Nuclear fusion material research: diagnostic mirrors and castellated tiles

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Abstract

Nuclear fusion research is to provide a new attractive electricity generation method. Fusion energy is produced in a type of nuclear reaction between light element such as hydrogen isotopes. In order to operate this reaction, the tokamak which is torus-shaped magnetic confinement fusion devices is currently used. The high energetic hydrogen isotope particles moving around in the toroidal vacuum vessel as a plasma state for fusion reaction.

Plasma-wall interactions (PWIs) occur because energetic particles are transported across the field and eventually impinge on the surrounding first wall. Such interactions lead to physical surface modification and chemical erosion of plasma-facing components (PFCs). Subsequently, the eroded particles from the wall end up in the plasma core where it constitutes an unwanted impurity. In addition, particles may be deposited elsewhere on the wall, possibly together with fuel atoms (deuterium and tritium). Deposited layers decrease the performance quality of PFCs and diagnostics.

In this study, PWIs issues will be presented with metallic mirror for diagnostics and castellated tungsten. Metallic so-called first mirrors are essential components of all optical spectroscopy and imaging systems in next-step fusion devices. The optical performance is degraded by erosion and deposition on mirror surface. The first mirror test for future tokamak has been carried out in Joint European Torus (JET) in the UK with carbon wall and metallic wall. After the last campaign, tested 25 polycrystalline molybdenum mirrors were retrieved and analysed by optical methods for total and diffuse reflectivity determination in the range 300-2400 nm, and microscopy (optical, atomic force and electron including EDS) and ion beam techniques (RBS, NRA, HI-ERDA) in Sweden for surface composition. The mirrors have degraded by surface modification and show different results depends on the installed location. [1] And the PFCs have castellated structure for thermo-mechanical durability and integrity under high heat flux loads in future tokamak. This castellation structure also may lead to fuel co-deposition in the gap. In KSTAR in Korea, castellated tungsten tiles were tested to investigate the impact of tile shaping and misalignment of leading edges on the retention. The tiles with poloidal and toroidal gaps of 0.5 mm were exposed to L- and H-mode discharges at the divertor during a whole 2015 campaign [2]. Several gaps were analysed by means of 3He-based μ-NRA and PIXE at Uppsala university in Sweden. Modelling of carbon and deuterium co-deposition was performed by Jülich research centre in Germany with the impurity transport code 3D-GAPS [3] assuming ballistic impurity penetration into gaps.

Keywords: *Nuclear fusion, Plasma-wall interaction, Diagnostic mirror, Castellated tungsten, Ion-beam analysis*

References

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Biography

Sunwoo Moon is doctoral student at Royal institute of technology (KTH) in Sweden. The major is plasma-material interaction in nuclear fusion field. He studied physics in bachelor at Yonsei university, and material engineering in master at Korea university.