Evaluation of Interface Strength between Metal and Ceramics to be Utilized for Development of Fusion Reactor Components

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Coating and bonding techniques between different materials is essential to the field of technology including fusion reactor engineering. Protective coating layer on the structure materials would improve performance of components in the corrosive environment. The interfaces between different materials, typically metals and ceramics, are of interest from various field of engineering. Fundamental understanding of metal and ceramics interfaces would be a useful guideline to develop the advanced coating and bonding technique for fusion reactor components. Since self-cooled blanket design with liquid lithium is primarily considered when vanadium alloys would be used as structure materials for fusion reactor, it is vital issue to reduce pressure drop due to MHD force in magnetic field. Insulator coating inside of the lithium channel is major option to solve the issue. From successful assessments, $Y_2O_3$ and $Er_2O_3$ resulted in the prime candidates. Selection of coating method that can be applied to the complex structures like tubing channel and elbow are now under consideration. A good knowledge of the mechanical properties of the interface between the ceramics and vanadium base alloy is of essential for reliable design of the coating including their preparation methods. In this paper, yttrium oxide as prime candidate ceramics was selected for fundamental study of the metal and ceramics bonds in terms of their strength. Solid-state diffusion bonding at elevated temperature, DC-sputter coating of yttrium in oxidation atmosphere followed by heat treatment and low-vacuum plasma-spray coating were utilized to make $Y_2O_3$/Vanadium bonds. Strain due to the bonding process and crystallinity of the coating were evaluated by X-ray diffraction method. Micro-hardness of the coating was carried out. Heat treatment conditions of the coating were affected very much the magnitude of the strain and the crystallinity of the coating and the interface strength. Bonding behavior will be discussed compared with their interface strength measured by several techniques like scratch test and the ideal strength evaluated by the first-principles calculation.

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