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Progresses of divertor plasma research in RF plasma device DT-ALPHA

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One of the major challenges in the magnetic confinement fusion research is the safe control of large plasma heat load on the divertor plates. Control scenarios of the heat load are based on the detached divertor operation. When the divertor is in high-recycling condition, plasma density increases and plasma temperature decreases through collisions with neutral gases, and finally plasma is detached from the divetor plates. Therefore, understanding reaction rates of atomic and molecular processes associated with the plasma detachment or development of plasma diagnostic techniques necessary are important issues.

Conventionally laboratory experiments on divertor plasma have been carried out with DC arc plasmas. However, we propose use of an RF plasma because RF sources enable us to (1) inject energetic ion beam into a divertor-simulating plasma [1], (2) form non-Maxwellian electron energy distribution [2], and (3) produce relatively high ion temperature plasma [3].

Figure 1 is a schematic view of the RF plasma source DT-ALPHA. Total length of the device and plasma diameter are approximately 2 m and 20-30 mm, respectively. Plasma is produced by 13.56 MH RF discharge. Maximum magnetic field strength is 0.2 T. Working gas is fed into the device near upstream end. Secondary gas for facilitating volumetric recombination is fed at downstream region.

Recently we are working on production of hydrogen MAR (molecular activated recombination) plasma as a target of the ion beam injection. Rollover of the electron density and monotonic decrease of the electron temperature were clearly observed as amount of the hydrogen secondary gas was increased [4]. Spectroscopic measurement and analysis of some reaction rates indicated that the MAR attributed to the ion conversion had a strong contribution to the density rollover [5]. Reaction rate of MARs depends on ion temperature, and ions in small linear machines as DT-ALPHA usually have temperature anisotropy. Therefore, we have developed a new technique to determine parallel and perpendicular ion temperatures simultaneously [6]. This technique utilizes the selective ion transmission associated with the ion Lamour motion arises in retarding field analyzers (RFAs). Figure 2 shows a typical analysis by this method. Figure 2(a) represents an experimentally obtained *I-V* curve by an RFA and its slope gives $T_i^{\parallel}$ = 1.2 eV. In Fig. 2(b), the experimental data (squares) and calculated curves (solid lines) are compared. The curve calculated with $T_i^{\parallel}$ = 1.2 eV and $T_i^{\perp}$= 2.0 eV fits the experimental one very well. Figure 2(d) is an *I-V* curve obtained by an ion sensitive probe, indicating $T_i^{\perp}$ = 2.0 eV. $T_i^{\perp}$ indicated in Figs. 2(b) and (d) are showing good agreement.

In the presentation, recent progresses on the divertor plasma research in DT-ALPHA device will be reported, focusing on mainly these two results.

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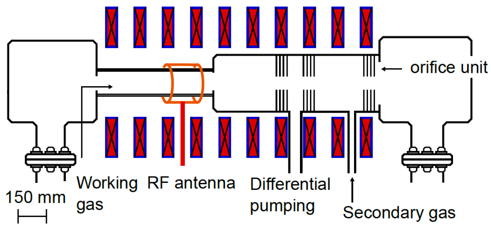

Figure 1. A schematic of DT-ALPHA device.

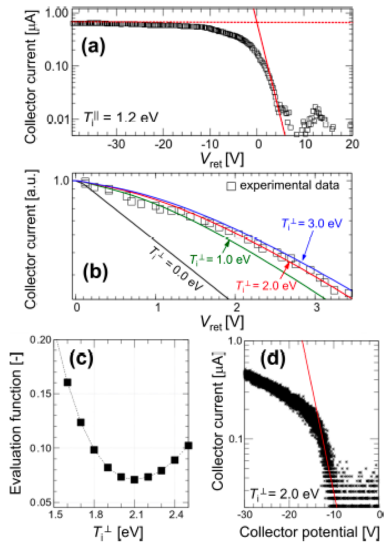

Figure 2. (a) *I-V* curve obtained by an RFA, (b) comparison of *I-V* curves, and (d) *I-V* curve obtained by an ISP [6].

References
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