsten fiber reinforced tungsten (Wf/W) composites are being developed relying on an extrinsic toughing principle.
Recently, progress has been made for upscaling the production by powder metallurgy (PM) routes. Using large scale spark plasma sintering facility, samples with a diameter of 105mm and a thickness of 30 mm can be produced based on the porous matrix Wf/W concept, allowing the preparation of mock-ups (both flat tile design and monoblocks) for high-heat flux testing. Additionally, a new breakthrough has been made in terms of unidirectional long fiber Wf/W using powder metallurgy process. By alternately placing W weaves and W powders in the graphite mold, unidirectional long fiber Wf/W composite material has been prepared through PM process. The newly developed material shows a significant improvement regarding the mechanical properties, compared to the short fiber Wf/W. Apart from manufacturing progress, for the development of plasma-facing components, the issues regarding material joining, plasma erosion, tritium permeation, and fuel retention have also been tackled.

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