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INVESTIGATION OF THE RO-VIBRATIONAL LEVELS OF H_2/D_2 MOLECULES BY VUV-ABSORPTION SPECTROSCOPY FOR THE PRODUCTION OF H^-/D^- NEGATIVE IONS FOR FUSION APPLICATION

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Abstract. Neutral beam injectors (NBI) will be employed to heat-up the plasma of future pre-industrial fusion reactors. Negative ions, created in the the ion source on ceasiated surfaces, will then be accelerated to 1 MeV and neutralised prior to their entrance in the fusion plasma. The caesium (Cs) layer reduces the work function of the tungsten surface but its use in NBI could be problematic as it potentially escapes the surfaces on which it is deposited and might promote aberration. Hence, a 'Cs-free' ion source is a conceivable solution to produce a uniform beam of H_0/D_0 neutral atoms for the DEMO reactor.
An alternative, omitting the need of Cs could be the creation of H^-/D^- ions by dissociative attachment (DA) between H_2/D_2 highly ro-vibrationally excited molecules (v">5) in their electronic ground state X $^1\sum_g^+(v^{"}, J^{"})$ and cold electron (<1eV). Ro-vibrationally excited molecules are created via plasma-volume reactions and enhanced by surface recombinative desorption (RD). RD mechanisms produce excited molecules—involved in the DA reaction—via different reaction pathways when an atom produced in the plasma volume reacts with an adsorbed atom present on the surface. The direct measurement of molecules in these ro-vibrationally excited v'' and J'' levels is essential to evaluate the effectiveness of RD mechanisms vs. volume production. The DESIRS beam line at the SOLEIL synchrotron offers a unique solution to diagnose these states thanks to an unparalleled VUV Fourier Transform spectrometer (FTS). In this study the VUV-FTS is applied to directly scrutinize the ro-vibrationally excited levels of the D_2 ground state in an electron cyclotron resonance plasma. Different plasma-facing materials are employed—to compare their relative impact in RD mechanisms—and various positions of the plasma source in the reactor are set to measure the distribution of these levels in the plasma volume.
A significant effect of these materials on the absolute distribution of the vibrationally states has been found above $v'' = 3$. Tantalum appears to be, at $v'' = 7$, ∼4.8 times more efficient than a quartz surface at populating high v'' levels which leads to an increase by a factor of 3, compared to quartz, of the negative ion production. The distribution of $v'' = 6$ shows an unexpected homogeneity, ∼10%, up to 75 mm from the plasma source.

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