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Preliminary development on a conceptual first wall for DEMO

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For a DEMO reactor, the first candidate material for plasma facing material(PFM) is tungsten(W) and current available structure material is reduced activation ferritic/martensitic (RAFM). And tungsten coating material is promising to be applied on first wall. Since chemical vapor deposition tungsten (CVD-W) has a higher density, less porosity and better thermal shock resistance, thick CVD-W coating is used as the plasma facing material here. Southwestern Institute of Physics (SWIP) has developed a new RAFM material, which is called CLF-1. The new conceptual first wall for DEMO in this work is designed and developed with CVD-W and CLF-1.

Due to different thermal expansion coefficients of tungsten and steel, CVD-W will detach from CLF-1 steel under heat load and plasma exposure if it is coated onto the CLF-1 directly. As a result, an interlayer must be applied to mitigate the stress between CVD-W and CLF-1. Furthermore, the tungsten will generate cracks under steady state and transient heat loads in reactors and crack in the tungsten will make tritium to penetrate into the substrate rapidly. Tritium accumulation is a critical parameter for reactors which is very important for safety and steady state operations.

The new conceptual first wall consists of CVD-W, CLF-1 and an interlayer between them. The interlayer is required to have good bonding property and tritium prevention, which is crucial for controlling the inventory buildup and maximizing the fuel efficiency. SiC and TiN applied as the interlayer between W and CLF-1 in the first wall are investigated. In order to figure out the influence of fabrication technology, layer thickness and coating rate, a series of material samples are fabricated and tested. The SiC interlayer on the CLF-1 substrate is made by three means of coating technologies including physical vapor deposition (PVD), chemical vapor deposition (CVD) and Chemical Vapor Infiltration (CVI) while TiN interlayer is obtained by CVD. On the top of the interlayer SiC or TiN, a CVD-W layer with the thickness of 1mm is coated with the rate of 0.5mm/h at the temperature of 450-550 oC.

The material analysis and mechanical tests on those samples present that SiC by CVI and TiN by CVD and TiN by CVD have sufficient adhesiveness as an interlayer between W and CLF-1, which show good bonding property and no obvious detachment or delamination is found.

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