7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Studies on the retarded recrystallization of tungsten in the CPP-IPR CIMPLE-PSI device

M. Kakati[1], M. Rahman[1], S. Chetri[1], C. Corr[2], S. Shekhar[3], G.De. Temmerman[4]
[1] CIMPLE-PSI Laboratory, Centre of Plasma Physics-IPR, Sonapur 782402, India
[2] Department of Materials Physics, Australian National University, Canberra ACT 2601, Australia
[3] Department of Materials Science & Engineering, IIT Kanpur, Kanpur 208016, India
[4] Mines Paris Tech, University PSL, IHEIE, 75006 Paris, France
e-mail (speaker): mayur@cppipr.res.in

This talk will commence with a brief review of the tokamak divertor simulator devices developed at CPP-IPR, for controlled plasma fusion research relevant plasma surface interaction (PSI) studies. [1-3] This includes the segmented arc assisted High Heat Flux (HHF) and the CIMPLE-PSI devices, which can successfully reproduce plasma parameters at ITER like extreme limits. A collimated helium plasma beam can be produced in CIMPLE-PSI that can deliver $10^{24}m^{-2}s^{-1}$ ion-flux and more than 5 MWm^{-2} heat flux on a remotely placed material target. [1] Results will be presented from some recent experiments carried out in CIMPLE-PSI, to understand the recrystallization of tungsten exposed under extreme target temperature (1866±5 K) and ITER relevant long ion-fluence ($3.6\times10^{27}m^{-2}$), and the effect of the helium bubbles on the possible retardation of the process. Ion exposure and annealing were carried out simultaneously in this study, in contrast to the previous experiments which were accomplished sequentially. A challenge during this experiment was to first remove the W-fuzz layer and characterize the surface underneath, analysis of which is not straightforward because of the nano-tendril imprints. It was observed that the sample under the highest temperature suffered retarded grain growth and also contained very small grains which still remained deformed. The fraction of recrystallization for this sample was measured as 34% by electron backscattered diffraction (EBSD). Another sample exposed at a temperature 170 K less but for a duration three times longer than the former was almost fully recrystallized, which indicates retardation diminishes very fast with the time of exposure. FESEM imaging of the focused ion beam made cross-sections of the exposed tungsten samples confirm that the recrystallization was impeded locally whenever very small helium bubbles/pinholes were forming along the grain boundaries.

Reference:

[1] M. Kakati et al., Nuclear Fusion 59 112008 (2019)
[2] T. Sarmah et al., Nuclear Fusion 60 106026 (2020)
[3] N. Aomoa et al., Fusion Engineering and Design 106 63 (2016)