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PhD Thesis Abstract

Establishment of tungsten alloys based materials for fusion environment

This work presents a possible way to improve the ductility in W based materials in order to avoid intense thermal and radiation stress in operative plasma scenarios, suggesting the production of W-alloys films by implantation of Ta. W plates were irradiated with Ta+, He+ (pre implantation step) and D+ ion beams at RT temperature with fluences in the 1020 - 1021 D/m2 range. Microstructural modifications and deuterium retention in W-Ta composites were studied with scanning electron microscopy (SEM) revealing that after Ta implantation the W plates evidenced cavities and a more severe effect is observed after D implantation. In addition blistering was observed in W-Ta plates implanted with He. Simultaneous Rutherford Backscattering spectrometry (RBS) and Nuclear Reaction Analysis (NRA) with multiple 3He beam energies was performed in order to evaluate the retained content of D and He within the samples. The decrease of the superficial backscattered yield indicates surface modifications in the material associated with helium surface enrichment. The NRA analysis shows that D retention in the W-Ta alloys is higher after sequential He and D implantation compared to single D implantation. The diffractogram of W-Ta alloys implanted with He evidenced the presence of broadened W peaks which is believe to be associated with the high volume fraction of the bubbles that may cause internal stress field giving birth a considerable defects as self-interstitial-atoms and dislocations resulting in a distortion of the crystal lattice. In order to understanding of plasma-surface interactions like tungsten (W) erosion, beryllium (Be) deposition and plasma fuel (deuterium, D) retention to divertor tiles via implantation or co-deposition a set of W and W-coated tiles removed after the second ITER-like Wall campaigns (JET-ILW) from 2012-2014 has been analysed. The results of the analyses of tungsten tiles removed from JET allows us to understand and compare with the results obtained for W-(Ta or Ti) alloys produced. The results show a similar pattern of material migration as the first JET-ILW campaign. The upper divertor remains the region of highest deposition with Be rich films 10-20 microns thick present at the top of Tile 1, fuel retention on Tile 1 remains similar with Be:D of the order 10-15:1 for both JET-ITW campaign. Be and D in the remote inner corner (Tile 4) are an order of magnitude lower than the maximum band of deposition seen at the bottom of sloping surface, i.e., ~5cm beyond the main strike point position on Tile 4. Analysis on Mo marker coating on Tile 4 shows a band of W deposition at the top of the tile at the corner of the horizontal and sloping surface. Deposition at the outer corner also shows a maximum deposition at the furthest region of the tile accessible by the plasma. The maximum Be deposited in this band is 3× 1018 at./cm2 and ~5 times higher than observed in the 2011-2012 campaign, although the total time in divertor x-point plasma is similar; 13 hours (2011-2012) compare with 14 hours (2013-2014). However the time the outer strike point was locate on Tile 6 was ~ 4 times longer in 2013-2014, which is likely to account for more material migration to this region.