First Mirror Test in JET for ITER: complete overview after three ILW campaigns

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Metallic so-called *first mirrors* will be essential components of all optical spectroscopy and imaging systems in next-step devices. Therefore, their performance is crucial for reliable plasma diagnosis and operation. The First Mirror Test (FMT) for ITER has been carried out in JET [1-3] first in the presence of carbon wall and then during all three campaigns with the ITER-like wall (JET-ILW). The aim of this work is to provide an overview of results obtained for mirrors exposed during: (i) the third ILW campaign (ILW3, 2015-2016, 23.6 h plasma) and (ii) all three campaigns, i.e. ILW1 to ILW3: 2011-2016, 62 h in total. This is the first report on erosion-deposition in the shadowed zone of the divertor for the entire ILW operation.

Nine cassettes with 25 polycrystalline Mo mirrors were retrieved: one with five samples from the main chamber (ILW-3 only), two sets with 10 mirrors each from the divertor. One set was facing plasma for 24 h and the other one for 62 h. The examinations performed by means of optical methods for total and diffuse reflectivity determination in the range 400-1600 and 300-2400 nm (two systems used), microscopy (optical, atomic force and electron including EDS) and ion beam techniques (RBS, NRA, HIERDA) have brought a number of key results.

(a) Main chamber wall. The total reflectivity of all mirrors 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 affected the optically active layer (15-20 nm on Mo) thus leading to the increase of diffuse reflectivity. Neither W nor N have been found on the surface. There are no differences between mirrors exposed in standard and baffled channels of the cassette.
(b) All mirrors from the divertor (inner, outer, base under the bulk W tile) lost reflectivity by 20-80%. This result confirms earlier findings and could be expected, but there are significant differences in the surface state dependent on the location and exposure time.
(c) The thickest layers composed mainly of Be are in the outer divertor: 850 nm after ILW1-3.
(d) The measured layers thickness is not directly proportional to the exposure time: 50-60% may be attributed to the last campaign when comparing results for ILW3 and ILW1-3.
(e) Only in a few cases, on mirrors located at the cassette mouse, flaking of deposits occurred.
(f) Nitrogen, tungsten and nickel are on all divertor mirrors. The highest N and W concentrations are in the inner divertor: N reaches 1×10^{17} cm^{-2}, W is up to 3.0×10^{16} cm^{-2}, while the content of Ni is the greatest in the outer: 2.5×10^{17} cm^{-2}.
(g) Oxygen-18 content is up to 7×10^{15} cm^{-2} (first report) and nitrogen-15 is over 1.8×10^{16} cm^{-2}.

The obtained results in this work will be compared with earlier data and the next steps in the FMT programme will be presented, i.e. impact of plasma or ion irradiation on pre-damaged mirrors. The implications for cleaning of mirrors will also be discussed.

[1] D. Ivanova et al., Phys. Scr. T159 (2014) 014011
[2] M. Rubel et al., Phys. Scr. T170 (2017) 014…
[3] A. Garcia-Carrasco et al., Nucl. Mater. Energy 12 (2017) 733-735

**See author list in the paper, X. Litaudon et al., Nucl. Fusion, 57 (2017) 102001.*