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Recent development on upscaling functionally graded W/EUROFER coating for the DEMO First Wall application

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A functionally graded W/EUROFER coating has been planned as a protective layer for the structural material EUROFER of the DEMO First Wall. Tungsten has high thermal conductivity, high melting temperature, high sputtering resistance, and low neutron activation which makes it a suitable candidate for a protective layer over steel. The coefficient of thermal expansion mismatch between W and steel generates high thermal stress during the deposition and fusion applications, which can lead to failure/delamination of coatings. A functionally graded W/EUROFER layer has been introduced between top-coat W and steel substrate to solve this problem.
This work shows a recent development of functionally graded W/EUROFER coating over the First Wall relevant flat and curve structures of steel. A functionally graded W/EUROFER coating was deposited by a low-pressure plasma spraying process over the large flat and curved steel structure and the quality of the coating was evaluated. A phased array ultrasonic method was developed to evaluate the interface properties of the coating. Furthermore, structural and mechanical characterizations of these coatings were performed using cross-sectional images by scanning electron microscope and indentations. The performance of functionally graded W/EUROFER coating in fusion-relevant plasma exposure conditions was also evaluated using the linear plasma device PSI-2. The first set of experiments was performed by exposing the coating to Ne plasma to determine the sputtering of the coating as compared to bulk tungsten. The second set of experiments was performed by exposing it to deuterium plasma to evaluate the deuterium retention properties of coating as compared to bulk tungsten.
Castellation of coating was introduced as an additional method to further reduce the thermal stresses in the coatings. Finite element simulations were performed to determine the optimized castellation. Castellation of the straight coated sample was performed which shows the reduction in bending after castellation indicating the reduction in residual stresses. Afterwards, a thermal fatigue test was performed on the castellated sample and no crack/delamination was found till 5000 cycles which shows a successful castellation of coatings.