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In situ spectroscopic ellipsometry measurements on deuterium plasma exposed tungsten and tungsten oxide: reflectivity variation

In future nuclear fusion reactors such as ITER, the tungsten (W) divertor will withstand hydrogen isotopes and helium (He) ion flux of the order of 1024 m-2 s-1. The interaction of charged particles with W can induce modifications in the material, such as surface blisters (in the case of deuterium, D) and near-surface bubbles (for He). Such modifications can be responsible, for example, of an increased fuel inventory in reactor walls. Moreover, D and He implantation can affect the optical properties of W, due to both a change of surface roughness and a change in the electronic properties of implanted W. A cursory knowledge of the evolution of the divertor's optical properties during interaction with plasma may lead to inaccurate thermography measurements of plasma-facing components, which are realized through optical diagnostics whose response are based on the emissivity and reflectivity of the wall materials. For this reason, it is fundamental to improve the understanding of the variation of W optical properties during plasma exposure. The same can be said about tungsten oxide (WO3), that is always present on W surface as native oxide and can grow also as consequence of possible external contaminations, and therefore has to be taken into account.

In this work, we investigate the evolution of W optical properties during the exposure to D and He plasma. All experiments were performed at Aix-Marseille University using the RF plasma chamber of the CAMITER setup, where in situ ellipsometric measurements (400-1000 nm) were carried out on polycrystalline W and WO3 thermally grown on W (thickness in the 50-400 nm range), exposed to D and He plasma, exploring different ion flux values in the 1019-1020 m-2 s-1 range. Such optical technique allows a real-time monitoring of the sample modification (in the first 100 nm) during plasma exposure, and through adequate modelling one is able to retrieve the plasma-exposed material optical constants n and k. Upon plasma exposure in CAMITER, the sample temperature increases up to about 300°C. Thus, we additionally studied the effect of sample temperature onto ellipsometric measurements and a proper modelling of the observed change was used to subtract the temperature effect from the ellipsometric measurements. Atomic Force Microscopy and Confocal Microscopy was used to measure the change of roughness due to plasma exposure. Taking into account the variation of W temperature and roughness, we observed a small change in the reflectivity of W (˜1%) due to D ion implantation. Preliminary measurements on D plasma exposed WO3 and He plasma exposed W will be presented.

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