§37. Development of a Miniature Ion Gun for Fast-Ion Orbit Loss Study in LHD

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Confinement of alpha particles is a key issue to achieve self-ignition of nuclear fusion reactor. To investigate experimentally fast-ion orbit confinement in LHD, we have developed miniature ion guns, which can launch ions with defined energy from defined spatial points. In the last year, we developed an ion gun (16mm in diameter) using a thermionic alkali metal ion source. The emitter was a mesh filament (tungsten, 6mmx4mm, transparency 50%) on which mortar of molecular sieve-3A ($K_{12}[(Al_2O_3)_{12}(SiO_2)_{12}]\cdot 27H_2O$) was painted. The mesh filament was then sintered slowly to approximately 1200°C. The extracted ion beam current was typically 15μA when the applied bias voltage was 600V. We succeeded in operating this ion gun for about 4 hours. A problem of this type gun is that the mesh filament might be destroyed due to strong electromagnetic force in the high magnetic field of LHD since the mesh filament is free standing.

We have designed and assembled a new ion gun using a commercially available ion source (Heat Wave Inc, Model-1139). Figure 1 shows a schematic drawing of the new ion gun. The ion source is 6.4mm in diameter and is contained rigidly in a boron-nitride container. The emitter consists of a porous tungsten disk into which the emitter material (potassium) has been fused. It is indirectly heated (heating power < 13W) with a non-inductively wound molybdenum filament. A mesh cathode (tungsten, transparency 92%) is set in front of the emitter and an extraction voltage V_B is applied between the cathode and the emitter. The cathode and the aluminum case are kept at the earth potential.

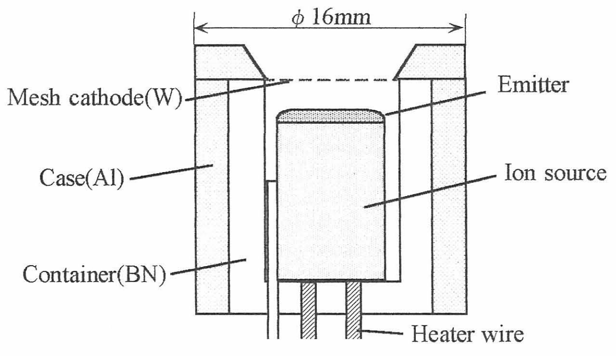

Fig. 1. A schematic drawing of the new ion gun.

Figure 2 shows the extracted ion beam current as a function of the ion emitter temperature (Te) that is measured with an optical pyrometer. The ion beam current starts to grow at Te~830°C and it reaches to 2.3μA at Te=1040°C.

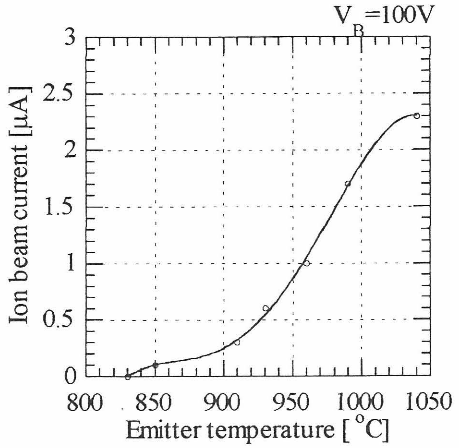

Fig. 2. Ion beam current as a function of the emitter temperature Te.

Figure 3 shows the ion beam current as a function of V_B. The ion beam current increases with increase of extraction voltage even though the ion gun is considered to be operated in the temperature limited emission current regime. A possible reason might be the Schottky effect.

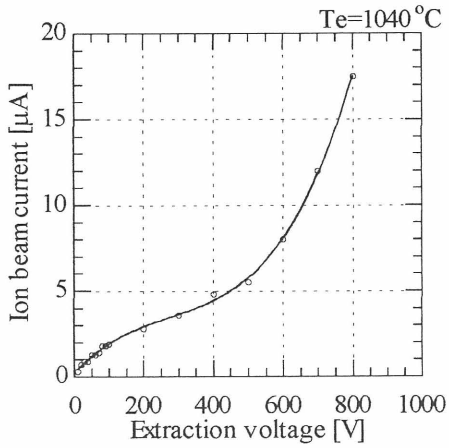

Fig. 3. Ion beam current as a function of the extraction voltages V_B. The emitter temperature is 1040 °C.

We are planning to test this ion gun in high magnetic field of B=(1.5-3)T. After that, the ion gun will be installed in Heliotron DR and a preliminary test of fast-ion loss measurement using the modified stellarator diode method[1] will be carried out.

Reference

1) Morimoto, S., Kitamura, T., et. al., Europhysics Conf. Abstracts 23J, (1999) 445.