



IPPLM activities in 2023: Electron microscopy and nanoindentation of JET PFCs – plans

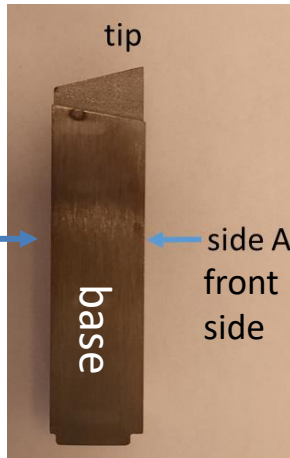
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This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Langmuir probes



Material:

Three probes designated as LP 1, 3 and 5 removed from Module 16W, Tile 5, in 2015, after ILW-2 (probe 1 mounted at stack A, probes 3 and 5 at stack B). All probes have the same geometry.

Experimental procedure:

When examining the probes, we utilize the procedure successfully implemented when examining the probes removed after the second ILW campaign and presented in the work M. Spsychalski et al. „Tungsten Langmuir probes from JET-with the ITER-Like Wall: Assessment of mechanical properties by nano-indentation”, Phys. Scr. 96 (2021) 124072.

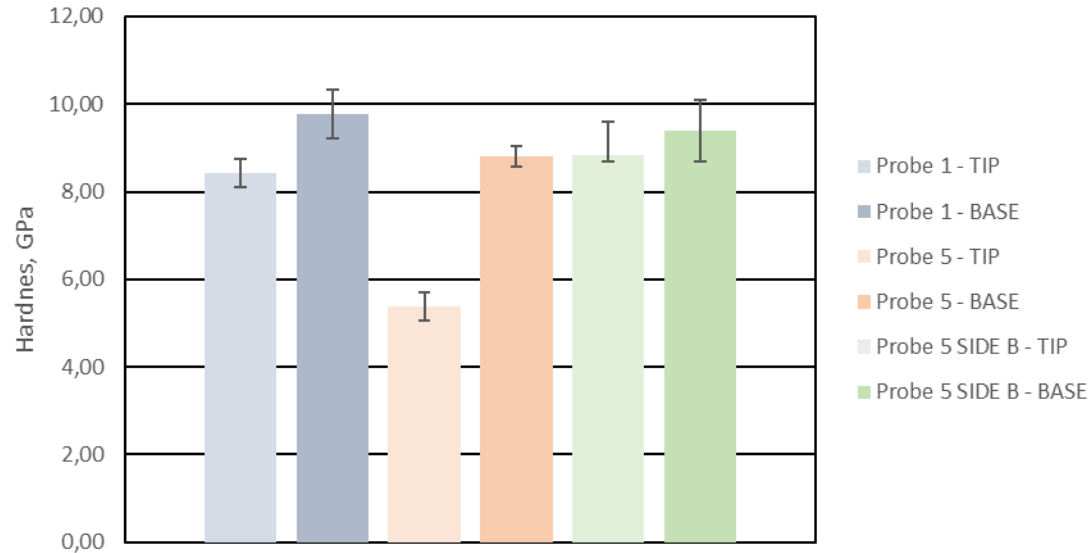
Mechanical properties were determined by nanoindentation using a Hysitron Ti-900 triboindenter, while surface development was examined by optical profilometer Veeco NT9300. Because of the small dimensions of the tip, the force applied was 10 mN. Due to the large development of the surface, it was imaged in the SPM mode before and after each measurement. Only measurements resulting in regular imprints are included.

The nano-hardness measurements were carried out in four regions of LP-5: in the tip and the base, at two sides A and B, and in two regions of probe LP-1, at side A, in the tip and the base.

Highlight talk on microscopy investigation and assessment of mechanical properties of Langmuir probes, the 3rd WPPWIE project meeting, 7-02-2023
<https://indico.euro-fusion.org/event/2457/>



Nanomechanical properties



Results of nanohardness measurements in the LP-5 and LP-1.

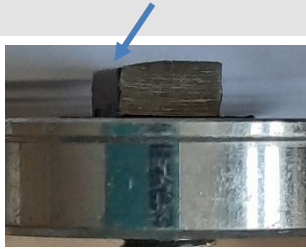
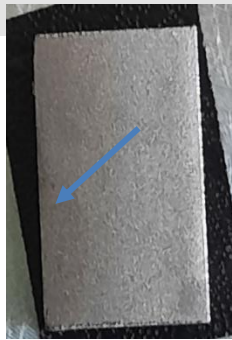
- *The most important result is the large difference in the hardness value in the tip and the base of LP-5 at side A, 5.4 GPa versus 8.8 GPa, respectively. The hardness values measured on the base and tip on the B-side were similar to those measured on the base on the A-side.*
- *The differences in hardness on the base and tip of probe 1, measured on the A-side, were small, which is expected considering the fact that the probe was placed next to stack A.*

Langmuir probes further plans



- Nanoindentation of probe No. 3.
- FIB cross-sections to assess the grain size in individual zones of LPs.
- More observations on the probes' sidewalls to try to correlate surface morphology/chemical composition to Per's IBA results
- XRD measurements (if possible)

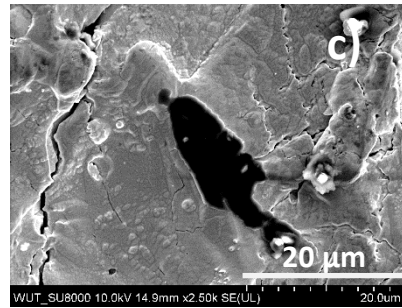
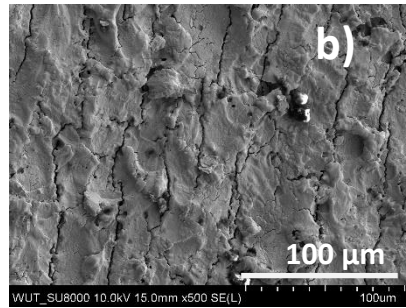
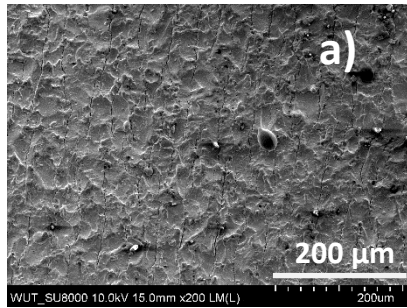
Lamellae from bulk divertor Tile 5



Lamella 164 from stack B12 (ILW1+3)

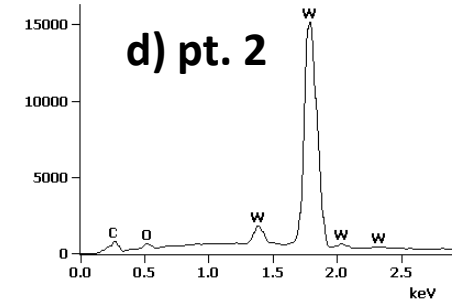
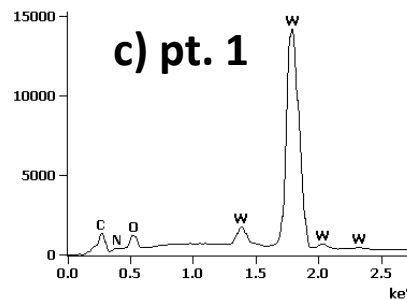
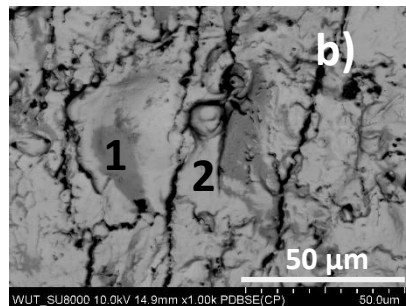
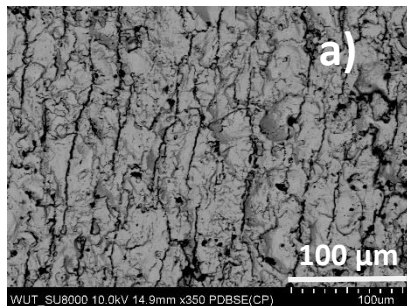
Dimensions $10 \times 6 \times 2.5 \text{ mm}^3$

(Additionally, lamella 157 from stack B2 – shadowed region ILW3)



- *surface re-melting*
- *surface voids*
- *network of longitudinal cracks with a constant distance*
- *splashes (very likely beryllium)*

SEM images of lamella 164 surface.



SEM images of lamella 164 (a-c) surface together with corresponding EDX spectra (c-d).

Redeposition is visible in the images recorded in the BSE mode. EDX point measurements confirm higher levels of C, N, and O in the darker contrast areas.



Langmuir probes

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Study of lamellas from Tile 5

- TEM examinations of sub-surface structure
- More SEM observations

Others...

- The core sample from Tile 0