Highly Efficient Production of Excited Neutral Helium Beams for Spectroscopic Diagnostics of Electric Fields in IEC Plasma

Tetsuya Nishi, Kei Yoneda, Kai Masuda and Kiyoshi Yoshikawa
Graduate School of Energy Science, Kyoto University
Gokasyo, Uji, Kyoto 611-0011, Japan
Tel/Fax: +81-774-38-3443, +81-774-38-3449, E-mail: tetsuya@iae.kyoto-u.ac.jp

The Laser-Induced Fluorescence (LIF) method could be an efficient tool for understanding the electric potential formation in plasmas. Our LIF diagnostics system making use of the Stark effects in forbidden transition of helium has successfully revealed potential profiles in helium discharge Inertial Electrostatic Confinement (IEC) plasmas under relatively high operating gas pressure (center spot mode), where ample 2^1S metastable atoms are provided by the IEC discharge itself. In order to extend its application to lower pressure (i.e. higher voltage) operational plasmas (star mode), and deuterium plasmas as well, we are developing a pulsed beam injector of low-energetic 2^1S helium atoms. The key R&D issues are the production of a highly efficient exciter plasma under low operational gas pressure and the minimization of the beam diffusion produced in the beam passage.

We have developed a magnetron-discharge-based exciter which can produce a race-track-shaped plasma with a 5 cm long straight section capable of strong interaction with the injected beam. In order to evaluate the exciter plasma properties, a Langmuir probe and emission spectroscopy measurements have been performed under a low helium gas pressure of 1.2×10^{-1} Pa. Comparison of these two measurements strongly imply a high excitation rate of ~ 2×10^{-4} into 2^1S state.

Meanwhile, an intense helium pulsed beam with a peak density of 1.5×10^{13} cm^{-3} (= 6.2×10^{-2} Pa) had been also obtained by optimal arrangement and operation of the fast electromagnetic valve and the skimmer. These are very encouraging results for the target density of 2^1S metastable atoms (~10^{13} cm^{-3}).

We are then carrying out the experiment of pulsed helium beam injection under the background deuterium gas with the exciter plasma in order to evaluate the scattering effect of the gas jet by the background deuterium in IEC devices.