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

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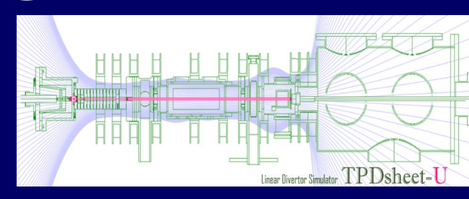

INTRODUCTION

Parameters

	ITER-NBI		Tokai Univ.(TPDsheet-U)	
	D-Beam	H-Beam	90A discharge	80A discharge
Cs seeding	W/	W/	W/O	W/O
Extracted Current Density [mA/cm^2]	29	33	7.7	3.4
Current Ratio I_e/I_{H^-}	≦1	≦0.5	2.6	0.5

TPDsheet-U is a Cs-free negative ion source using magnetized- sheet plasmas, which is being researched and developed at Tokai University.
In this study, the extracted system was modified with soft magnetic materials and spacers to reduce the large number of co-extracted electrons.

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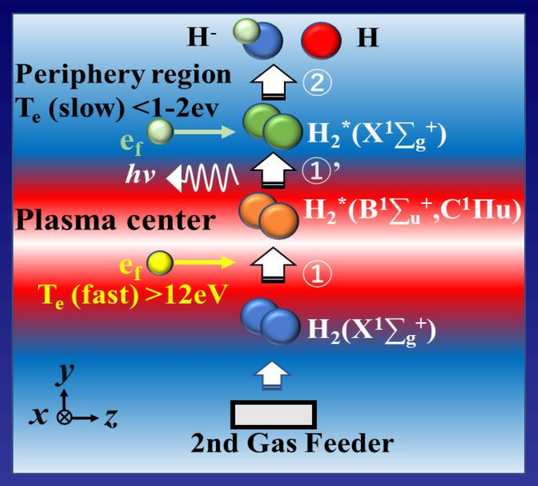
H⁻ PRODUCTION ON Cs-FREE



Volume production in sheet plasma

Volume Production

①Electron impact excitation

$H_2(X^1\Sigma_g^+) + e_f\ (>12eV) \rightarrow H_2^*(B^1\Sigma_u^+, C^1\Pi_u) + e$

①' Spontaneous radiative transition

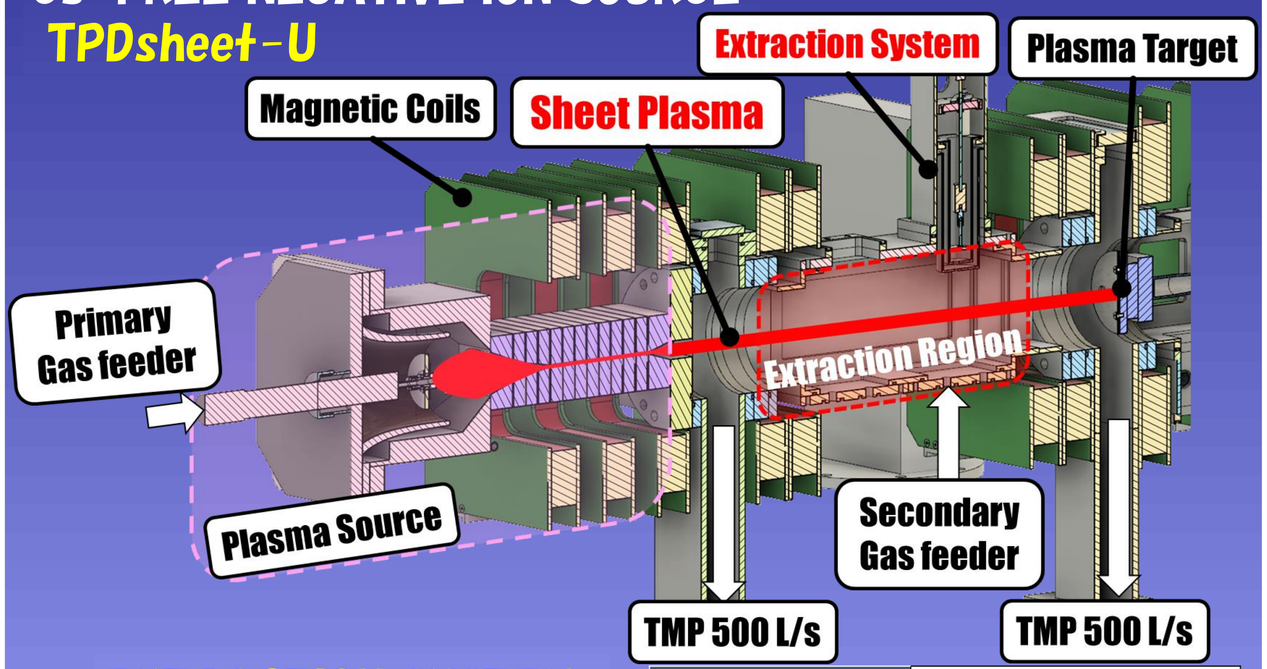
$H_2^*(B^1\Sigma_u^+, C^1\Pi_u) \rightarrow H_2^*(X\Sigma_g^+) + h\nu$

② Dissociative attachment

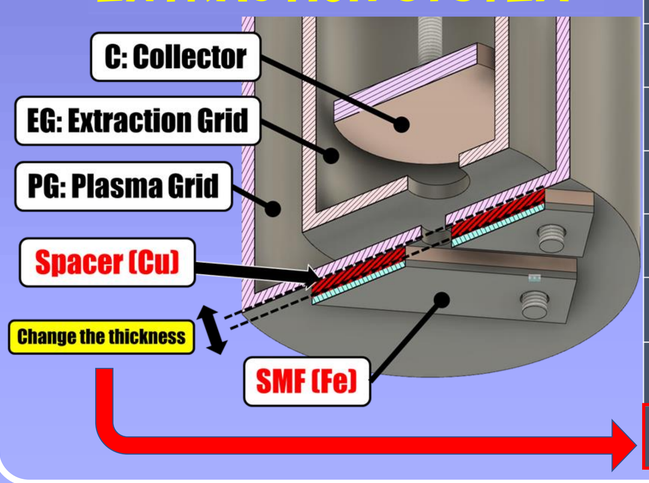
$H_2^* + e_s\ (<1\text{-}2eV) \rightarrow H^- + H$

Cs-FREE NEGATIVE ION SOURCE

TPDsheet-U

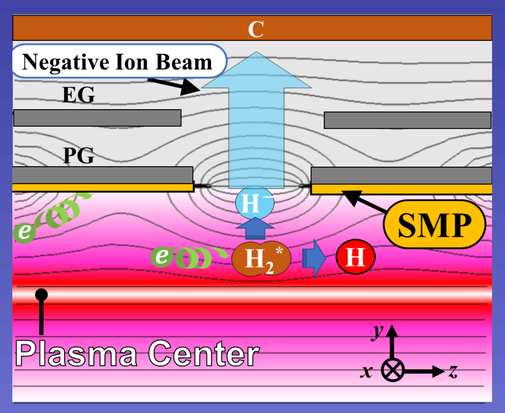


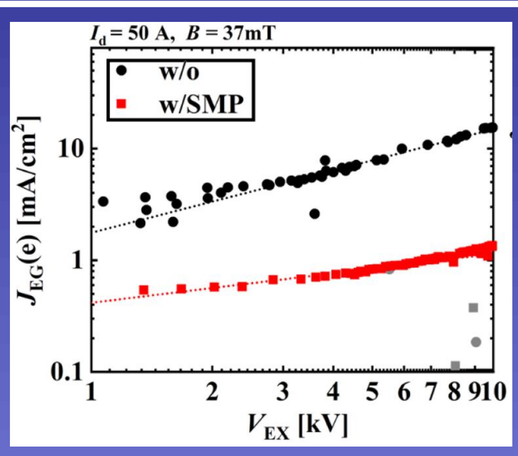
EXTRACTION SYSTEM



Gas pressure	~ 0.3 Pa
Magnetic flux density	37mT
Discharge current	40 ~ 80 A
Extraction voltage	≦ 10 kV
PG hole	φ 4 mm
EG hole	φ 8 mm
Thickness of SMF	0.2mm
Thickness of Spacer	0.3,0.5,0.8,1.0,1.8mm

PREVIOUCE RESEARCH



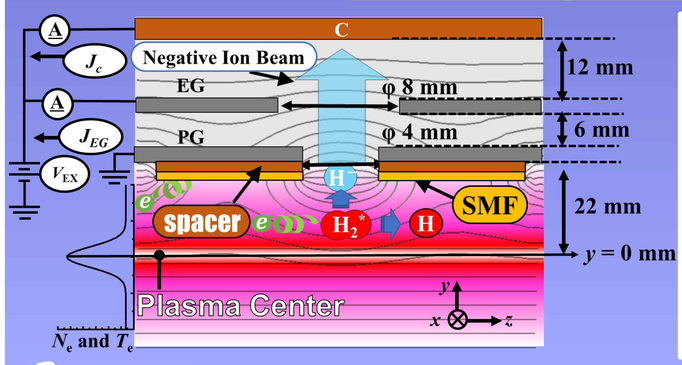


In the past, the maximum measured co-extracted electrons current decreased from 15 mA/cm^2 to 1.3 mA/cm^2 at discharge current of 50 A in previous study.

H. Kaminaga, et al., Fus. eng. des. 168 (2021) 112676.

ABOUT THE SMF

SMF: Soft Magnetic material plate for Filter

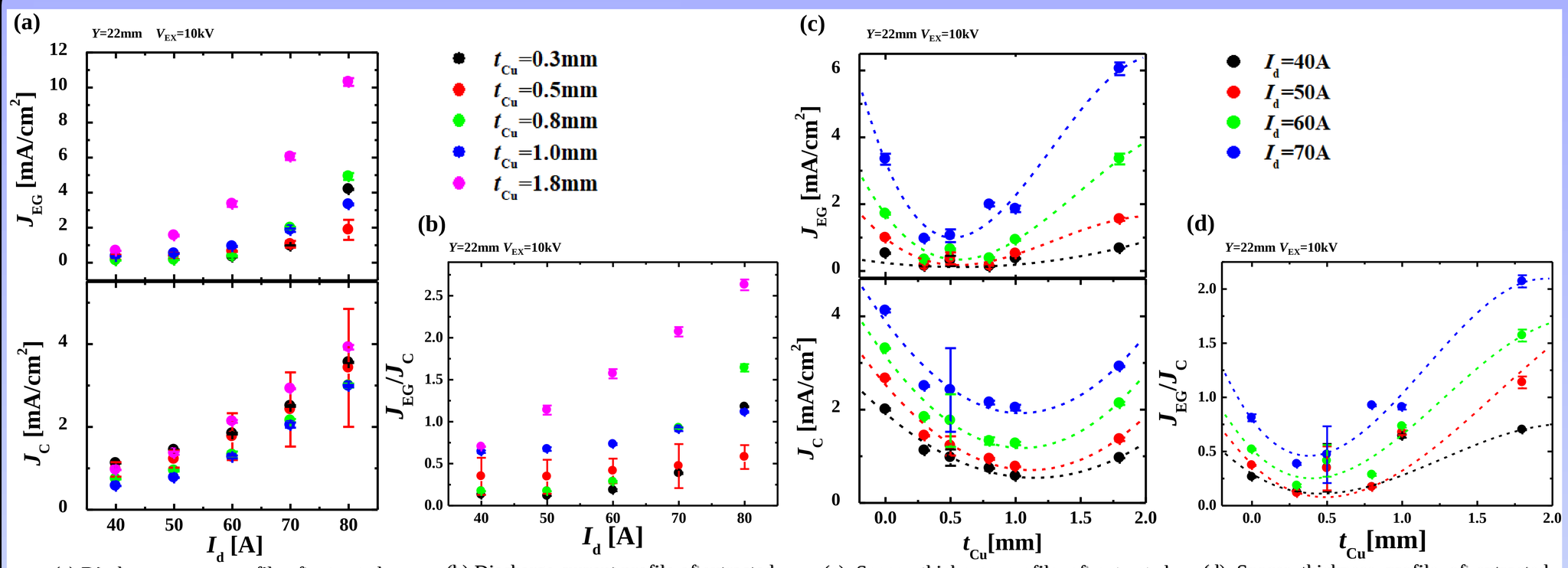


SMF on plasma facing grid (PG) traps the electrons in locally curved magnetic field lines and reduces the co-extracted electrons current.
We varied the local magnetic field vicinity of PG by thickness of copper spacers installed between the SMF and the PG.

Purpose

By placing a copper spacer between the extracted electrode (PG) and the SMF, we aim to evaluate the effect of the filter field distribution by the SMF on the co-extracted electron current density and to determine the optimal SMF arrangement.

SPACER EFFECT IN EXTRACTION



(a) Discharge current profile of extracted current density with thickness of spacer at extraction voltage of 10 kV and Y-axis of 22 mm.

(b) Discharge current profile of extracted current ratio with thickness of spacer at extraction voltage of 10 kV and Y-axis of 22 mm.

(c) Spacer thickness profile of extracted current density with discharge current at extraction voltage of 10 kV and Y-axis of 22 mm.

(d) Spacer thickness profile of extracted current ratio with discharge current at extraction voltage of 10 kV and Y-axis of 22 mm.

(a):
- **The more the discharge current was increased, the larger the change in the co-extracted electron current and H- current.**

(b):
- **The more the discharge current was increased, the larger the change in the increasing current ratio became.**

(c):
- **The co-extracted electron current peaked around t_{Cu} =0.3-0.5mm and the graph was convex downward.**

(d):
- **The extracted current ratio was a convex graph with a peak around t_{Cu} = 0.3-0.5 mm.**

⇒ **It was suggested that the minimum values of the co-extracted electron current and extracted current ratio were located around 0.3-0.5 mm.**

CONCLUSION

In this study, we performed an experiment to evaluate the effect of the filter magnetic field by SMF on the co-extracted electron current density by installing copper spacers and to determine the optimal SMF configuration.

- ✓ **The rate of increase in the co-extracted electron current, H$^-$ current, and current ratio increased as the discharge current increased.**
- ✓ **The co-extracted electron current and extracted current ratio showed a convex graph with a peak around t_{Cu} = 0.3-0.5 mm.**

⇒ **It is suggested that the optimum spacer thickness is around t_{Cu}=0.3-0.5mm.**

Future Plans

- ✓ **Optimize SMF by varying its structure (thickness, shape, material).**
- ✓ **Direct biasing of the SMF increases the negative ion current density.**

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