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High Flux Plasma Interactions with Materials

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Low energy high flux helium plasma is known to lead to significant modification of metallic surfaces, including sub-surface bubble formation and the spontaneous growth of fine nanoscale fuzz. These structures can be grown on many technologically relevant metals such as palladium, tungsten and iron, and are compelling candidate materials for use in fuel cell, gas sensing and water splitting applications. The mechanisms that drive this nanostructure growth are not well understood, though fuzz growth is widely believed to be linked to the formation of sub-surface bubbles and their interactions with the material surface.

A recent investigation by the ITER organization has revealed that helium-induced nano-bubble formation has the potential to enhance the performance of ITER's tungsten divertor by suppressing recrystallization. To better understand this bubble growth and the impact it has on material properties in the context of fusion reactor operation we exposed a series of tungsten samples to differing helium plasma fluences, across a range of exposure temperatures (400-1000 K). Grazing incidence small angle X-ray scattering was then performed on each sample to determine bubble size distributions, shapes, and orientations [1]. Samples were then heated in a vacuum furnace beyond the recrystallization temperature of tungsten (1600K) to determine how the bubbles affect recrystallization and whether bubble formation can improve material properties such as fracture toughness.

We also report on a recent investigation into the use of high-flux helium plasma to produce coral-like nanostructures across a range of semiconductor materials. To our knowledge, this is the first time such structures have been produced using helium plasma in a non-metal.

References

[1] M. Thompson, R. Sakamoto, E. Bernard, N. Kirby, P. Kluth, D. Riley, C. Corr, GISAXS modelling of helium-induced nano-bubble formation in tungsten and comparison with TEM, J. Nucl. Mater. 473 (2016) 6–12. doi:10.1016/j.jnucmat.2016.01.038.