Characterization of neutral particle fluxes in the 100 eV range of ICWC and ECWC plasmas in TOMAS


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Conditioning of plasma facing surfaces in nuclear fusion reactors and experiments represents an integral part of stable high performance operation. This includes the removal of impurities, but also the control of retained hydrogen isotopes outgassing during fusion plasma operation enabling improved plasma density control. ITER relies moreover on conditioning techniques in its tritium recovery strategy.

RF discharge conditioning techniques in the ion (ICWC) and electron cyclotron (ECWC) range of frequencies are being developed for fusion devices with super-conducting magnetic field coils, such as W7-X, allowing for repeated surface conditioning before and in between fusion plasma discharges, i.e. when the coils are energized [1]. The different plasma production principles of ECWC and ICWC induce differences in the particle fluxes to the plasma facing components. The types and energy of the particles affect the sputtering efficiency and therefore the conditioning effect.

TOMAS is dedicated to wall conditioning studies with 10-50 MHz (IC), 2.45 GHz (EC), and DC plasma production systems up to 6 kW at magnetic fields up to 0.12 T. ECWC and ICWC were investigated in TOMAS regarding ion and neutral particle fluxes, as ICWC is generally believed to produce more energetic neutrals. Neutrals strongly contribute to the homogeneity of the conditioning in particular in strong magnetic fields. The detection and quantification of these neutrals is however technically challenging, in particular since the largest flux is expected <100 eV. A neutral particle time-of-flight based analyser (ToF NPA) [2] was installed for this purpose at the TOMAS plasma facility.

This contribution will compare neutral particle energy distributions and flux under different plasma conditions to ion fluxes for ECWC and ICWC. First results with 1.2 kW input power demonstrate only negligible amounts of neutrals in ECWC, while in ICWC a relevant population with a flux peak at 75 eV was found. The data are compatible with a Kappa rather than a Maxwell distribution function as modelling indicated. The impact of the new findings will be discussed via given surface sputtering models, looking at the removal of common materials and mixed layers in present fusion devices. Conclusions towards the application of ICWC on ITER and W7-X will be drawn.