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Characteristics of co-extracted electrons reduction for the Cs-free negative ion source using TPDsheet-U

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In fusion devices such as ITER, negative ion based neutral beam injection (NNBI) system is used for plasma heating. Cs-seeded RF driven negative ion source is typical for high-density negative ion production with surface production. However, Cs vapor seeding derived frequent maintenance and it makes long-term operation difficult. Therefore, it is necessary to develop the Cs-free negative ion source.
We are developing a Cs-free negative ion source based on TPDsheet-U[1].Generally, in all the negative ion sources using the volume production, a large amount of co-extracted electrons with the negative ion beam is observed. A large heat load on the extraction grid is occurred by co-extracted electron. In order to solve this issue, we devised a mechanism to reduce electron co-extraction with a Soft Magnetic plate for Filter (SMF) for TPDsheet-U. SMF on plasma facing grid (PG) curves magnetic field lines locally and traps the electrons. Actually, the maximum measured electrons current decreased from 15 mA/cm2 to 1.3 mA/cm2 at discharge current of 50 A in previous study[2].
In this experiment, we changed the distance between SMF and PG by using spacer to investigate the effect of the magnetic field distribution vicinity of PG on extracted current density. At the discharge current of 80 A and gas pressure of 0.3 Pa, the co-extracted electrons current density was most reduced by using the 0.5 mm thick spacer, resulting in 6.7 mA/cm2 to 2.3 mA/cm2 and extracted negative ion current density was lower. (i.e., 5.2 mA/cm2 to 3.5 mA/cm2) In this case, the current ratio Ie/IH- was 0.67. From these results, it was obtained that changing the magnetic field distribution vicinity of PG is effective to reduce the co-extracted electrons.

[1] A. Tonegawa et al., Nucl. Fusion 61 (2021) 106030.
[2] H. Kaminaga, et al., Fusion Eng. and Des., 168 (2021) 112676.

Author: GOKA, Taiga (Tokai university)

Presenter: GOKA, Taiga (Tokai university)

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