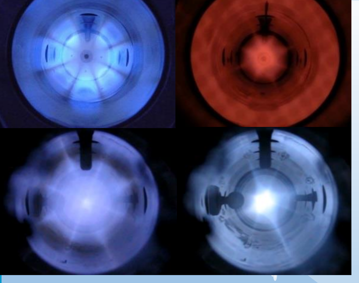


Low Z Gas Mixing Effects of Ar and Xe Multicharged Ions in Electron Cyclotron Resonance Ion Source

Kazuki Tsuda, Wataru Kubo, Shuhei Harisaki, Issei Owada, Koichi Sato, Masahiro Anan, Takumu Maenaka and Yushi Kato

Division of Electrical, Electronic and Infocommunication Engineering, Graduate School of Engineering, Osaka Univ.
2-1 Yamada-oka, Suita-shi, Osaka 565-0871, Japan
Corresponding Author: Kazuki Tsuda, e-mail address: k.tsuda@nf.eie.eng.osaka-u.ac.jp

OSAKA UNIVERSITY

§ 1. Introduction

Background

- In general ECRIS, high yield of multicharged ion currents have been achieved by increasing the magnetic field strength and microwave frequency.
- Our group aims to increase the yield of multicharged ions by introducing other electromagnetic waves without changing the magnetic field strength and microwave frequency.
- In our previous studies, the increase of Ar multicharged ion yield has been confirmed by the upper hybrid resonance (UHR) using 4-6 GHz X-mode microwaves and the dual-ECR heating method in which microwaves are fed from two antennas simultaneously.
- In order to further increase the multiply charged ion beam, we are trying to introducing low frequency RF electromagnetic waves in mixing the low Z gases.

Objectives

- It is important to investigate the characteristics of the gas mixing effect in order to conduct the above experiments.
- We have investigated the change in the multicharged ion yield, the change in the average charge of Ar ions, and the plasma parameters (electron density n_e, electron temperature T_e) by mixing low Z gas.

§ 2. Experimental Setup

ECRIS in Osaka Univ.

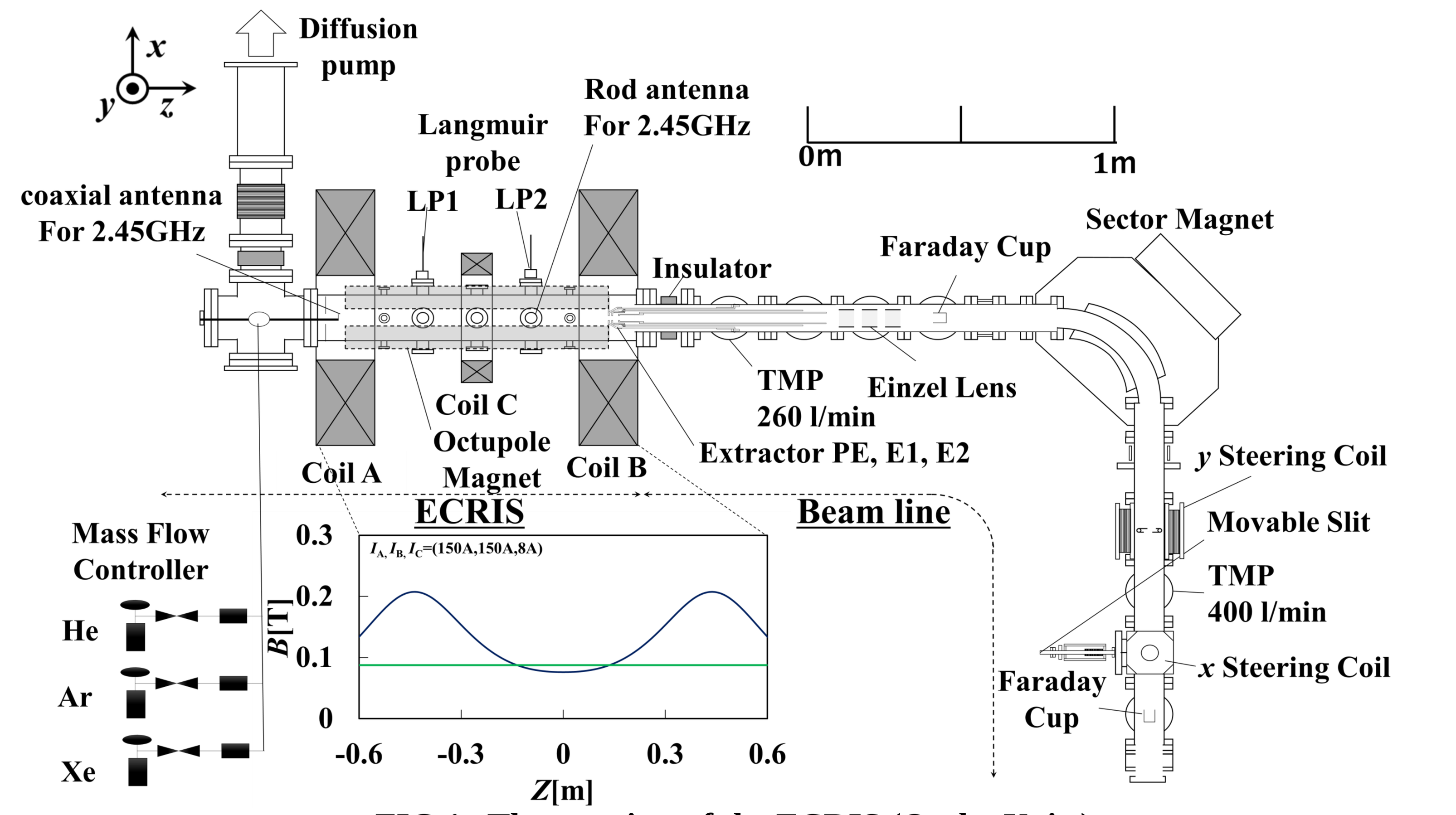


FIG.1 . The top view of the ECRIS (Osaka Univ.)

§ 3. Experimental Results

Experiment of He mixing into Ar plasma under constant Ar partial pressure

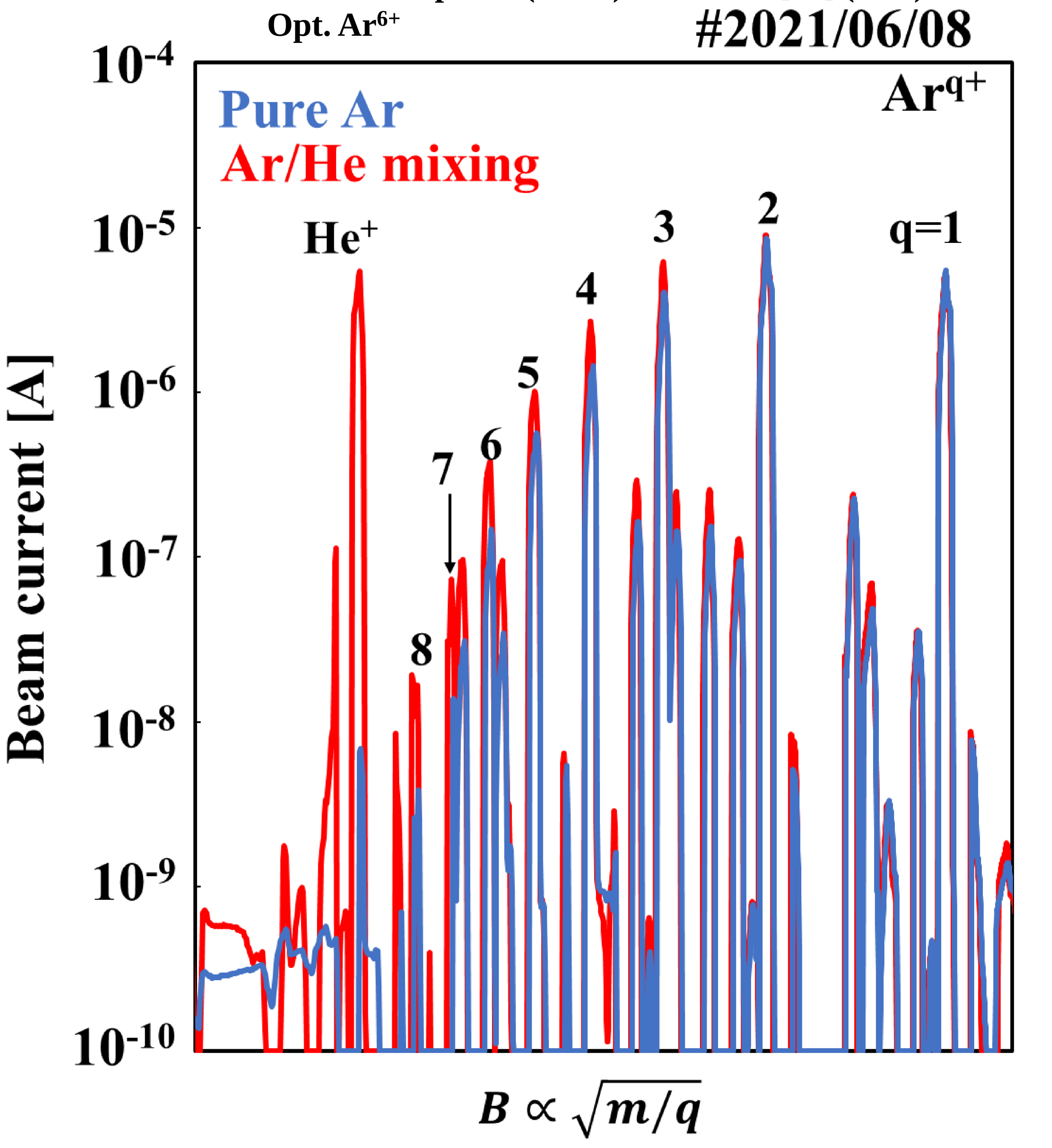


FIG.2 . Typical Ar ion beam CSD under constant Ar partial pressure

- The blue line is the CSD of Ar ion beams with pure Ar.(pure Ar).
- The red line is the CSD of Ar ion beams with He mixing (Ar/He mixing).
- We have confirmed that Ar/He mixing is much larger than pure Ar for Ar multicharged ions.

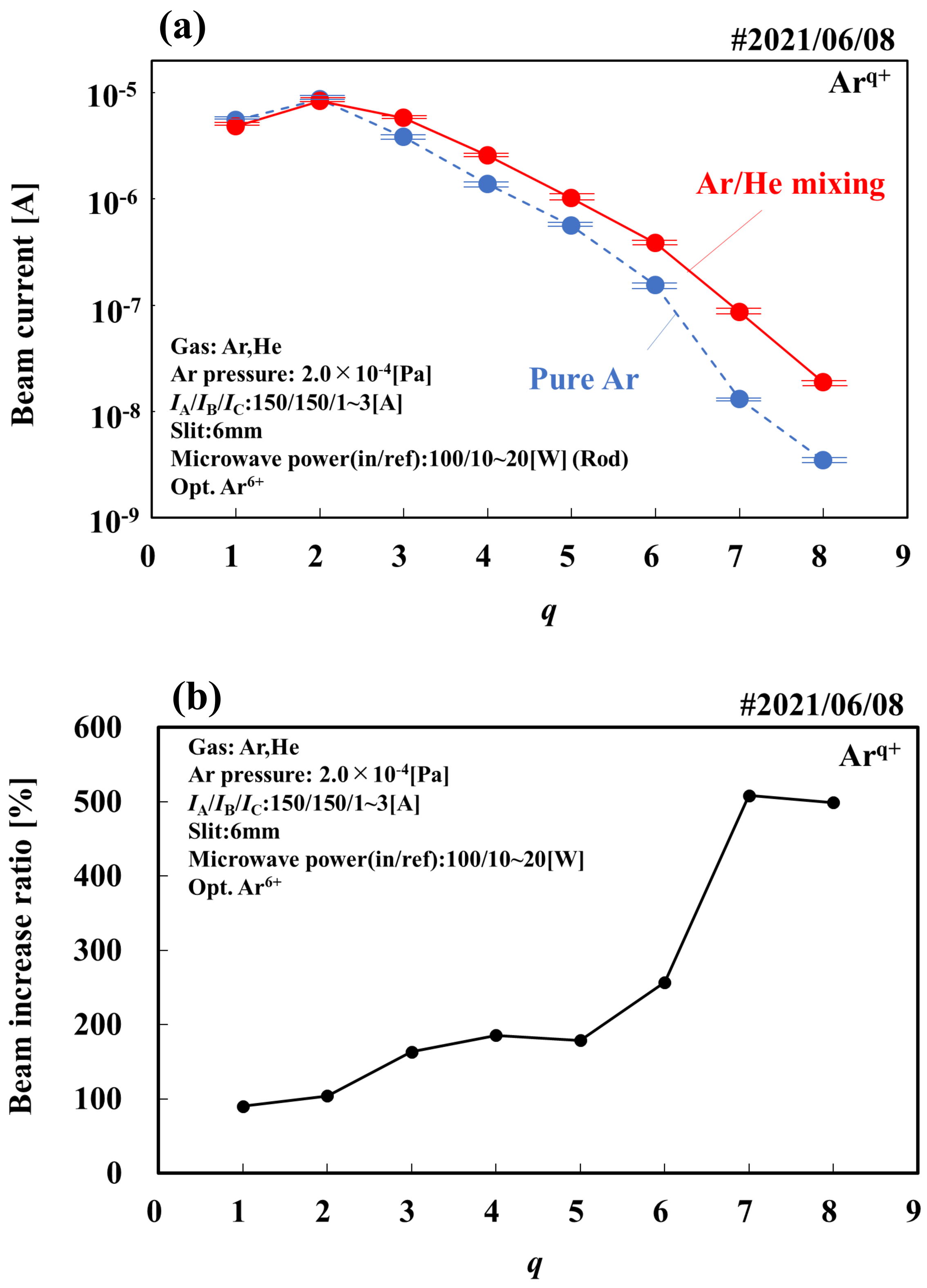
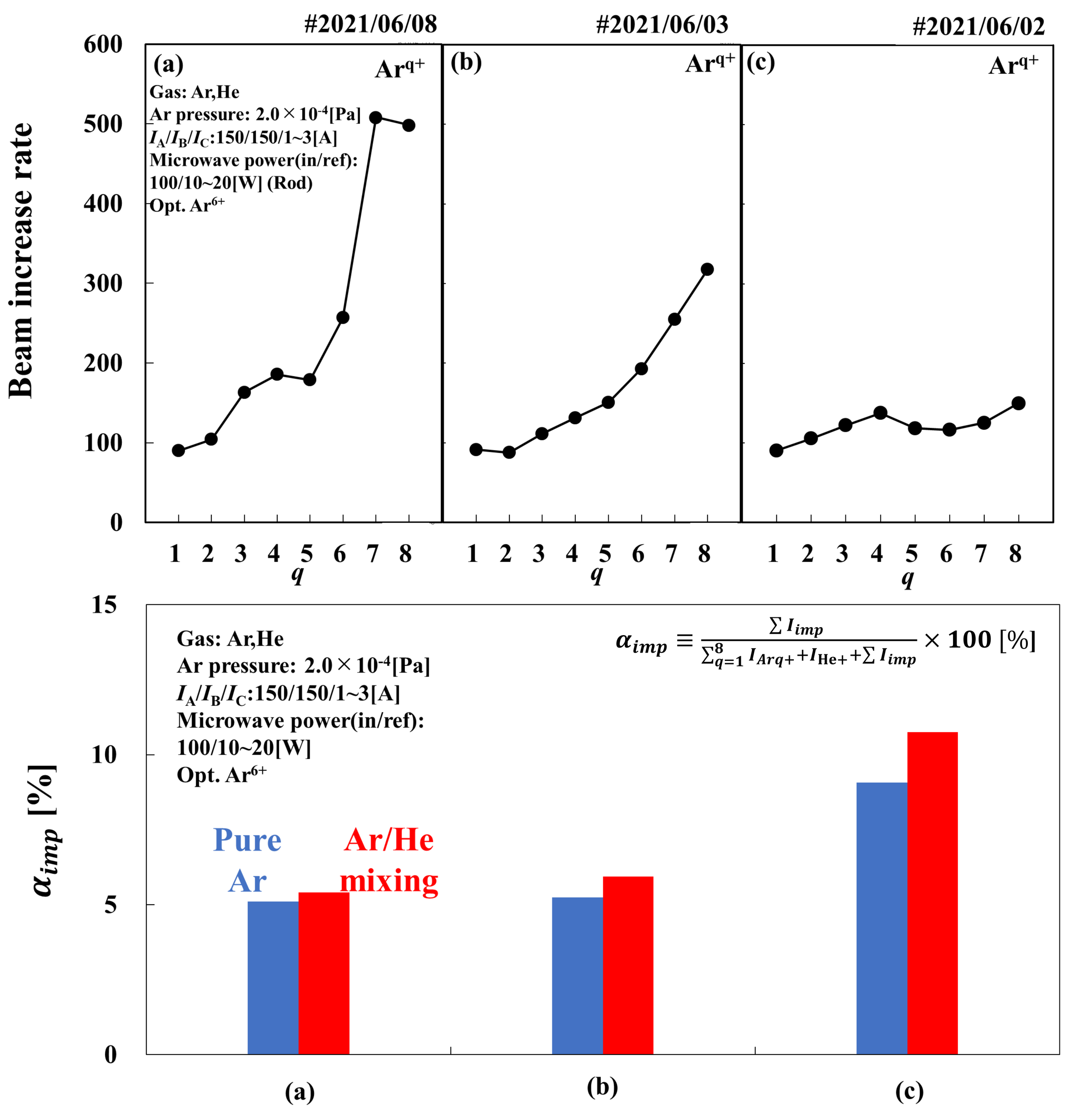


FIG.3 . (a)Effect of He mixing under constant Ar partial pressure
(b)Ar ion beam current increase ratio before and after He mixing

- Each point shows the average value of the He mixture measured three times, and the error bars show the standard errors.
- It was sufficient reproducibly confirmed that Ar/He mixing was higher than pure Ar for Ar multicharged ions.
- It is confirmed that the beam enhancement rate also increases with increasing charged q.

Effect of impurities under gas mixing



$$\alpha_{imp} \equiv \frac{\sum I_{imp}}{\sum_{q=1}^{8} I_{Arq+} + I_{He+} + \sum I_{imp}} \times 100\ [\%]$$

FIG.5. Beam increase rate and impurity percentage α_{imp} of He mixing on Ar gas under the same conditions

- In Fig. 5, the experimental conditions (a), (b), and (c) were all the same, but the He mixing effect was sufficiently observed in some cases and not in others.
- For Ar^{8+}, the increase rates were 499%, 318%, and 150% in the order of (a), (b), and (c), respectively.
- In spite of the same conditions, the effect was observed in (a) and (b), but not so much in (c).
- In the case of (a) and (b), where the effect of He mixing was observed, it was about 5% for both pure Ar and Ar/He mixing, while in the case of (c), where the effect was not observed, it was about 10%.

Results of plasma parameter measurement by probe under gas mixing

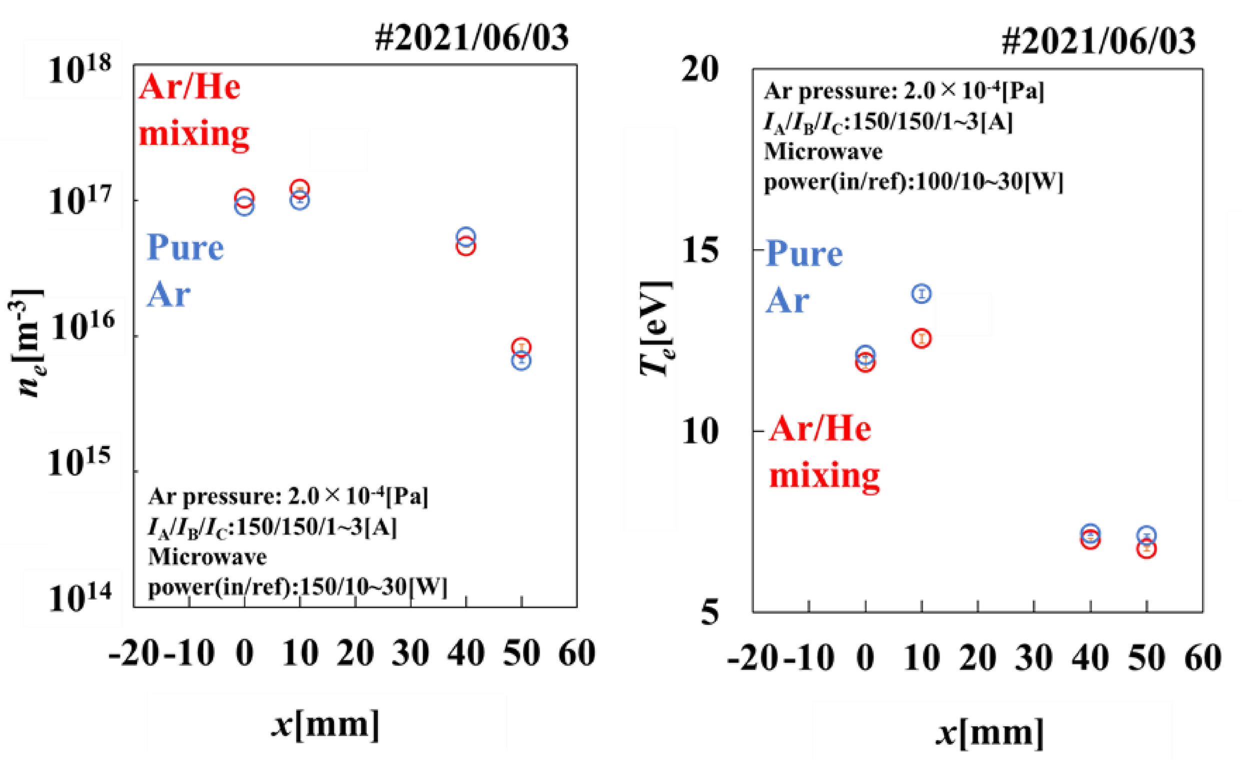


FIG.4 . n_e, T_e in radial direction on Ar and Ar/He mixing

- The values of n_e and T_e are similar with and without mixing He to Ar plasma.
- For the points between $x = 10$ and 40, reliable data could not be obtained due to the probe emission.

Experiment of He mixing into Ar plasma under constant total pressure

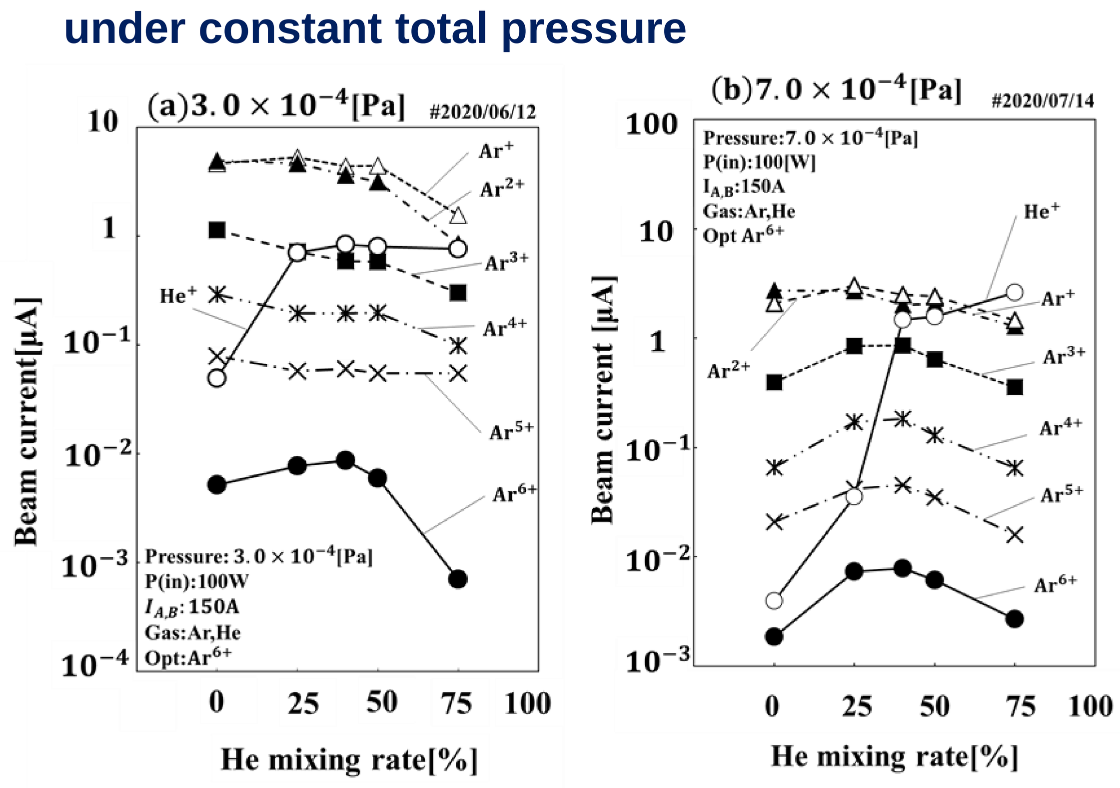


FIG.6 . Dependence of Ar ion beam current on He mixing ratio under constant total pressure

- We confirmed that the maximum Ar multicharged ion yield was obtained when the He mixing ratio was about 30~40%.

§ 4. Conclusion & Future Planning

Conclusion

- Under the conditions where the $Ar^{3\sim8+}$ ion beam yield is maximized in pure Ar, we have confirmed that the current value increases with sufficient reproducibility by mixing He.
- In order to obtain a sufficient gas mixing effect, the percentage of impurities must be less than around 5%.
- Since there is no significant change in n_e and T_e with and without mixing He to Ar plasma, it can be concluded that the increment of Ar multicharged ion currents with He mixing is not due to the change of plasma parameters, but is mainly due to cooling effects.

Future plan

- The emittance measurement will be carried out to estimate the ion temperature T_i before and after the low Z gas mixing in order to obtain further confirmation of the selective heating of low Z ions.
- The introduction of pulse modulated microwaves and the application of the dual ECR heating method under gas mixing are being investigated.