



National Institute for Laser, Plasma and Radiation Physics, Bucharest, Romania
EURATOM Association - MEdC

Tungsten coatings for fusion applications

C. Ruset¹, E. Grigore¹, H. Maier², H. Greuner², R. Neu², M. Mayer², G. Matthews³

¹ National Institute for Laser, Plasma and Radiation Physics, Association Euratom-MEdC, Bucharest, Romania

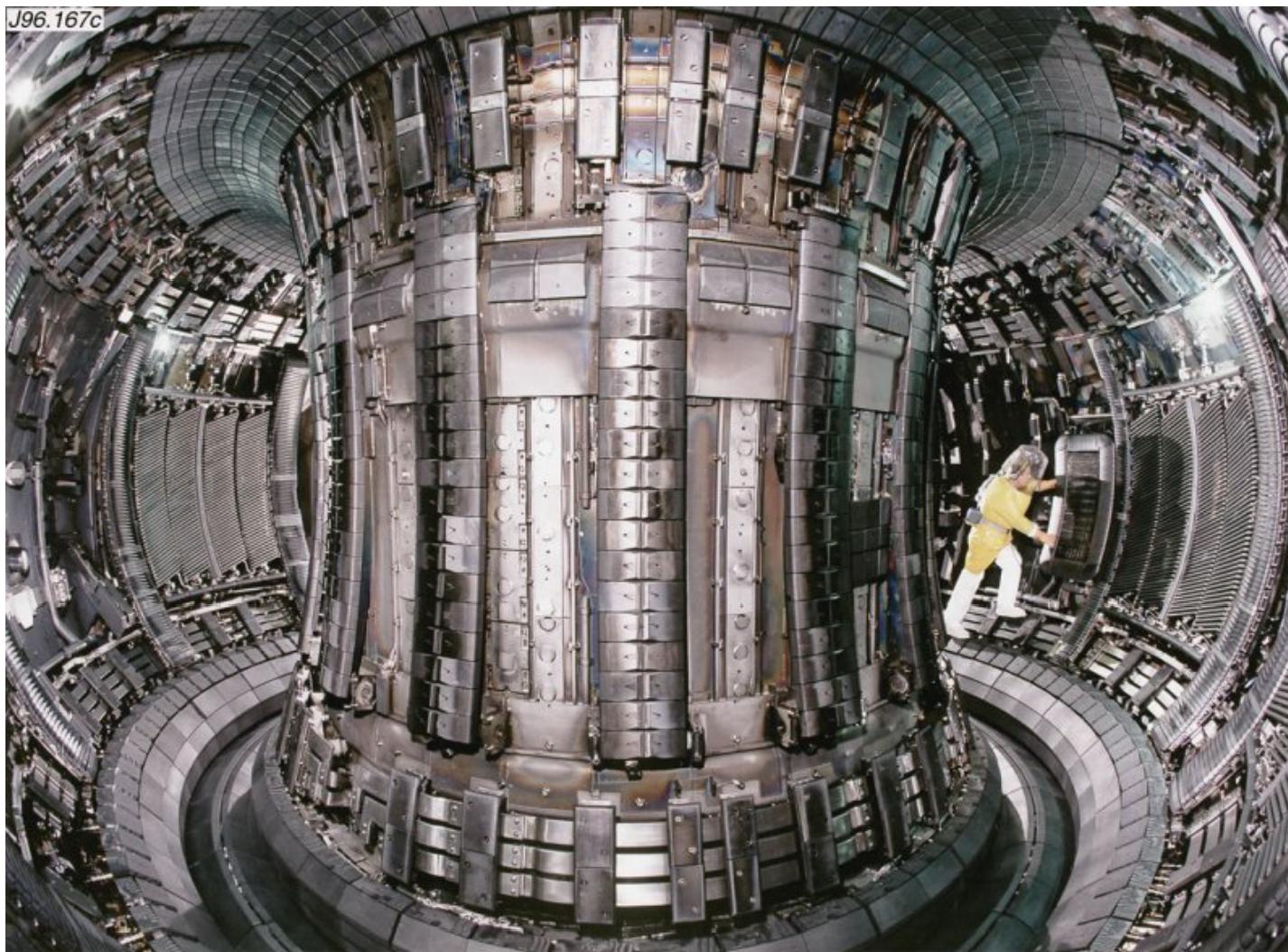
² Max-Planck Institut für Plasmaphysik, Euratom Association, 85748 Garching, Germany

³ EURATOM/CCFE Fusion Association, Culham Science Centre, Abingdon, UK

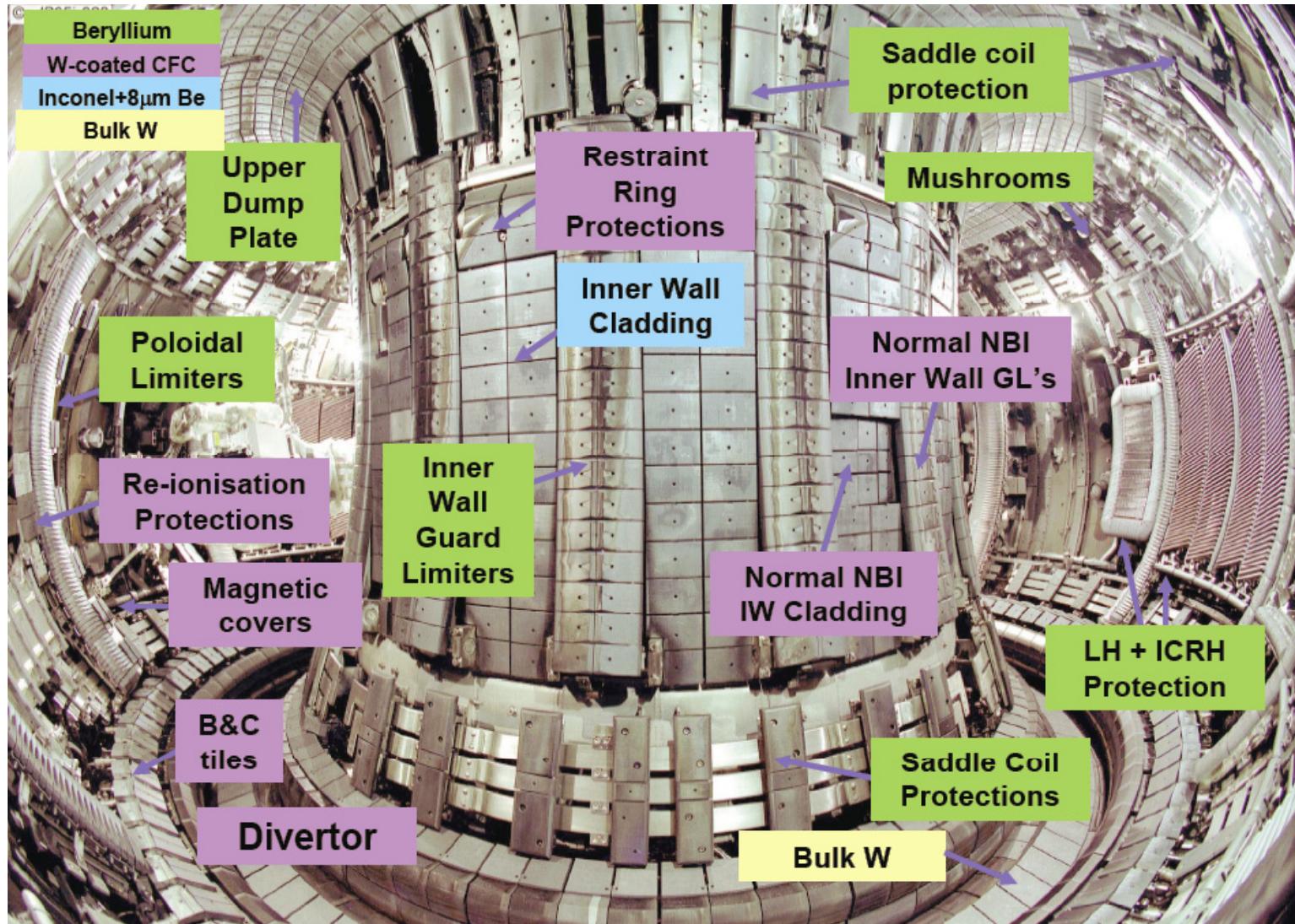
Outline

- Relevance of the W coating technology for JET
- CMSII – Equipment, technology and performances
- Current status of W coated tiles for the ITER-like Wall project at JET
- Conclusions

Relevance of the W coating technology for JET (1)



Relevance of the W coating technology for JET (2)

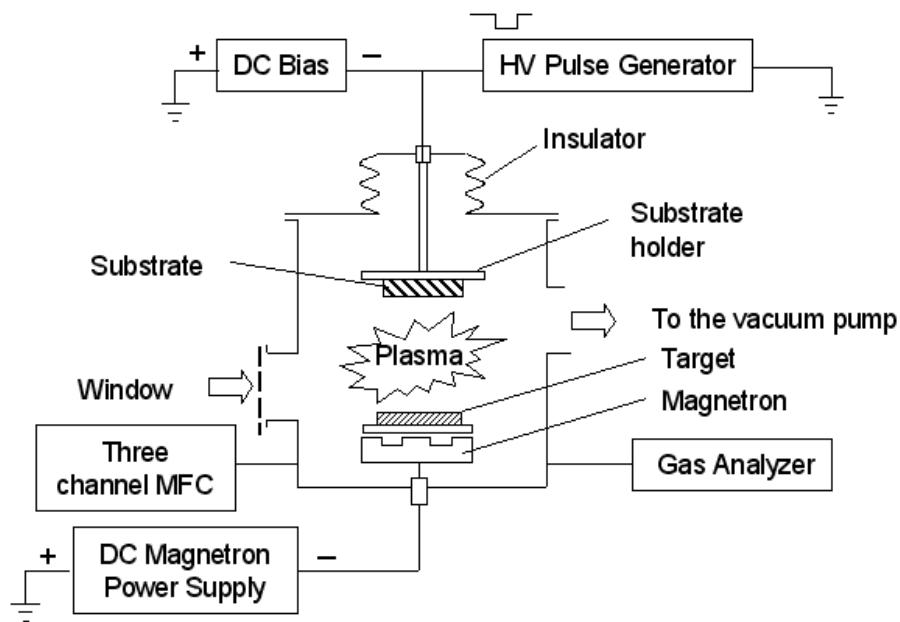


More than 5000 tiles to replace – 2 tons of Be

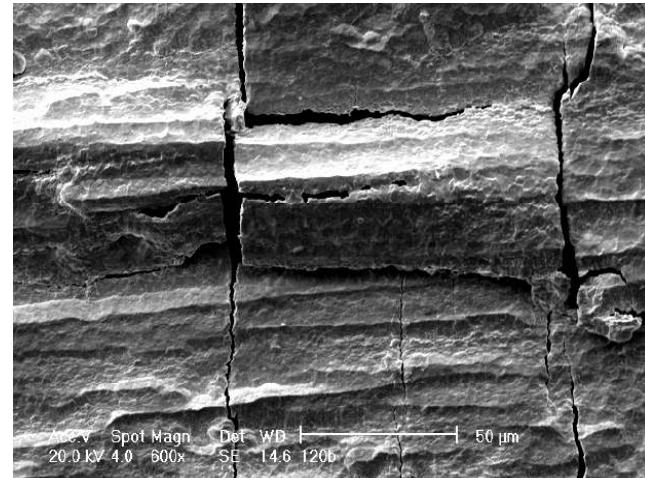
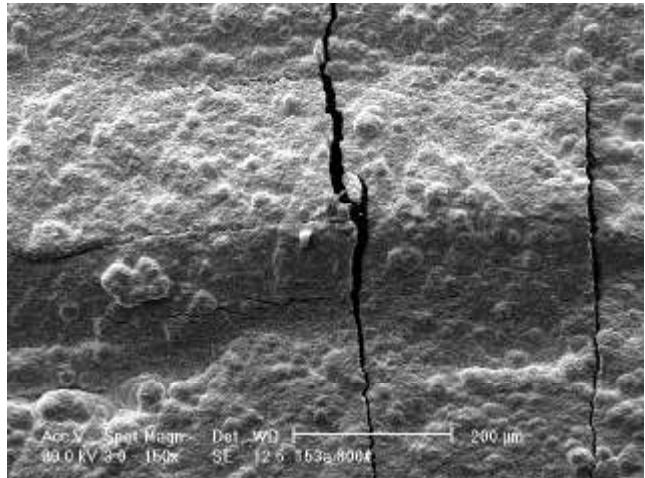
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CMSII – Equipment and technology

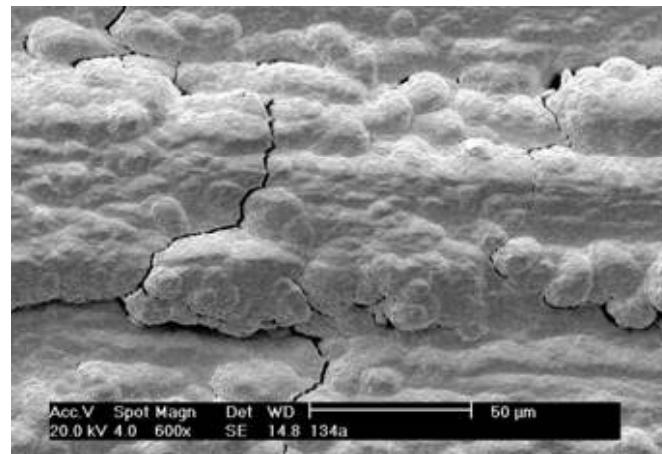
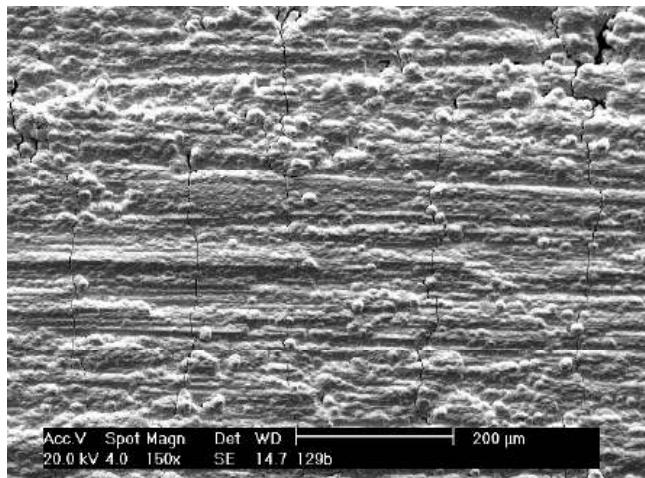
- In the R&D phase of the ITER-like Wall project it was demonstrated that CMSII technique is the only one able to produce W coatings of 10 μm on CFC substrates which survived to HHF up 23 MW/m² ($T_{\max} \leq 2100$ °C)
- In 2009 the CMSII technology was extended to 20-25 μm and was successfully applied for W coating of JET divertor tiles.



After HHF tests in GLADIS

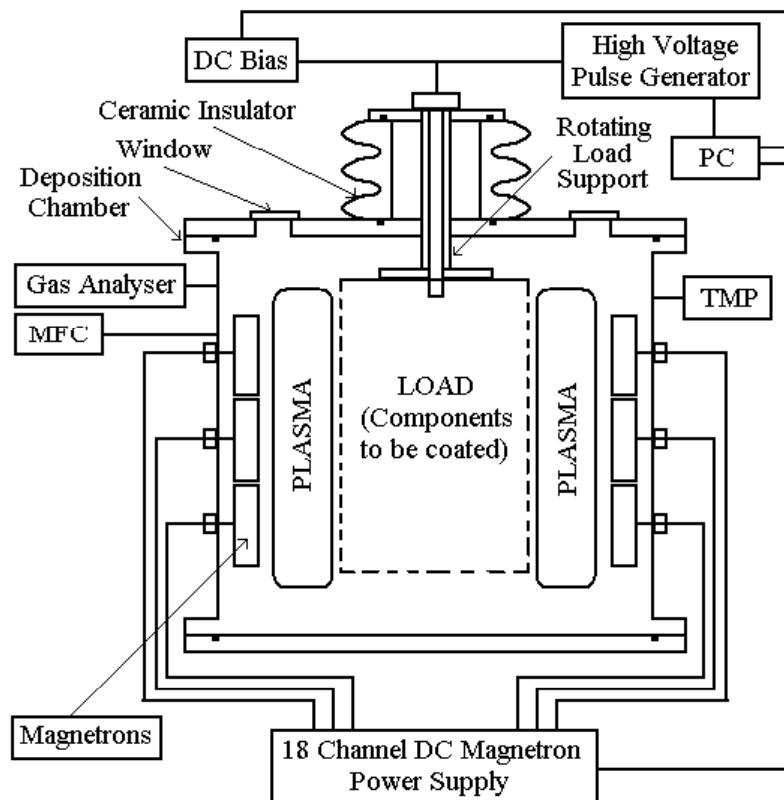


Coatings deposited by conventional PVD or CVD techniques

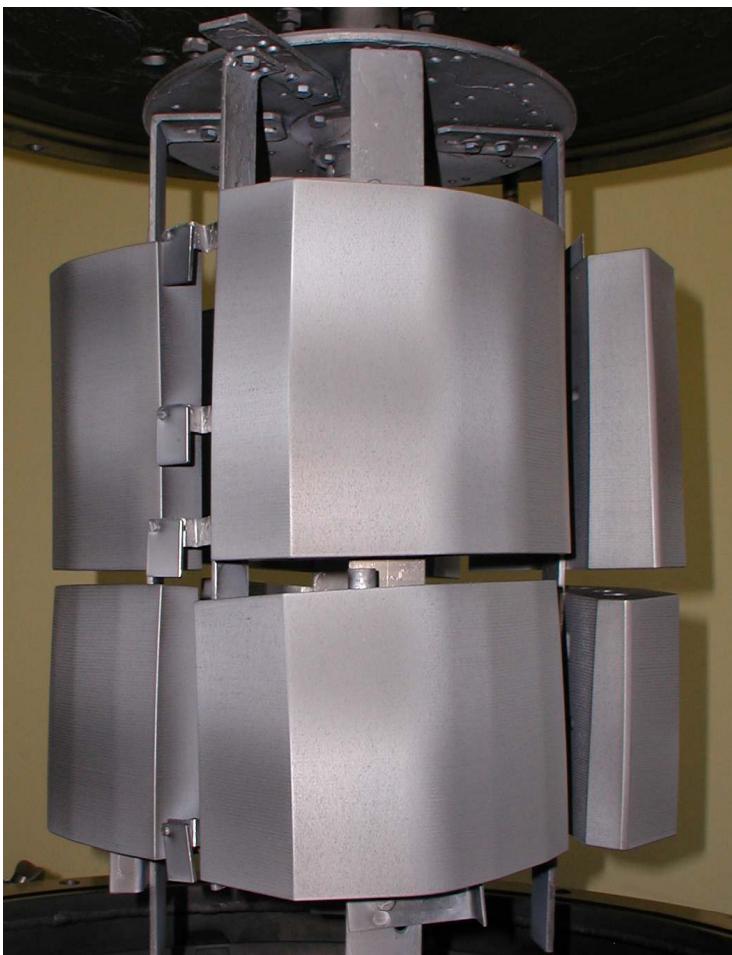


Coatings deposited by CMSII technique

Combined Magnetron Sputtering and Ion Implantation (CMSII)



W COATED CFC TILES (1)

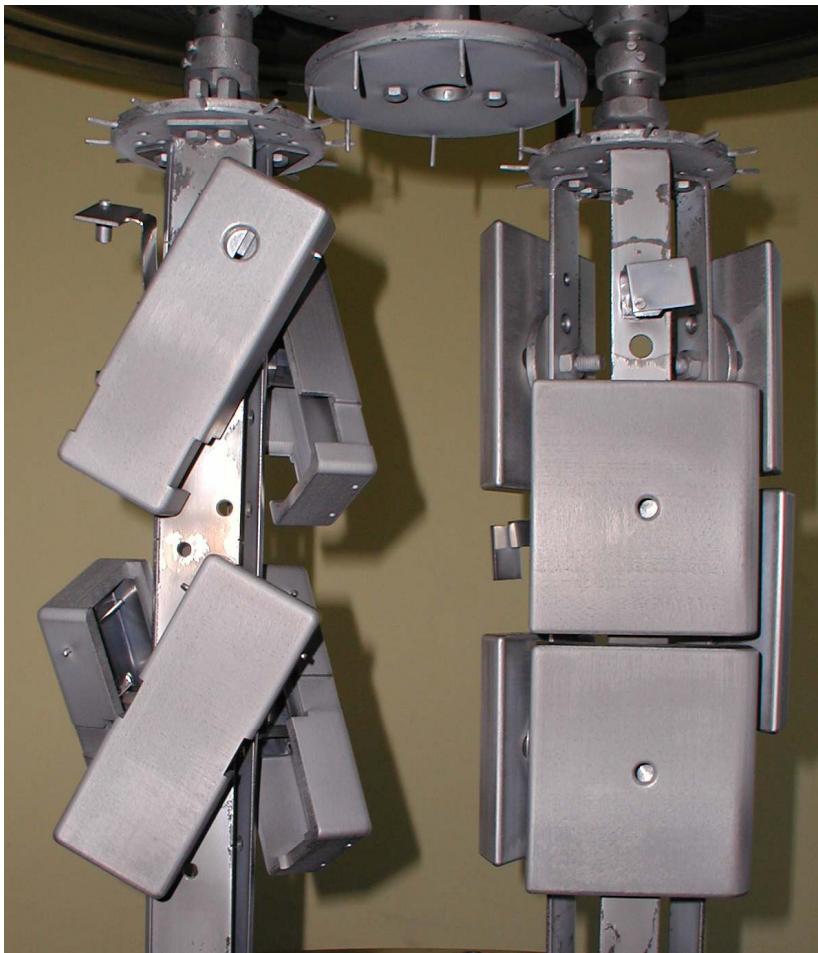


G 1 and G8 divertor tiles coated with
20-25 μm W in series production



G 6 and G7 divertor tiles coated with
20-25 μm W in series production

W COATED CFC TILES (2)

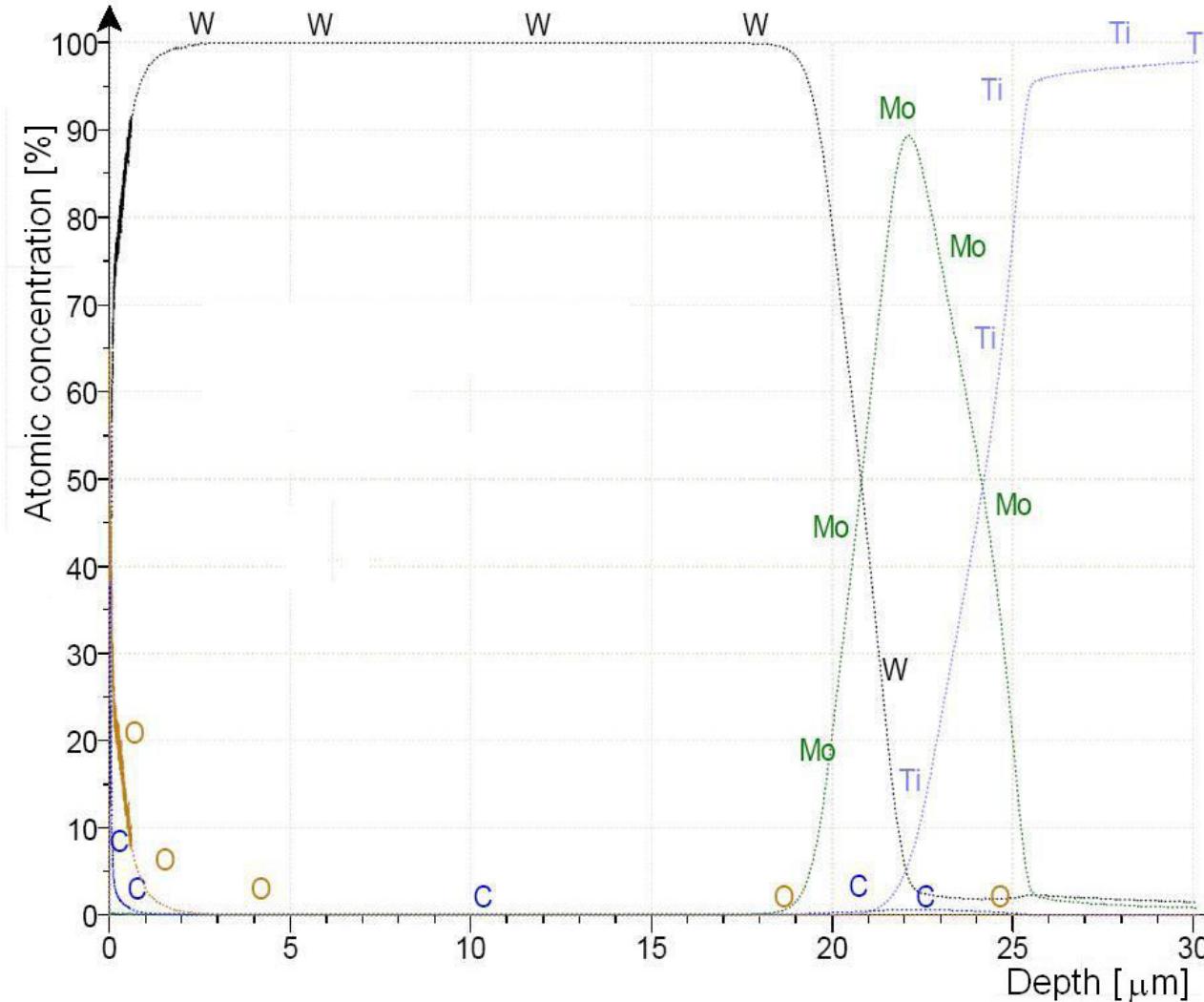


Diagnostic covers and shinethrough protection tiles from the main chamber; coating thickness 10-15 μm



IWGL (Be) from the main chamber; coating thickness 10-15 μm

Glow Discharge Optical Spectrometry – current technique for quality control of the W coatings



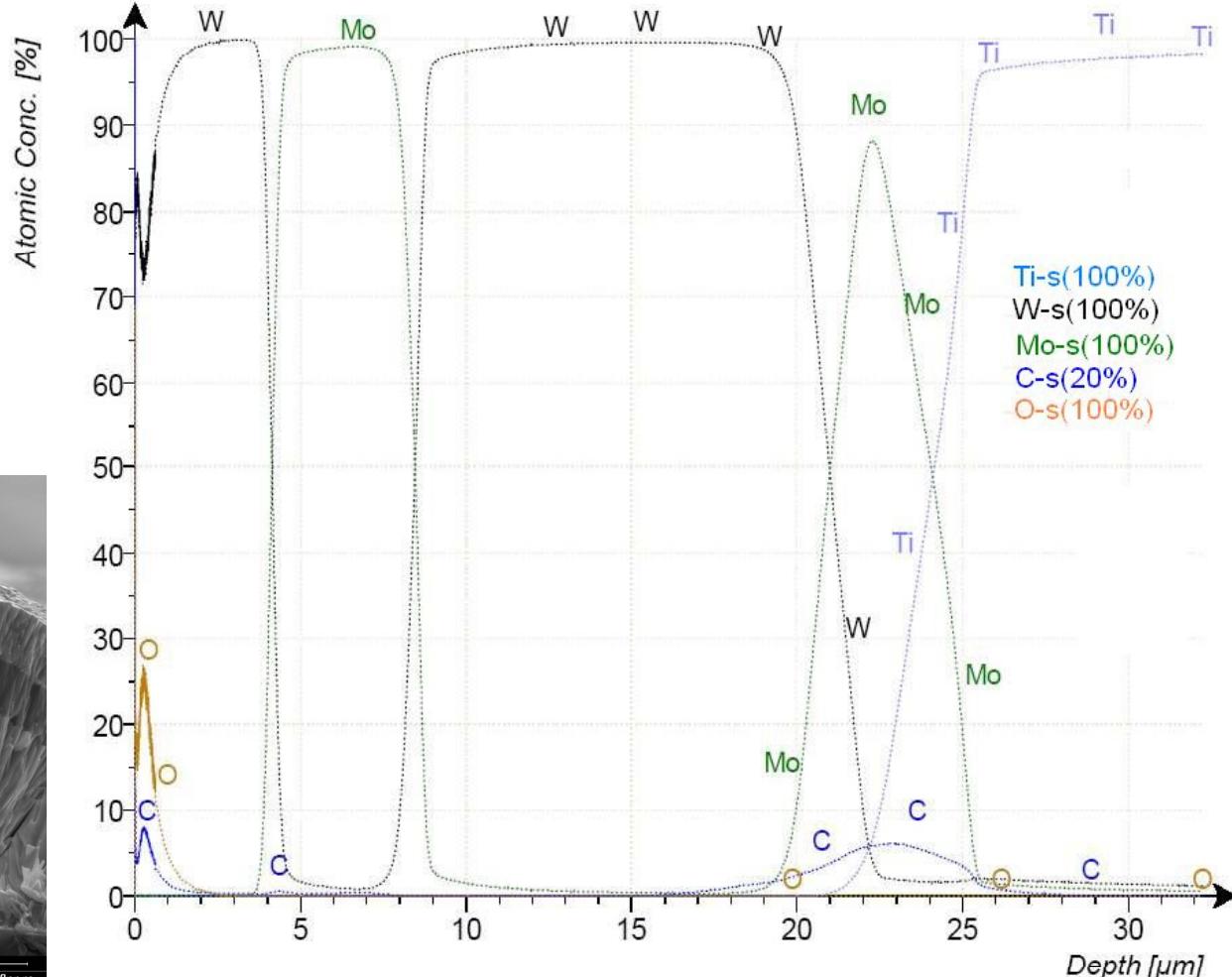
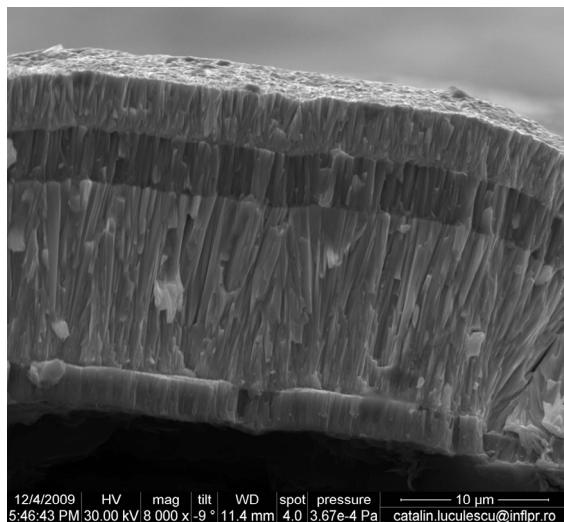
- 10% of the series production tiles are tested at HHF in GLADIS, IPP Garching

W/Mo markers for measurement of W erosion in JET divertor

➤ Structure of markers:

- 2-3 μm Mo
- 12-14 μm W
- 3-4 μm Mo
- 3-4 μm W

➤ Applied on particular G6, G7, G1, G8, G3 and G4 tiles



Current status of W coating for JET tiles

➤ Divertor tiles:

- G3, G4, HFGC (10-15 μm); 254 Off, coated 100% and delivered to JET
- G1, G6, G8 (20-25 μm); 313 Off, coated 100% and delivered to JET
- G7 (20-25 μm); 53 Off coated 100% and delivered to JET
- LBSRP (20-25 μm); 106 Off coated 90%

Total: coated 714 tiles (98%)

➤ Main chamber tiles:

- IWC, Shinethrough Protection, Restraint Ring Protection, LBSRP Protection, Divertor C, Divertor B, IWGL, IWGL(Be), etc.

Total: coated and delivered 918 tiles (91%)

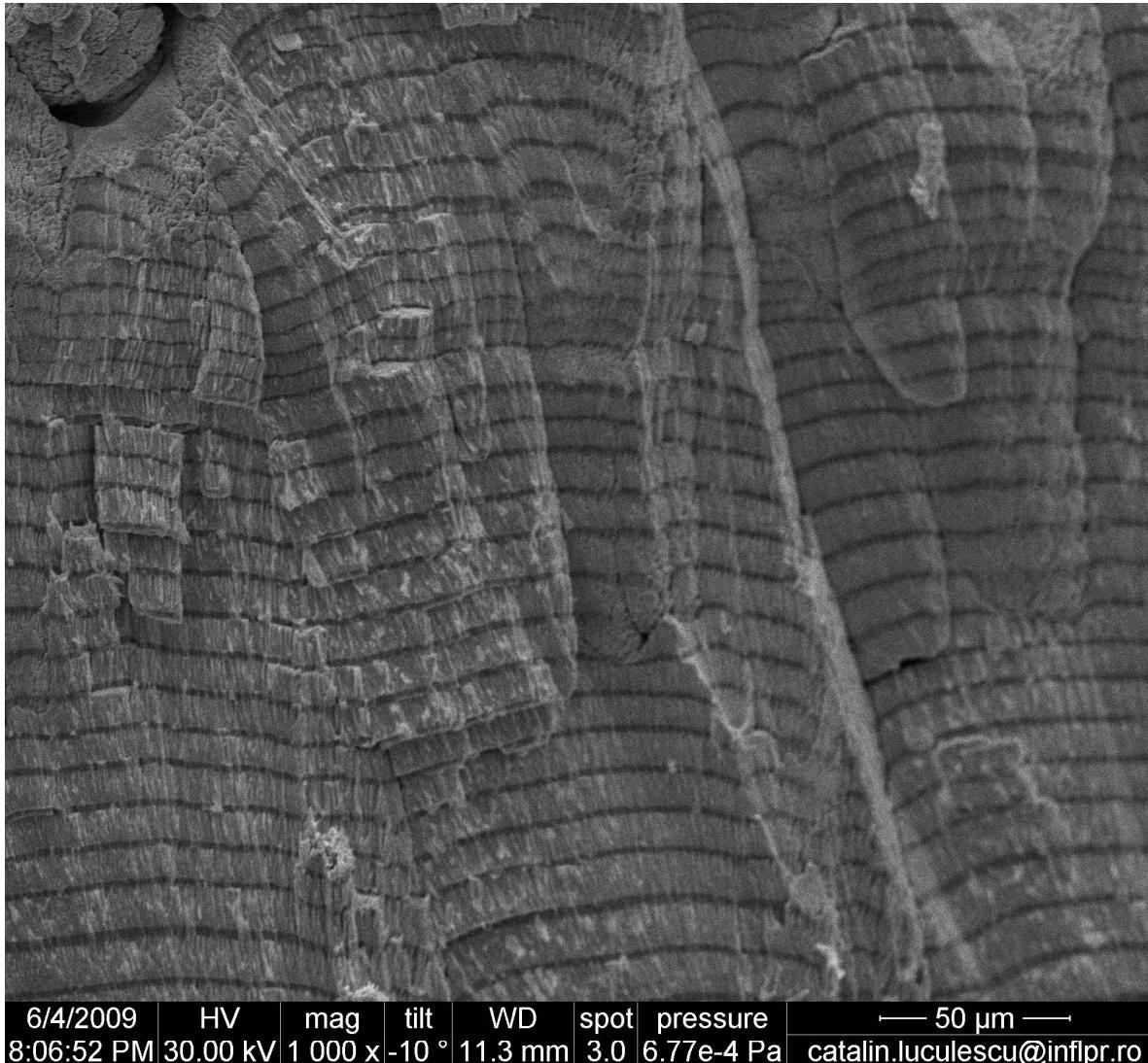
Conclusions

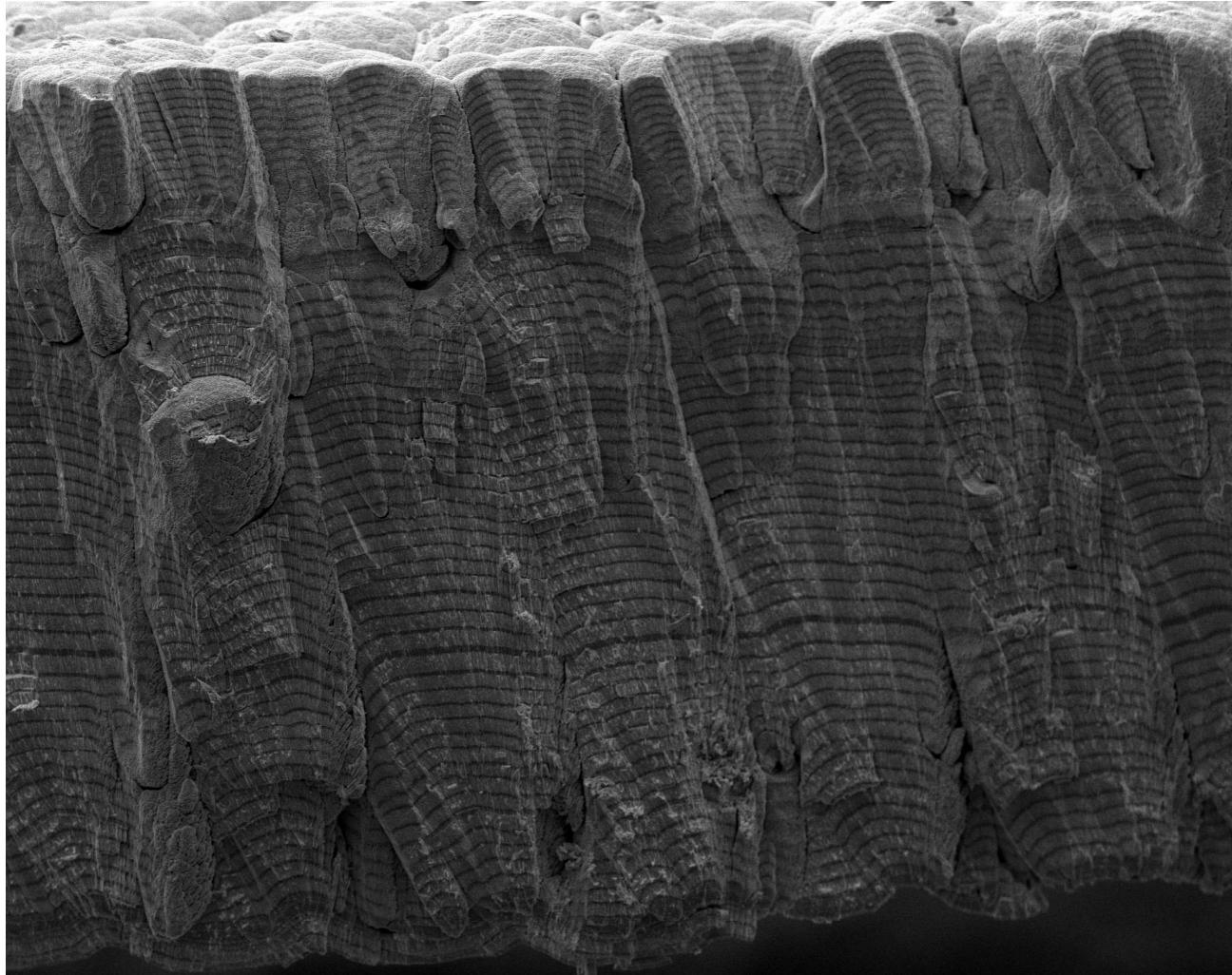
- CMSII technique has been developed from laboratory research to industrial scale and it is currently applied for W coating of CFC and FFG components, including divertor, for JET and ASDEX Upgrade
- Coating thickness: 10 – 25 μm
- The coatings survived to a screening test up 23.5 MW/m² for 1.5s and cycling loading at 10.5 MW/m² for 5s; $T_{\max} \leq 2100$ °C.
- A quality management system has been implemented and it is applied in accordance with ISO 9001 standard.
- The divertor tiles needed to be installed in JET for ITER-like Wall project were coated and delivered.
- Approx. 90% of the CFC tiles for the main chamber are also coated and delivered to JET. The remaining tiles will be coated by November 2010.

Future plans

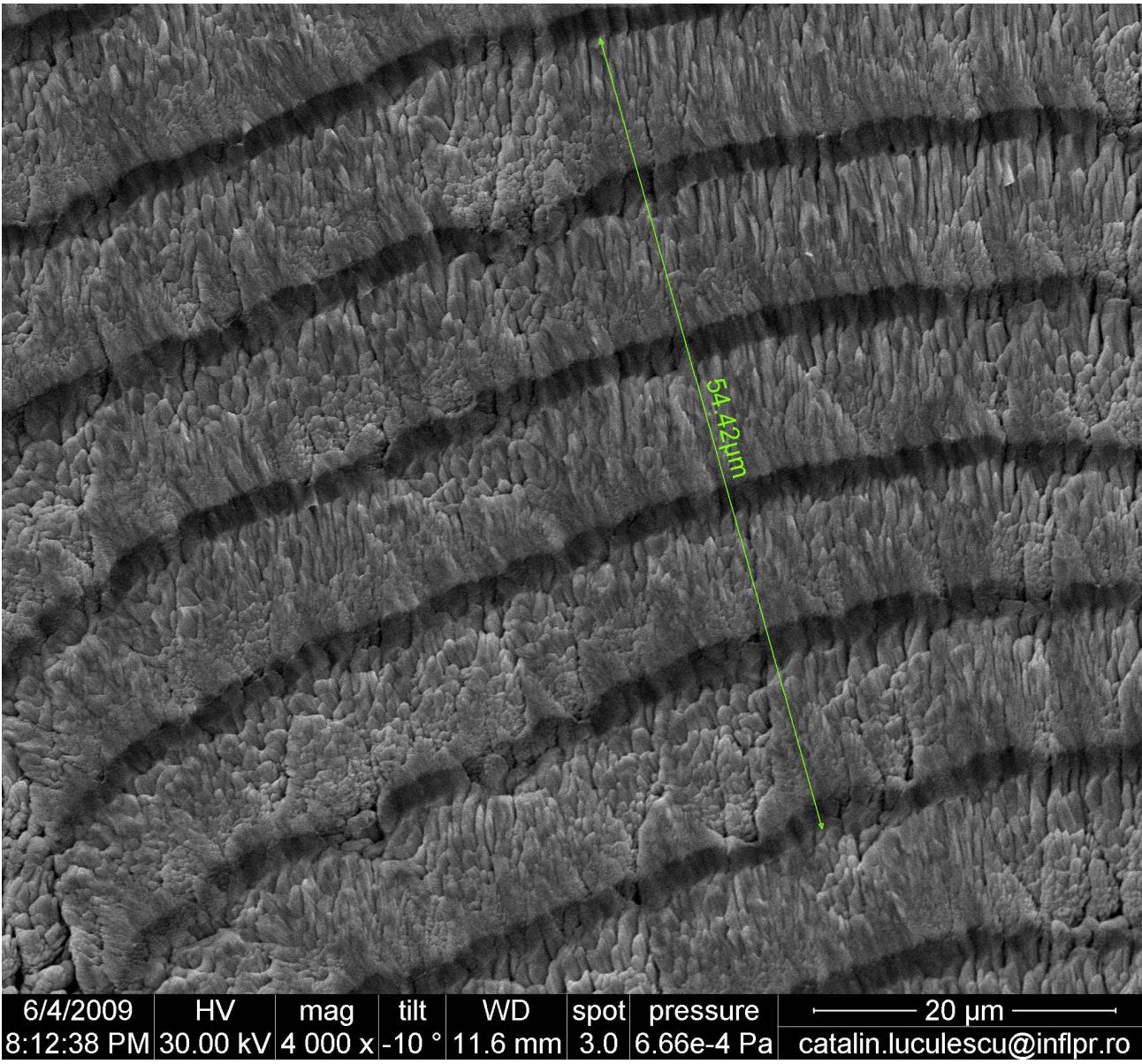
- Identify the actual limitations of this type of coatings, particularly those associated with carburization at the CFC-Mo interface
- Push the coating thickness to 50 μm

Thank you for your attention!





6/4/2009 | HV | mag | tilt | WD | spot | pressure | —— 200 µm ——
8:09:07 PM | 30.00 kV | 350 x | -10 ° | 11.3 mm | 3.0 | 6.77e-4 Pa | catalin.luculescu@inflpr.ro



6/4/2009 | HV | mag | tilt | WD | spot | pressure | — 20 μ m —
8:12:38 PM | 30.00 kV | 4 000 x | -10 ° | 11.6 mm | 3.0 | 6.66e-4 Pa | catalin.luculescu@inflpr.ro