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FET高周波水素負イオン源の負イオン生成評価と大型化
Negative H^- ion production in a FET-based RF ion source and experiments in a larger source

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Neutral beam injection (NBI) is one of the powerful heating and current drive tools for fusion reactors, and NBI is based on a negative hydrogen and deuterium ion source. A negative H^-/D^- ion source with radio-frequency (RF) plasma is requisite to be developed for ITER NBI, where quasi-CW operation of 3600 sec in pulse length is required [1]. IPP-Garching has developed RF sources using 1MHz RF driver. The RF plasma is produced in a cylindrical ceramic tube with 254mm in diameter, which is wound by loop coil antenna. The plasma expands to a larger chamber to extract ions.

We have successfully developed a small size RF ion source using MOSFET based RF system [2]. A compact RF power supply with tunable frequency is fabricated using a full bridge type inverter circuit with MOSFET, which switches DC voltage with the frequency of several hundred kHz. Although the operation frequency is relatively low for plasma production (~500 kHz), it can be operated with high efficiency of DC to AC conversion without any high voltage part in the source. High density RF plasma more than $10^{19}m^{-3}$ is produced in a driver region of 70 mm in diameter and 200 mm in length.

In the experiment, addition of axial magnetic field in the driver region works well to enhance the plasma production. We measured magnetic field fluctuation in the driver and expansion region, and found wave propagation in the source corresponding to the excitation of helicon wave. The axial magnetic field can be applied by an array of permanent magnet [3]. H^- ions are extracted from the source and dependences on RF power, gas pressure, bias voltage to plasma grid are measured.

In order to apply the FET-based RF system to a larger device, experiments should be performed to ensure an efficient RF production in a larger source. We have started experiments in an negative hydrogen RF ion source with a larger driver source (230mm in inner diameter and 300mm in length). Figure 1 shows the schematic of the ion source. The driver region made by an alumina ceramic tube is wound by a 10 turn external antenna. Axial magnetic field up to 20mT can be applied using a couple of magnetic coils attached at the driver region. The driver is connected to an rectangular expansion chamber with the size of 200×300×400 mm^3. Filter magnets (NdFeB) are attached at the expansion region to form a filter field to eliminate electron current. Electron density and temperature can be measured by a Langmuir probe at both the driver and expansion regions. The negative hydrogen ion beam is extracted and accelerated with electrodes attached to the expansion chamber.

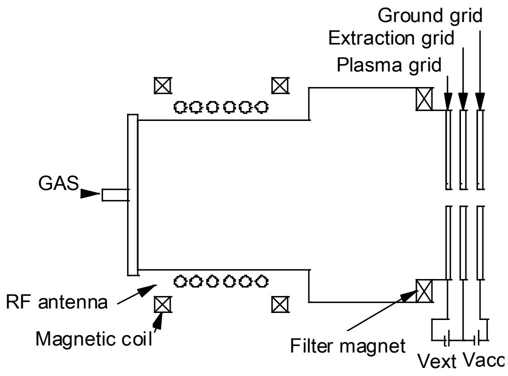

Fig.1 Schematic of a H- ion source with cylindrical ceramic tube of 230mm in diameter.

Several plasma parameters in the larger source and an extracted negative hydrogen ion current will be presented. Cesium seeding effect in the source will be also discussed.

Reference

[1] U. Fantz, et al., Nucl. Fusion. 49 125007 (2009).
[2]A.Ando, et al., Rev. Sci. Instrum. 83, 02B122 (2012).
[3]K.Oikawa, et al., to be published in Rev. Sci. Instrum.