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Effects of surface roughness on W sputtering

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Kinetic sputtering of materials during bombardment with energetic particles is a well understood process for the case of perfectly flat surfaces. Both analytical models and numerical simulation codes have been established in the last decades showing good agreement for quantities accessible by experiments like the sputtering yield. Still, for many applications, e.g., plasma-facing materials in a fusion device, the assumption of a perfectly flat surface may fail to account for the important role of surface roughness.

A range of effects can be introduced by the geometry of a rough surface, e.g., redeposition of sputtered particles, shadowing, or the influence of locally tilted surface segments on the incidence angle of incoming projectiles. Thus, the assessment of sputtering yields for rough surfaces remains a difficult task.

During the last years, the effect of roughness on W sputtering has been comprehensively investigated at TU Wien by conducting laboratory experiments with a quasi-non-invasive low-flux ion source and a high precision quartz crystal microbalance. Furthermore, the development of a binary collision approximation - based raytracing code called SPRAY allowed for quick calculation of sputtering yield data, where large-scale AFM images of rough W surfaces could be considered as input. It was possible to identify the mean inclination angle δm as a scale-independent roughness parameter that allows consistent prediction of sputtering yields for rough W surfaces [1,2].

Furthermore, oriented and periodically patterned topographies like nano-columnar W structures have also been investigated. In comparison to flat W surfaces, nano-columnar W shows a substantial reduction in the sputtering yield, which appears interesting for applications in nuclear fusion [3,4,5].

In this invited talk, an overview and explanation of roughness effects on W sputtering will be presented, including results for conventionally rough and nano-columnar W surfaces.

[1] C. Cupak, et al., Appl. Surf. Sci. 570 (2021) 151204

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[3] A. Lopez-Cazalilla, C. Cupak et al., Phys. Rev. Mat. 6 (2022) 075402

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