priority topic

CEA/CADARACHE
DIRECTION DES SCIENCES DE LA MATIÈRE (DSM)
INSTITUT DE RECHERCHE SUR LA FUSION PAR CONFINEMENT MAGNETIQUE (IRFM)
CEA/Cadarache - 13108 St Paul-lez-Durance Cedex - France

PhD PROPOSAL 2013

Supervisor : Christian GRISOLIA	**e-mail :**	Christian.grisolia@cea.fr
	phone :	+33 442 25 43 78
	mobile :	+33 676 08 47 62
Research Team : SIPP/GP2B		

Title : Study and modeling of the deuterium trapping in ITER relevant materials.

Summary :
During the ITER operation, huge particles outflow are interacting with the Plasma facing Components (PFCs) of the machine. In case of light materials as Be or Carbon, the surface of the PFCs is sputtered. All the eroded materials are then redeposited on the walls trapping large quantities of hydrogen isotopes (tritium/deuterium) which constitute the fuel of the fusion plasma. In case of heavy metals as Tungsten, the impinging deuterium and tritium fluxes are implanted at the surface and then diffuse towards the bulk material leading to tritium trapping. For safety reasons, the ITER tritium inventory is limited. Moreover, the core plasma density which is related to the total ions plasma inventory is closely linked with the deuterium/tritium inventory in the tokamak wall, the PFCs. As an example, it is impossible to start up a plasma discharge if the neutral sources surrounding the plasma is too high e.g. if the PFCs fuel inventory is above an operational limit.
It is thus mandatory to know, at any time of the plasma operation, the tritium/deuterium inventory in the PFCs. In order to predict this inventory, it is also important to assess what are the trapping processes occurring in these materials. This can be done by modeling the thermo-desorption (TDS) experiments undertaken with relevant samples in which deuterium has been implanted. Thermo-desorption consists to heat homogeneously in a very control way the samples to be investigated. The gas produced during TDS is analyzed by mass spectrometry and all the chemical species detrapped are recorded. This technique is operational at the IRFM.
In the ITER tokamak, it is also needed to recover the tritium trapped. Several techniques could be considered. Among them, laser induced heating of the PFCs surface could be proposed. However, this process which lead to a partial tritium desorption could also induce a deeper tritium trapping towards the bulk due to high tritium diffusion provoked by thermal gradient at the material surface.
During this PhD project, the student will first study classical TDS and laser induced desorption applied to ITER relevant samples pre-implanted with deuterium. With the help of a model which has been developed at the IRFM, he will fit the TDS observations in order to identify the trapping processes occurring in the considered material. The results obtained by both experiments, classical and laser TDS, will be compared in term of fuel recovery. Complementary experiments will be undertaken as SIMS (Secondary Ions mass Spectrometry) or NRA (Nuclear reaction analysis) to strengthen the results obtained.
Then, samples implanted in tokamak will be studied and the trapping processes identified. This part of the PhD work will be used to complement the previous analysis with samples experiencing a more realistic environment. In the same way, in order to mimic neutrons damage that will be induced in PFCs materials during ITER operation, the samples will be submitted to high energy ions bombardment. Then, they will be implanted with deuterium and TDS will be used as a tool to identify the changes induced in the trapping processes.
All this set of experiments will be used to predict the fuel trapping in the PFCs of the WEST (the Tore Supra W evolution) and the ITER tokamak. A simple plasma wall interaction model will be used to deduce the wall contribution to the core density in Tore Supra, WEST and ITER.
This PhD work will be undertaken in a strong collaborative way involving several French and European teams (Romania, Slovenia). The student must be ready to participate actively to these collaborations.

Skills : materials science, surface science, plasma