Contribution ID: **31** Type: **not specified**

Influence of the permeation barrier oxide layers on hydrogen permeation of W and RAFM steel

Tuesday, 24 November 2020 16:00 (20 minutes)

In fusion reactor, the interaction between plasma and fusion reactor materials caused by D-T reaction discharge directly determines the operation safety, selection of related materials and service life of fusion device. In particular, the diffusion, penetration and retention of hydrogen isotopes usually reduce the ductility of the material, resulting in hydrogen embrittlement and cracking. For the sake of safe operation, it is important to know as much as possible about the behavior of these materials with respect to permeation of hydrogen isotopes. Thus, we can assess the suitability for containing and isolating the radioactive T fuel of a fusion reactor from the surrounding components, then understand and mitigate the potential damage that could be caused to key components in a fusion reactor.
Tungsten (W) and reduced-activation ferritic martensitic (RAFM) steels are the primary candidate materials for the first wall and structure materials respectively due to their excellent physical and mechanical properties, and have been successfully tested on some tokamak devices. In the process of operation, hydrogen isotopes have obvious diffusion, penetration and retention in W and RAFM steel, which not only affect the mechanical properties of materials, but also have potential harm to plasma quality and discharge safety. So, it is urgent to develop and master the hydrogen permeation data of W and RAFM steel. At the same time, some studies have found that the retention and diffusion of hydrogen isotopes in W or steels with oxide coatings were much lower than that in materials without oxide coatings. Therefore, the hydrogen-impermeable oxide barrier layer can be studied to provide basic theoretical data and safe service support for the use of W and RAFM steel as the fusion-relevant materials.
Therefore, on the basis of mastering the deuterium permeation behavior in W and RAFM steel, the influence of surface oxide coating on the deuterium permeation behavior of the materials will be investigated. The oxide coating, e.g. Al2O3, Y2O3, Er2O3 and Cr2O3, will be prepared on the surface of W and CLAM steel by magnetron sputtering deposition combined with thermal annealing treatment. Based on the linear experimental plasma system (LEPS) of the laboratory in LICP, the deuterium permention behaviors of W and CLAM steel with and without surface oxide coatings will be studied. Finally, it will evaluate the effect of material surface and microstructure on hydrogen permeation behavior. The experimental results will provide basic data for hydrogen permeation behavior in the fusion-relevant materials, and provide reference for development of anti-hydrogen permeation materials and material treatment schemes suitable for the reactor.

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Session Classification: Plasma-driven perm. I