Overview of first mirror cleaning using radio frequency plasma in EAST

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In-situ plasma cleaning has been regarded as the most promising method to recover the reflectivity of the contaminated first mirror (FM), which is very critical to ensure the accuracy and effectiveness of related diagnostic signal in ITER [1, 2]. First mirror cleaning experiments in EAST tokamak have been performed and radio frequency (RF) plasma cleaning has been proved to be an effective method. The ITER edge Thomson scattering (ETS) mock-up mirror using RF plasma has been successfully cleaned in-situ for the first time in a tokamak, which is promising for plasma cleaning baseline scenario of ITER.

Firstly, stainless steel (SS) mirror with carbon deposits due to tokamak exposure was effectively removed by argon (Ar) plasma in the laboratory. The reflectivity of the cleaned mirror was recovered by up to 90%. Then, the Ar plasma cleaning was applied for the non-plane large-size (80 × 300 mm^2) mirror used for EAST charge exchange recombination spectroscopy (CXRS) diagnostic. The inhomogeneous deposition with particles size of up to tens of micrometer was uniformly removed using RF plasma. More than 90% recovery of the reflectivity and negligible difference of the recovered reflectivity were obtained.

The FM in-situ cleaning system was developed using material and plasma evaluation system (MAPES) in EAST. The cleaning experiments for the ITER ETS mock-up (200 × 300 mm^2) with 5 small Mo mirror inserts on SS substrate have been carried out to address the application of the in-situ RF plasma cleaning in a tokamak. The neon and argon plasma can be successfully generated and maintained for several hours on the ETS mock-up with a 1.7 T magnetic field in the main chamber of EAST tokamak. For an inclined magnetic field angle of 20° and 5°, the achieved absolute self-bias was lower by factors of 2 and 10 respectively than that without the magnetic field. The 10 nm Al_2O_3-coating used as the substitute of Be deposits, was successfully cleaned for half an hour with a self-bias of -20 V and -80 V at 5 and 20 degrees, which was at least 40 times faster than laboratory experiments without magnetic field. Due to asymmetric sputtering caused by the local variation of ion flux, the central inset mirrors systematically exhibited higher diffuse reflectivity and surface roughness. Difference on the redeposition of the sputtered ETS mock-up materials was found for both cases as the iron (Fe) was only detected on the mirrors at 5°. Besides, the cleaning at 20° was slightly faster than that at 5° which is consistent with the higher absolute self-bias achieved at 20°. The total reflectivity was completely recovered for all the mirrors except the most edge one for the 5° case.

[1] Litnovsky A, Philipps V, Wienhold P, et al. J. Nucl. Mater. 2011 417 830–3

[2] Moser L, Marot L, Eren B, et al. *Nucl. Fusion* 2015 **55** 63020