

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

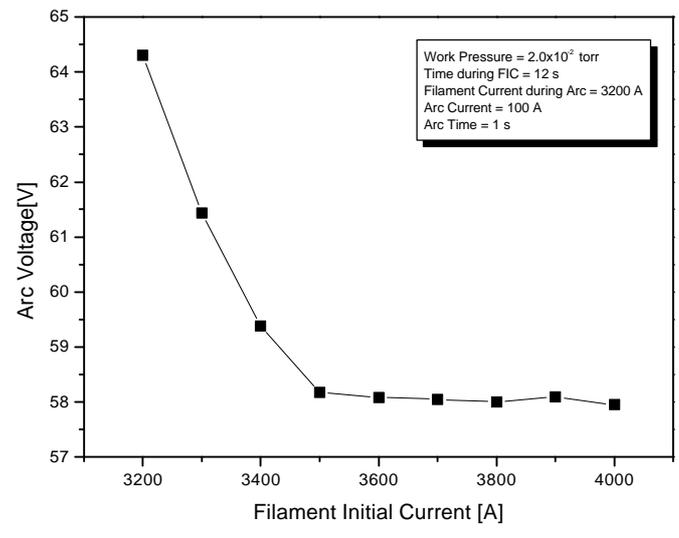
+50 -150 V, 4 Hz

가 . 가 가 99.999 %
 99.95 % .

3.

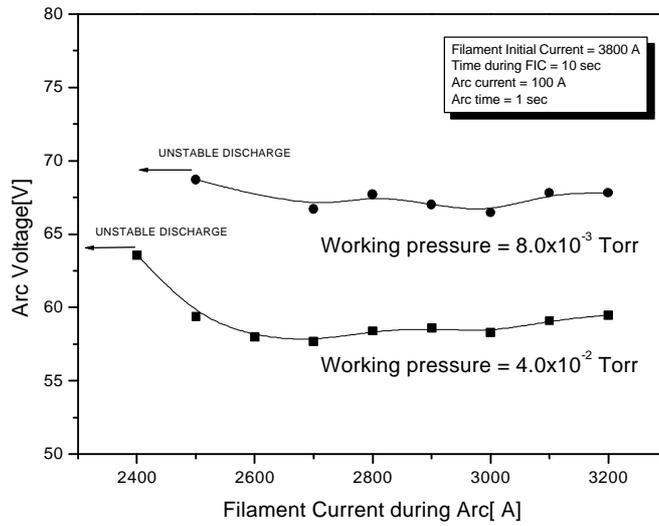
3-1. 가

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 4×10^{-2} Torr 가 (FCR)가
 가 FCR 가 가
 가 2 FCR 가 sheath
 가 full Power FCR 2700 A
 FCR



2. FIC

Fig. 2. Discharge voltage characteristics at various FIC



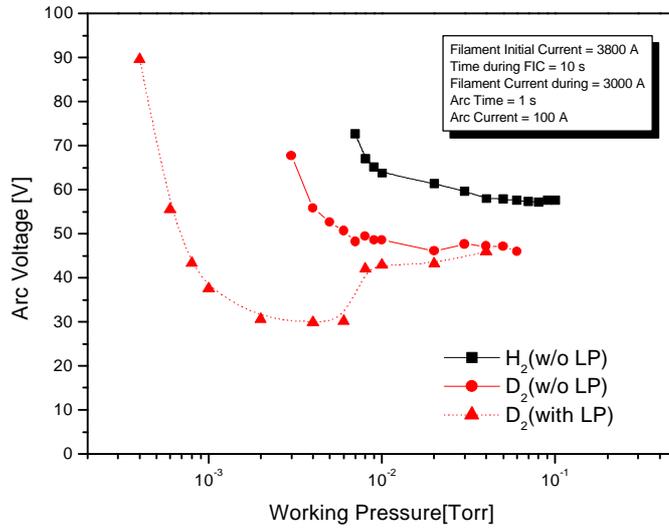
3. FCR

Fig. 3. Discharge voltage characteristics at various FCR

3000 A

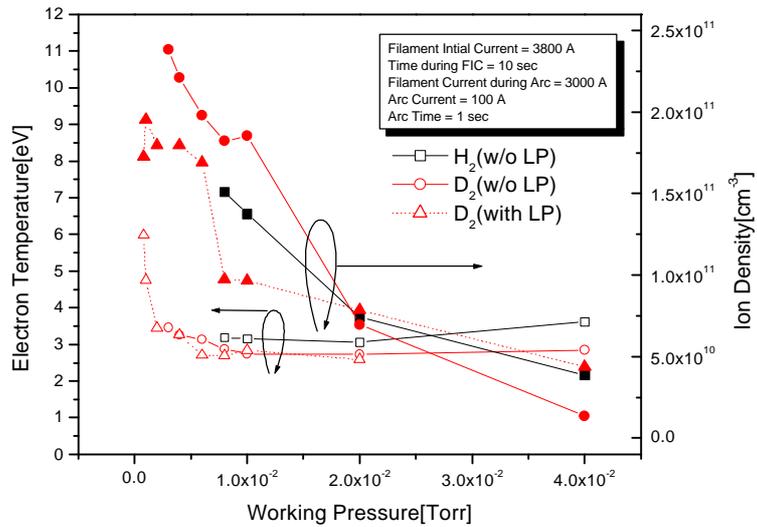
3-2. H₂ D₂

| | | | | | |
|-------|-------------------------------------|-------------------------|-----------------------|--------|-----------------------|
| 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

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

가
 가
 가
 10⁻²
 4 × 10⁻² Torr

5

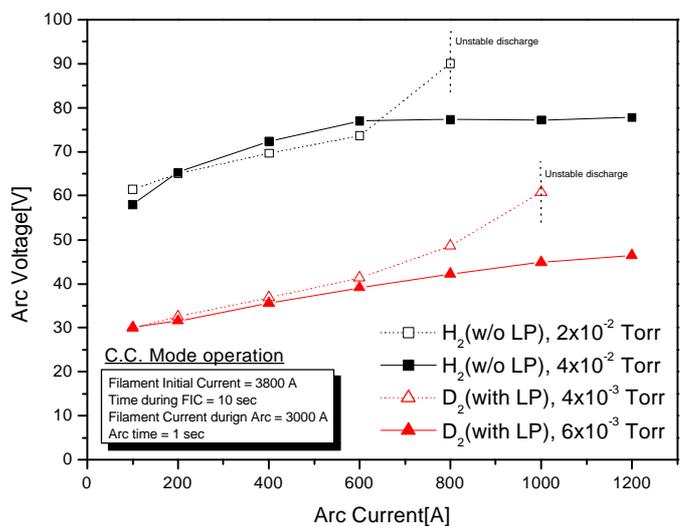
$4 \times 10^{10} \text{ cm}^{-3}$
 10^{-3} Torr

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)

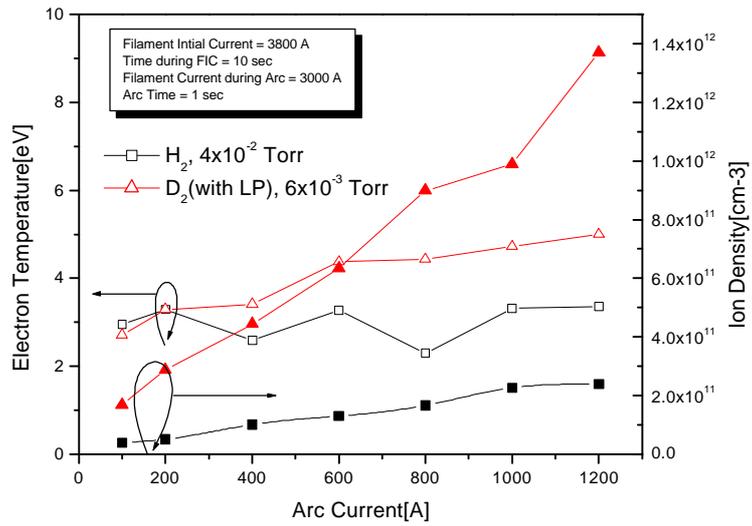
full power
 $6 \times 10^{-3} \text{ Torr}$

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

10^{-3} Torr

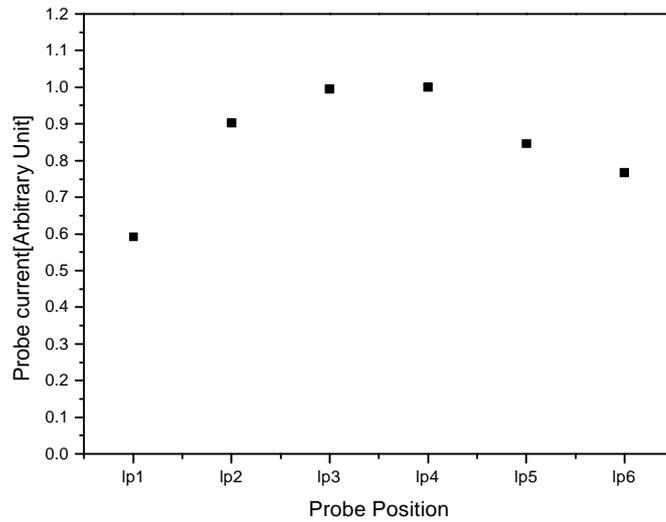
10^{-3} Torr (with probe plate) 1200 A full power

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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