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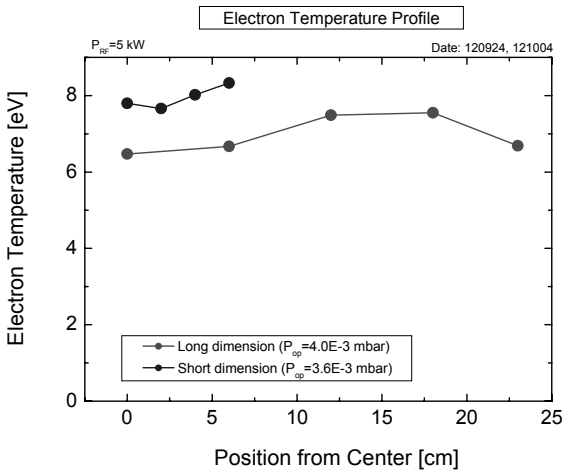
Development of RF Ion Source for Neutral Beam Injector in Fusion Devices

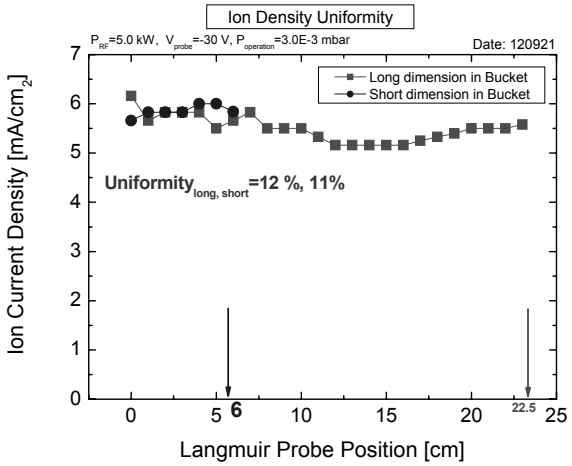
장두희, 박 민, 김선호, 정승호

한국원자력연구원

Large-area RF-driven ion source is being developed at Germany for the heating and current drive of ITER plasmas. Negative hydrogen (deuterium) ion sources are major components of neutral beam injection systems in future large-scale fusion experiments such as ITER and DEMO. RF ion sources for the production of positive hydrogen ions have been successfully developed at IPP (Max-Planck-Institute for Plasma Physics, Garching) for ASDEX-U and W7-AS neutral beam injection (NBI) systems. In recent, the first NBI system (NBI-1) has been developed successfully for the KSTAR. The first and second long-pulse ion sources (LPIS-1 and LPIS-2) of NBI-1 system consist of a magnetic bucket plasma generator with multi-pole cusp fields, filament heating structure, and a set of tetrode accelerators with circular apertures. There is a development plan of large-area RF ion source at KAERI to extract the positive ions, which can be used for the second NBI (NBI-2) system of KSTAR, and to extract the negative ions for future fusion devices such as ITER and K-DEMO. The large-area RF ion source consists of a driver region, including a helical antenna (6-turn copper tube with an outer diameter of 6 mm) and a discharge chamber (ceramic and/or quartz tubes with an inner diameter of 200 mm, a height of 150 mm, and a thickness of 8 mm), and an expansion region (magnetic bucket of prototype LPIS in the KAERI). RF power can be transferred up to 10 kW with a fixed frequency of 2 MHz through a matching circuit (auto- and manual-matching apparatus). Argon gas is commonly injected to the initial ignition of RF plasma discharge, and then hydrogen gas instead of argon gas is finally injected for the RF plasma sustainment. The uniformities of plasma density and electron temperature at the lowest area of expansion region (a distance of 300 mm from the driver region) are measured by using two electrostatic probes in the directions of short- and long-dimension of expansion region.

Keywords: Neutral beam injector, RF ion source, KSTAR, Plasma uniformity, ITER, K-DEMO, Long pulse ion source


Electron Temperature Profile
P_RF=5 kW
Date: 120924, 121004
Electron Temperature [eV]
Position from Center [cm]
Long dimension (P_op=4.0E-3 mbar)
Short dimension (P_op=3.6E-3 mbar)


Ion Density Uniformity
P_RF=5.0 kW, V_probe=-30 V, P_operation=3.0E-3 mbar
Date: 120921
Long dimension in Bucket
Short dimension in Bucket
Uniformity_long, short=12 %, 11%
Ion Current Density [mA/cm2]
Langmuir Probe Position [cm]
6
22.5