

KSTAR NBI H₂ D₂ 가

Discharge Characteristics of Hydrogen and Deuterium in KSTAR NBI Ion Source

150

KSTAR NBI full power (120 kV, 65 A)

가 FIC 3800 A, FCR 3000 A

가 , 가 , full

power 4x10⁻² Torr 1200 A 가

3.36 eV 2.4x10¹¹ cm⁻³

Langmuir probe plate 6x10⁻³ Torr full power

가 5 eV 1.4x10¹² cm⁻³

full power 40%

Abstract

The optimum operation conditions of the KSTAR NB ion source have been studied with hydrogen and deuterium gases. A stable discharge has been earned at the optimum heating condition of filaments of 3800 A of FIC and 3000 A of FCR, respectively, and this could save filament power under this conditions. Discharge characteristics of hydrogen and deuterium had been affected by pressure, discharge gases and anode area. A full power operation of hydrogen has been done at the least working pressure of about 4x10⁻² Torr, and then ion density at arc current of 1200 A was about 2.4x10¹¹ cm⁻³. Langmuir probe plate was connected to anode to improve ion density of ion source. As results, the least working pressure of deuterium for full power was about 6x10⁻³ Torr, and then ion density was 1.4x10¹² cm⁻³. Uniformity of ion saturation current around bucket measured with 6 Langmuir probes was within 40%.

1.

KSTAR, JT-60U, JET, ASDEX-U, ITER, TFTR, D -D 가 KSTAR NBI(Korea Superconducting Tokamak Advanced Research Neutral Beam Injection) 가 1 3 8 MW 가 가

1.

Table 1. Electrical specification of filament P/S and arc P/S

	Filament P/S	Arc P/S
Output DC Voltage[V]	15	160
Output DC Current[A]	3200 CW 5500 for 6 sec	1200 CW
Current Ripple	2 %	2 %
Pulse Width	350 sec/30 min	320 sec/30 min
Current rising time	30 ms	30 ms at start 1 ms during operating
Current falling time	30 ms	0.1 msec
DC 가	inverter	Chopper

2. 가

Table 2. Conditions of filament heating

		Filament Initial Current		Filament Current during Arc	
		FIC[A]	FIC Time[sec]	FCR[A]	FCR Time[sec]
FIC 가	No.1	3200	12	3200	1
	No.2	3300	12	3200	1
	No.3	3400	12	3200	1
	No.4	3500	12	3200	1
	No.5	3600	12	3200	1
	No.6	3700	12	3200	1
	No.7	3800	12	3200	1
	No.8	3900	12	3200	1
	No.9	4000	12	3200	1
FCR 가	No.10	3800	10	3800	1
	No.11	3800	10	2900	1
	No.12	3800	10	2800	1
	No.13	3800	10	2700	1
	No.14	3800	10	2600	1
	No.15	3800	10	2500	1
	No.16	3800	10	2400	1

2

ON

FIC(Filament Initial Current)

FCR(Filament Current during Arc)

가

Full power

$4 \times 10^{-2} \sim 4 \times 10^{-4}$ Torr

가

가

C.C. (Constant Current Operating Mode)

1200 A

가

6

Langmuir

probe(

0.8 mm, 2 mm)

Langmuir probe

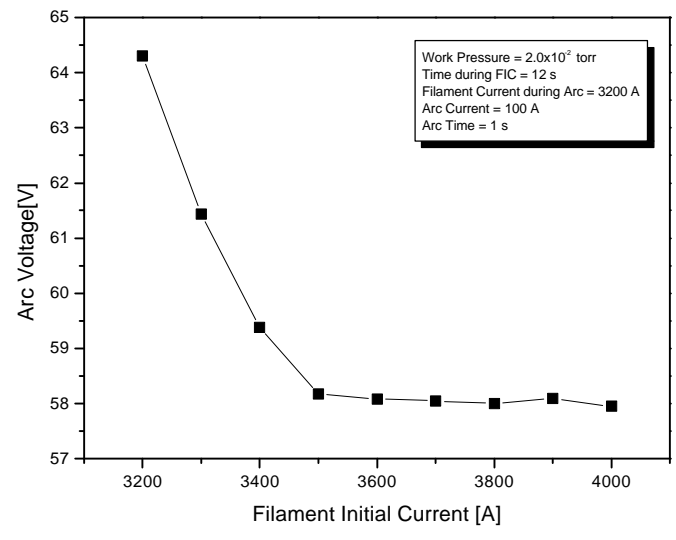
+50 -150 V, 4 Hz

가 . 가 가 99.999 %
 99.95 % .

3.

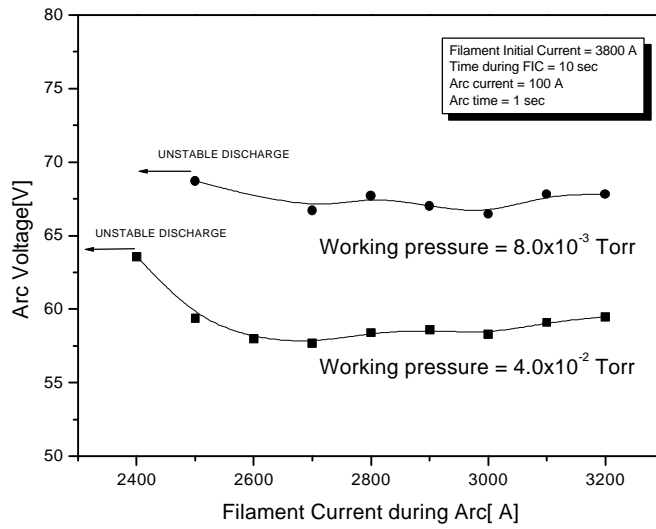
3-1. 가

2 2×10^{-2} Torr, FIC 12 sec, FCR 3200 A, 100 A, 1 sec
 FIC 가 3500 A 가 가 FIC 가
 Richardson 가 FIC 3500 A 가 sheath 가 가
 가 가 (FIC) 3500 A^2 가 가
 가 가 3800 A 10
 가 3 FIC 3800 A, FIC 10 sec, 100 A, 1 sec FCR
 2400 A 가 4×10^{-2} Torr 가 (FCR)가
 가 FCR 가 가
 가 2 FCR 가 sheath
 가 full Power 가 FCR 2700 A
 FCR



2. FIC

Fig. 2. Discharge voltage characteristics at various FIC



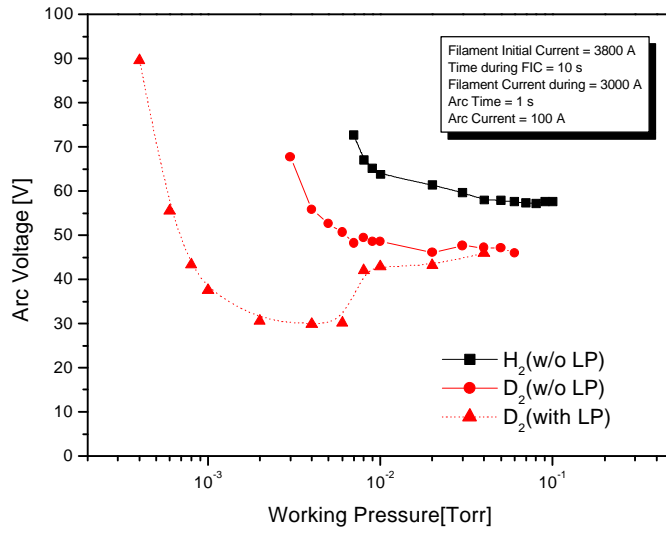
3. FCR

Fig. 3. Discharge voltage characteristics at various FCR

3000 A

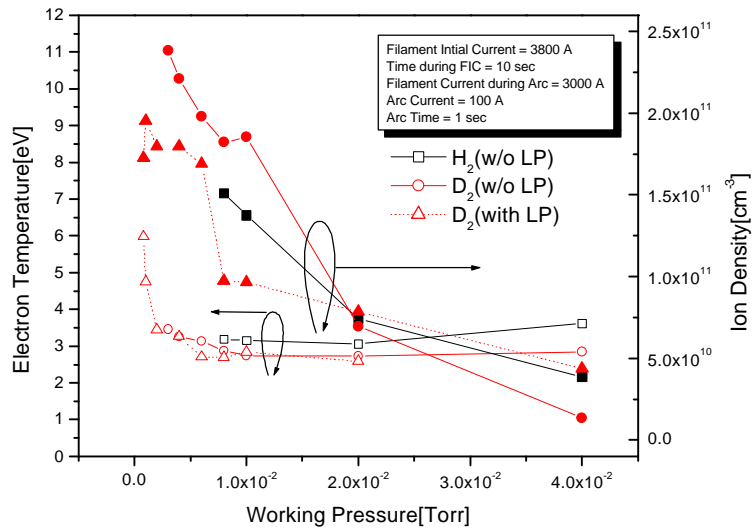
3-2. H₂ D₂

4	FIC 3800 A, FIC	10 sec,	FCR 3000 A,	100 A,	1 sec
	probe plate		(with probe plate)	4	1
	(w/o probe plate)				(w/o probe plate)
	(w/o probe plate)				10 ⁻² Torr
	15 20 V				가
2	$\bar{c} \propto 1/\sqrt{m}$				가
			probe plate		가
			10 ⁻² Torr		full
power	가 10 ¹² cm ⁻³				
	1		probe plate		
	(with probe plate)		10 ⁻³ Torr		
	(with probe plate)			가	가
5	4				
		8x10 ⁻⁴ Torr	6 eV		



4.

Fig. 4. Discharge voltage characteristics at various working pressure



5.

Fig. 5. Electron temperature and ion density at various working pressure

4 eV
 .
 (with probe plate)
 . 2 × 10⁻² Torr
 . 4
 Torr . 5

가
 8 × 10⁻⁴ Torr
 full Power
 (w/o LP)
 가
 4 × 10⁻² Torr

가
 가
 가
 10⁻²
 가

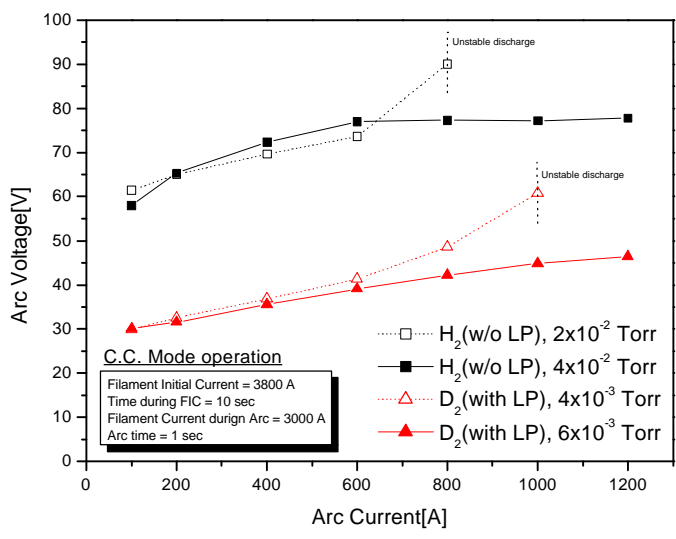
$4 \times 10^{10} \text{ cm}^{-3}$
 10^{-3} Torr

probe plate
 Torr

FIC 3800 A, FIC 10 sec, full power 1200 A
 $4 \times 10^{-2} \text{ Torr}$

FCR 3000 A, 100 A, 1 sec C. C. mode
 full power 800 A
 $2 \times 10^{-2} \text{ Torr}$ (with probe plate)

Torr 1000 A
 $6 \times 10^{-3} \text{ Torr}$
 4×10^{-3}



6. Full Power

Fig. 6. Electron temperature and ion density at full power operation

full power
 $4 \times 10^{-2} \text{ Torr}$ 1200 A full power
 3.36 eV $2.4 \times 10^{11} \text{ cm}^{-3}$ (with probe plate)

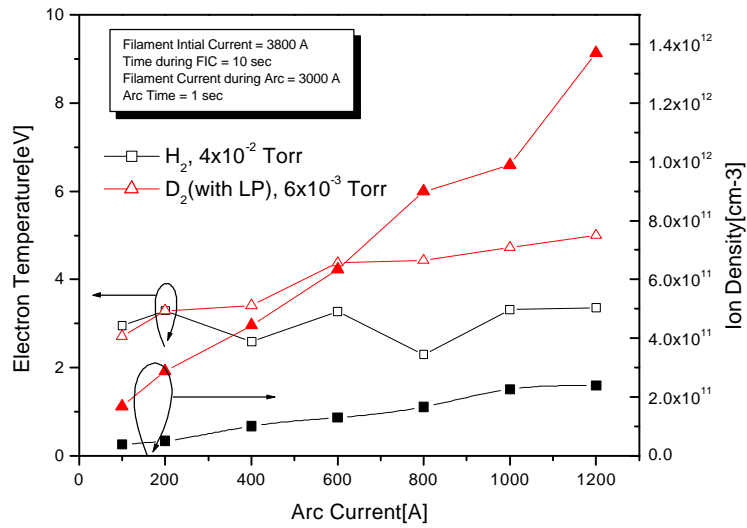
full power
 $6 \times 10^{-3} \text{ Torr}$

5 eV $1.4 \times 10^{12} \text{ cm}^{-3}$

10^{-3} Torr

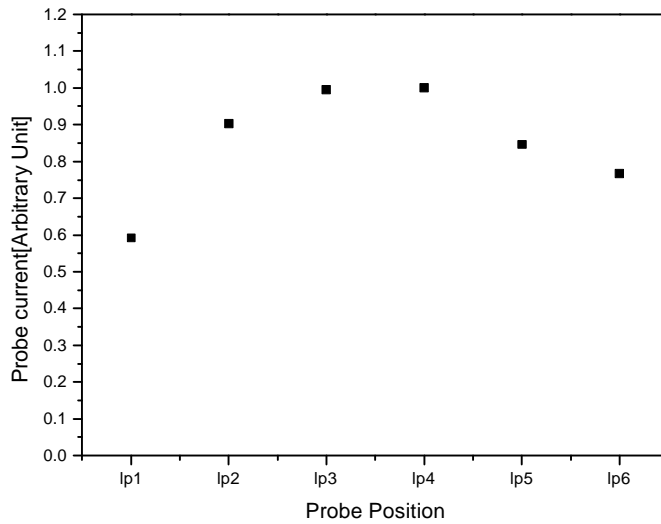
10^{-3} Torr (with probe plate) 1200 A full power

6 Langmuir probe
40%
bucket



7. Full Power

Fig. 7. Electron temperature and ion density at full power operation



8. Full Power

Fig. 8. Ion saturation current distribution at full power operation

4.

KSTAR NBI full power 가
 A FCR 3000 A , full power FIC 3800
 가
 full power , 가
 4×10^{-2} Torr 1200 A full power 가 3.36 eV
 2.4×10^{11} cm⁻³ 6x10⁻³ Torr full power 가 Langmuir probe plate
 5 eV 1.4×10^{12} cm⁻³ 40%
 10^{-3} Torr full power

5.

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