The impact of surface morphology on the erosion of metallic surfaces - modelling with the 3D Monte-Carlo code ERO2.0

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The surface roughness of metallic surfaces has a vital impact on the erosion of plasma-facing surfaces and determines the effective sputtering yield Y_{eff} transport of sputtered particles. The 3D Monte-Carlo code ERO2.0 [1] is a versatile tool for describing the erosion of surfaces and transport of eroded or impinging impurities in the plasma. An advanced model describing the plasma-surface interaction with rough surface was implemented into the ERO2.0 code in order to refine calculations performed by it assuming perfect, polished surfaces. Validation of the surface topography time-evolution algorithm was carried out using available ion-beam experiments [2]. A series of plasma experiments aiming in the detailed study of the surface roughness effect on the material sputtering, transport, and deposition have been carried out at the linear plasma device PSI-2 (helium plasma, impact energy of ≈90 eV, normal incidence). The experiments show in the case of molybdenum a reduction of the net erosion by up to 40% in comparison to the smooth case due to the surface roughness of Ra = 600 nm, which is in line with predictive ERO2.0 simulations. The developed ERO2.0 surface morphology model was applied to the JET ITER-like wall (JET-ILW) divertor. It is shown, that in the case of the oblique magnetic field typical for tokamaks, surface roughness of ~10 μm scale leads to reduced net erosion of rough W-coated surfaces (Tile 6 of the JET-ILW divertor) in comparison to smooth bulk-W surfaces (Tile 5) by up to 50%, which is in agreement with experimental observations [3]; deposition in the rough surface "valleys" and erosion of surface "peaks" is observed.

[1] Romazanov, J., et al. NME 18 (2019): 331-338

[2] Arredondo, R., et al. 17th International PFMC Conference (PFMC-17) 2019

[3] Mayer, M., et al. Physica Scripta 170 (2017)