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PhD Thesis Abstract

Behaviour of liquid tin (Sn) and lithium-tin (Li-Sn) samples exposed to tokamak plasmas

The high power loads impinging on the first wall and particularly the divertor of fusion reactors is a decisive factor to the success of nuclear fusion. Using liquid metals, such as lithium, gallium or tin as plasma-facing material has been pointed out as possible alternative to the solid walls option due to the regenerative properties of the liquid surface. However, the use of these materials in fusion reactors depends on the discharge performance degradation induced by the enhanced impurity contamination and on their affinity to retain hydrogenic isotopes, among other factors. Another suitable candidate is the eutectic lithium tin alloy (25 at.% Li) which is suggested to display beneficial properties of both its constituent elements.

An experimental setup has been developed to produce and expose samples to ISTTOK plasmas on both liquid and solid states. Samples of pure Sn and Sn-Li alloy were exposed at ISTTOK to deuterium plasmas at different total integrated exposure times. To achieve this the samples were irradiated under several half second AC discharges within ISTTOK edge plasma. Similar plasma conditions and a fixed radial positions were used for each individual irradiations. Post-mortem analysis of the samples was performed by means of ion beam diagnostics. To quantify the fuel retention on the samples the nuclear reaction analysis (NRA) technique was applied. Complementary, Rutherford backscattering spectrometry was used for determination material composition, particularly of impurities, on the samples.

At FTU two circular liquid metal limiters have been installed one with lithium and another with tin. These experiments allow to exploration of one possible implementation of a liquid metal plasma facing component consisting of a cooled liquid metal limiter held by a capillary porous system. The two systems used different cooling fluids, lithium's limiter used water while tin's used a mixture of argon and atomized water. Two important aspects of these implementations must be evaluated: their heat removal capabilities and their effect on the degradation of the plasma. To this end several diagnostics were used to access the state of the limiters during the discharges, namely visible spectroscopy of lithium and tin lines, thermal cameras and calorimetric measurements of the cooling water. However a fraction of the material is evaporated due to the high power loads from the plasma to the liquid metal and the local vapour cloud shields some of the power that would otherwise go to the surface. To allow a better understanding of this phenomena a new diagnostic was devised making use of several sets of two Langmuir and a Ball-pen probe to access the local plasma parameters near the surface.