Complete poloidal distribution of tritium retention in JET divertor tiles measured by AMS and FCM+SD analysing methods
International cooperation: MEdC/AEUL/TEKES EURATOM

The Full Combustion Method followed by Scintillation detection (FCM+SD) and the Accelerator Mass Spectrometry have already proven to be the experimental methods able to measure tritium in an efficient and accurate way in plasma facing materials. Many other ion beam techniques like PIXE, ERDA, RBS, SIMS, etc. have failed in different reasons to measure this heavy hydrogen isotope. On one hand, these other methods lack of sensitivity because they use very low energy β-decay and on the other hand due to the molecular interferences that can't be avoided or rejected from the registered data. Both, FCM+SD and AMS methods have practically the same sensitivity.

The difference is that AMS is measuring the tritium atoms one by one, it does not detect any β-decay for the event detection and it guarantees the highest event counting even in cases of very low concentration. Therefore, the AMS method provides the best known measurement sensitivity for small sample quantities. Disadvantage of the high sensitivity is that samples with high T activity concentrations pose a risk for a contamination of the detection system and therefore risk for a cross-contamination of the samples to be measured.

The FCM+SD method has the highest sensitivity among decay detection methods due to high inherent detection efficiency of the liquid scintillation counting. In order to achieve same sensitivity with AMS, the required sample quantity is larger. However, there are no principle reasons for upper T activity levels. Therefore, should be emphasized that the two methods (FCM + AMS) are complementary and highly useful **together**.

AMS is delivering a microscopic description of the concentration depth distribution (DP) of tritium in the bulk of the analyzed material, expressed for each measured time interval in units of atoms/cm^3. The time is converted at the end of the experiment to depth of material excavated in the sample by the sputter process in the negative ion source. This information is obtained by optic profilometry. The normal depth resolution of the AMS analyses is about 100 nm. AMS is also able to measure deuterium with a very high sensitivity.

The FCM+SD in order to measure the low beta disintegration energy (average energy 5.9 keV), without any absorption in the carbon or beryllium hosts, will first combust the entire sample material and then will capture the tritium in water, liquid solution that will be introduced into a scintillation detector. In this way the measured tritium concentration will reveal an average value over the entire mass of the sample and will be expressed in Bq/g.

In 2011 the Task JW11-FT-1.19 has promoted as one of its deliverables an inter-comparison study between AMS and the FCM + Scintillating detection (FCM+SD) based on a consistent set of samples cut from protection tiles of the JET divertor. The overall agreement between the experimental data delivered by the two methods (AMS data – averaged over the entire experimental points and FCM+SD the bulk concentration measurement) was good. The deviation of the results never exceeded 20% however; the main reason for such deviations might come from cross contaminations by the sample cutting procedures or by the uncertainties of the off beam evaluated craters sputtered in the AMS analysis, again produced by the very rough cuts of the samples.

The goals of the present task, approved for are as follows:

1) Study of T retention in W-coated protection tiles compared with the retention in uncoated (ordinary) CFC tiles.
2) Continuation of the D6 deliverable from JW11-FT-1.19. Complete poloidal distribution of the tritium retention in the new divertor geometry used in the discharge campaign from 2007-2009.
3) Investigation of the possibility of introducing Long Time Samples (LTS) at JET.

Description of the work:

One important task for JET is the study of T retention in W-coated protection tiles compared with the retention in uncoated (ordinary) tiles CFC tiles. As can be seen in the photo no.1 below the structure, very loosely bound, of the CFC protection tile can be well sealed by a compact thin deposition (3-4 um) of W. For this purpose, in this project, one deliverable will concern the AMS analyses and T-concentration depth profiles of divertor protection tiles in both coated and uncoated, configurations. Tiles 7 and 8, from the divertor geometry used at the JET discharge campaigns 2007-2009, will be used to cut cylinder samples from 3 location of each. A total number of 12 samples will be cut from the two types of tiles.

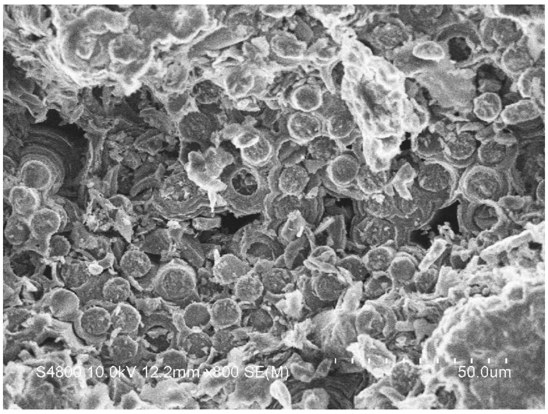

Photo 1: The CFC structure of protection tiles

Plasma facing surface samples will be accompanied with cross-sectional microscopical views in order to assess the depth profile measurement results. AMS will measure the T depth profile concentration and the retention of tritium will be studied according to the depth and host material of the combined sample in a dept up to 150 um. FCM+SD will determine the bulk concentration. The data evaluation will be performed by using both experimental results.

A second important task of the new project is to establish a complete poloidal distribution of the tritium retention in the new divertor geometry used in the discharge campaigns from 2007-2009. The complete distribution of tritium retention in the divertor will contribute to a better understanding of the plasma edge effects. With this aim, samples will be cut from the tiles exposed in 2007-2009 as follows: from Tile 1, Tile 3, Tile 4, Tile 6, Tile 7 and Tile 8 - 3 cylinder samples from different locations. From the base tilted Tile 14LBT-RW (2007-2009), cylinder samples from 4 different locations. Plasma facing surface samples will be accompanied with cross-sectional microscopical views in order to assess the depth profile measurement results. A total number of 21 samples (cylinders) for the complete distribution of T concentration will be send from TEKES to AEUL. AEUL will cut the samples in the desired geometries for AMS analyses and for FCM-SD. The complete characterisation of the samples, like history of irradiation and microscopy of the solid structure will be performed by TEKES.