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Development and characterization of W-V alloys for fusion reactor applications

Tungsten due to its superior properties is suggested to be used for both the divertor and the first wall of fusion reactor. As a plasma facing material, tungsten has to face high heat loads and bare intense flux of hydrogen/helium ions and neutral particles which degrade its properties and change its surface morphology. To improve the properties of tungsten, vanadium with different concentration has been added to develop tungsten vanadium alloys for fusion reactor applications [1]. The effect of spark plasma sintering temperature and dwell time as well as the impact of vanadium precursor powder size were evaluated [2]. For the comparative studies the samples were also sintered by other techniques namely hot press and pressureless hydrogen furnace sintering [3]. The thermal stability of materials is very important for plasma facing applications, consequently the thermal stability of the tungsten-vanadium alloy was also tested [4]. The developed samples were exposed to high ion flux (>1024 m-2 s-1) and low energy (40 eV) deuterium plasma irradiated by linear plasma generator (Polit-PSI facility) [5] and different high heat flux densities ranging from 340 to 675 MW/m2 for single shot of 5 ms duration in Electron-beam Material-test Scenario 60 kW (EMS-60) facility [6].
It was reported that the vanadium acts as sintering activator and an increased in vanadium concentration has shown a gradually improvement in densification and mechanical properties of the tungsten based materials. The study of consolidation conditions during spark plasma sintering was important and uniformly distributed vanadium microstructures in tungsten matrix with improve mechanical properties has been achieved at relatively low sintering energy consumption. Comparatively finer vanadium precursor sintered tungsten-vanadium alloy showed a huge improvement in microstructures, densification, micro-hardness and fracture toughness. Spark plasma sintering was an efficient and better option for the optimization of primary parameters of the tested materials, however hot press has proven better results for the development of tungsten based materials. It was concluded that the addition of vanadium improves the thermal stability of tungsten based materials during annealing process. The deuterium blister formation, size and shape on tungsten and vanadium surfaces, obviously depends on vanadium precursor particles size and the microstructures of the sintered samples. Furthermore, the addition of vanadium improve the barring ability of tungsten material against deuterium irradiation to suppress the blistering formation.

References:

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Primary author: Dr ARSHAD, Kameel (Pakistan Atomic Energy Commission, Islamabad, Pakistan)

Presenter: Dr ARSHAD, Kameel (Pakistan Atomic Energy Commission, Islamabad, Pakistan)