Study of the grain thermal stability in the nanostructured tungsten coatings

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Abstract

Tungsten has been proposed as a potential material to be used as plasma facing material (PFM) applications in both magnetic and inertial confinement fusion power plants. The main role of the PFM is to protect the wall vessel from the heat loads and curb the irradiation. Nowadays, the capabilities of nanostructured materials for such applications are being attracted much attention due to their radiation-resistant and self-healing behaviour. In this context, the thermal stability of the nanostructures is an important subject to be considered.

In this work the thermal stability and texture of nanostructured W (NW) coatings is investigated in the temperature range from RT to 1473 K. The coatings with a thickness of 5 µm in were deposited by combining pulsed and DC magnetron sputtering. The microstructural evolution was characterized by using in situ thermo-diffractometer. The grain size evolution was determined from XRD data combined with atomic force microscope (AFM) and scanning electron microscope (SEM) images. The grain growth activation energy was determined within the nanometre range. From Rietveld analysis of X-Ray patterns, two behaviours in the deformation parameter are observed: (i) From room temperature to 1000 K the micro deformation parameter softly decreases, indicating a small reduction in the induced stress during the NW coating growth (ii) at higher temperatures, a drastic decrease in the micro deformation parameter is followed which is associated with a thermal annealing and stress reduction. Texture analysis using X-ray diffraction was carried out prior to and after annealing indicating that the preferential orientation and columnar structure is preserved after the thermal treatment.

The results of this study suggest that the nanostructures growth starts around 1000 K, however it is important to notice that the average grain size remains in the submicron-sized even for samples annealed at 1473 K.