Contribution ID: **257** Type: **Poster**

First Mirror Test in JET for ITER: Complete overview after three campaigns in JET with ITER-like wall

Tuesday, October 23, 2018 8:30 AM (20 minutes)

Metallic first mirrors are essential plasma-facing components (PFC) in all optical spectroscopy and imaging systems used for plasma diagnosis. First Mirror Test (FMT) has been carried out at the JET tokamak with the ITER-like wall (JET-ILW). Over 120 test Mo mirrors were exposed in JET during the entire project. The aim is to provide an overview of results obtained for mirrors exposed during: (i) the third ILW campaign, ILW3, 2015-2016, 23.6 h plasma; (ii) all three campaigns, i.e. ILW 1-3: 2011-2016, 62h in total and (iii) a comparison to results in JET-C. Examinations were done by optical, electron and ion beam techniques.
The total reflectivity of all mirrors in the main chamber has decreased by 2-3% from the initial value. All of them are coated by a very thin co-deposit (5-15 nm) containing D, Be, C and O. This has affected the optically active layer (15-20 nm on Mo) and led to increased diffuse reflectivity. No W and N have been found on the surface.
All mirrors from the divertor lost reflectivity by 20-80%. There are significant differences in the surface state dependent on the location and exposure time. Reflectivity loss is connected predominantly with the co-deposition of Be and some C species. The thickest layers have been found in the outer divertor: 850 nm after ILW1-3, indicating the average growth rate of 4 pm s-1.

The layers thickness is not directly proportional to the exposure time. Nitrogen, tungsten and nickel are on all mirrors from the divertor. The highest N and W contents are in the inner divertor: N reaches 1×1017 cm-2, W is up to 3.0×1016 cm-2, while the greatest Ni content is in the outer leg: 2.5×1017 cm-2.
The results obtained for the main chamber mirrors allow some optimism regarding the diagnostics reliability in ITER. Tests done in JET-C and JET-ILW show that the degradation of optical properties in a machine with metal PFC is distinctly smaller than in the carbon surrounding. However, a long-term exposure and off-normal events may change surface properties of the mirrors. Laser- or plasma-induced cleaning techniques of tokamak mirrors have not brought any positive results. There are some indications that single crystal mirrors may be cleaned more efficiently than polycrystalline. Search for engineering solutions for mirror exchange in a reactor should not be abandoned especially for the divertor mirrors.

Country or International Organization

Sweden

Paper Number

EX/P1-17

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Session Classification: P1 Posters