Contribution ID: **174** Type: **Poster**

RIPER: An irradiation facility to test Radiation Induced Permeation and Release of deuterium for fusion reactor materials.

Tuesday 6 June 2017 13:40 (2 hours)

For successful future Fusion Power Plant operation, tritium self-sufficiency is an essential element of the multiple technical challenges facing the fusion programme. In particular all the different types of candidate blankets will have to make use of different functional materials, such as SiC for flow channel inserts (FCI), ceramic coatings on steel for liquid metal blankets, and Li-ceramic breeders for the helium cooled pebble blanket (HCBP). For all these advanced materials radiation enhanced tritium permeation and retention are of concern. Also thermochemical, and in particular radiation stability, must be taken into account. Radiation induced changes in composition and microstructure may alter either production and/or extraction of tritium, permeation, and retention, hence seriously affecting the achievable tritium breeding ratio (TBR). The validation of these advanced materials requires experimental data to be obtained under as near as possible reactor operating conditions.

At CIEMAT (Research Centre for Energy, Environment, and Technology) during the various Euratom and Broader Approach (BA) agreements, different experimental systems have been developed in the beam line of a 2 MV Van de Graaff electron accelerator. These allow one to study in situ numerous radiation enhanced and induced effects such as electrical, luminescence, and diffusion properties in fusion insulating and breeding blanket materials. Within this framework the Radiation Induced Permeation and Release (RIPER) facility has been developed to provide essential tritium related data. The facility consists of several special irradiation chambers and corresponding experimental systems to measure deuterium permeation for ceramic coated metals during irradiation at different irradiation temperatures and gas pressures, as well as deuterium release from Li-ceramic breeders during irradiation. In the same beam line facility it is also possible to measure hydrogen isotope (H and D) transport under relevant conditions, where deuterium adsorption, absorption, and desorption, including thermally induced desorption (TID) can be measured under controlled ionizing radiation and temperature conditions. The system also allows one to determine possible decomposition such as lithium vaporization/release during irradiation and/or heating of the Li-ceramic materials. All the above gas release processes are monitored using a Pfeiffer Smart Test commercial gas leak detector (He, D2 sensitivity ≥ 10-12 mbar.l/s) and a Pfeiffer PrismaPlus QMG 220 residual gas analyser –quadrupole mass spectrometer (sensitivity ≥ 10-14 mbar) connected to the vacuum system.

The paper will give a detailed description of the above experimental systems as used to test ionizing radiation and temperature effects on the functional properties of candidate breeding ceramics, silicon carbide for FCIs, and radiation induced permeation through alumina coated stainless steel.

Eligible for student paper award?

No

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Session Classification: T.POS: Poster Session T

Track Classification: Blankets and tritium breeding