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P4.124 High heat flux test results for a thermal break DEMO divertor target and subsequent design and manufacture development

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The European roadmap to fusion electricity attributes critical importance to the development of reliable plasma-facing component (PFC) technology. In the EUROfusion divertor project, a range of PFC concepts are explored, and two "Phases" of small-scale mock-up design, manufacture and high heat flux testing are underway. The rationale is to understand shortcomings revealed by the first phase in order to improve designs and manufacturing methods for the second phase. In this paper, we focus on the Thermal Break concept, which is an evolution of the ITER tungsten/CuCrZr monoblock design in which the copper interlayer has geometric features to reduce conductivity and stiffness thereby alleviating stress in the PFC. In Phase 1, six small-scale mock-ups of this design were subjected to high heat flux testing, with applied heat flux up to 25 MW/m^2 and thermal cycling of up to 500 cycles at 20 MW/m^2. Although all six mock-ups survived the campaign and maintained 20 MW/m^2 heat exhaust capability, at least two show signs of progressive damage. Detailed examination of these mock-ups was carried out to understand the damage mechanisms, using ultrasonic imaging, infrared thermography (SATIR), and destructive microscopy. Although there are signs of tungsten surface cracking, the predominant damage mode is not by "deep cracking" of monoblocks, but substantial permanent deformation of the interlayer features.

The results of the first phase manufacture and testing have informed the design and production of the second phase mock-ups. The manufacturing procedure has been updated to eliminate the need for one of the vacuum brazed joints, and the interlayer grooves have stress-relieving radii which are found by numerical analyses to significantly reduce the interlayer plastic strain range. Interlayer design parameters were selected following use of response surface-based design optimisation. Mock-ups of the new Phase 2 design are expected to be high heat flux tested during 2018.

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