Solid-state microwave (2.45GHz) pulsed generator for plasma

LPSC developed an ECR dipolar plasma source, and a microwave generator powered by a steady state module. The Compact, highly versatile and robust/reliable device offered works on DC mode, or pulsed mode and presents several advantages, such as high stability over a wide range of experimental conditions while recreating a plasma-surface interaction very close to that obtained in a full-scale ion source. The technology is relevant for big science infrastructures to improve the understanding and knowledge about plasma chemistry or in any industry application requiring a smooth surface treatment.

Description of the technology

The technology is a microwave (2.45 GHz) generator using a **DC solid-state module associated to a plasma source**. The key-technology development performed by LPSC lab. for fusion application is the design of a small experimental set-up. This setup consists of an ECR dipolar plasma source, designed at LPSC, and a microwave generator powered by a steady state module. The plasma source is housed in a cylindrical temperature controlled vacuum chamber. With this setup, the plasma-surface interactions which occur in the RAID reactor are mimicked and its size is small enough to fit the space offered on the synchrotron beam line.

The absorption spectroscopy performed by LPSC lab. on the DESIRS beamline at SOLEIL synchrotron offers a unique method to directly probe these molecular levels produced by recombinative desorption on surfaces of several materials and by vibrational excitation in the plasma volume.Technology Readiness Level reached for fusion applications in that case lies between 4 and 5 as the plasma-surface interaction we have recreated with our dipolar plasma source is very close to the one obtained in a full-scale ion source.

Innovation and advantages of the offer

The solution offered works on DC mode, or pulsed mode and presents several advantages, here are listed the main ones :

- *High stability on a large range of experimental conditions (gas, power, pressure) ;*
- *Compact, highly versatile and robust/reliable device ;*
- *Plasma-surface interaction very close to the one obtained in a full-scale ion source.*
- *A unique method to directly probe these molecular levels produced*

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Non-fusion Applications

Big Science and Fundamental studies on plasma kinetics and chemistry : this device could be used to process modeling which could help to improve the understanding of plasma chemistry. With a rapid pulsed plasma (falling time within few µs) any molecules of similar lifetime could be studied.

For non-fusion application, this plasma device offers the possibility to understand the complex chemical processes which occur in the plasma phase and between plasma and surfaces. Such a solution could find applications in the gas industry (for depolluting for example), Health sector (for sterilization of medical item) or in any application requiring a smooth surface treatment.

EUROfusion Heritage

This device has been successfully used at SOLEIL synchrotron (proposals #20170140 and #20180137) and at LPSC lab. for fundamental studies in Cs-free H2/D2 plasmas under the EUROFusion grant agreement n°633053. (Work package WP HCD entitled Neutral Beam (NB) R&D, Conceptual Design). Activities of the LPSC lab. (Grenoble – France) in fusion applications are related to neutral beam injectors (NBI). These systems designed for ITER, consist of an ion source maintained at HV (1 MV) plugged to an accelerating stage where negative ions are accelerated up to 1 MeV and neutralized in a cold gas by stripping reactions. These ions are going to be produced by direct ionization of H or D atoms on tungsten cesiated surfaces. However, cesium (Cs) material is a potential contaminator of the accelerating stage of the extractor unit where it can cause high voltage disruptions and could induce parasitic beams. An alternative to the use of Cs could be the production of H-/D- by dissociative attachment (DA) of ro-vibrationally excited molecules H2(v",J")/D2*(v",J") in their electronic ground state with cold electrons (Te < 1 eV). These high ro-vibrational levels of molecules are essential for the DA mechanism: the effective cross section increases by a factor of 10 000 between the v"=0 and v"=5 levels.*

Negative ion source (DESY-HERA) designed for particle accelerators provide up to 40 mA of H- negative ion current without the use of Cs. The RAID reactor, implemented with a helicon antenna, produces the same density at 7 kW than the one obtained at 40 kW in a ceasiated hydrogen plasma[8-10]. As reveled by these examples, a refine study focused on the production of H2(v",J")/D2*(v",J") molecules is of interest for fusion community both for NBI efficiency and reliability improvements.*

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