03aD22P

ITER NB用MeV級加速器での長パルス負イオンビーム加速
Long pulse negative ion beam acceleration of MeV class accelerator for ITER NB

梅田尚孝, 柏木美恵子、谷口正樹、戸張博之、渡邊和弘、山中晴彦、大楽正幸、
井上多加志、小島有志、花田磨砂也
Naotaka Umeda, Mieko Kashiwagi, Masaki Taniguchi, Hiroyuki Tobari, Kazuhiro Watanabe et al.

原子力機構那珂
JAEA

The neutral beam (NB) of 1 MeV, 16.5 MW for 3600 s per one injector unit are required for plasma heating and current drive for ITER. To inject such a high power neutral beam, negative ion beam of 1 MeV, 40A (current density of 200A/m^2) is required in a beam source. In order to realize ITER negative ion beam, multi-apertures and five stages electrostatic negative ion accelerator so called "MeV accelerator" has been developed at JAEA. The target of MeV accelerator is to demonstrate 1 MeV, 200 A/m^2 H$^-$ ion beam.

In 2011, negative ion beam acceleration of 185 A/m^2 at 0.98 MeV has been achieved, which is almost target of ITER design. However pulse duration time was restricted to be 0.4 s because of high grid heat load. To extend pulse duration time of high current and high energy beam, reduction of grid heat load was required. One of origins of the grid heat load was direct interception of the negative ion deflected by residual magnetic field in the accelerator. Aperture offset method has been applied to electron suppression grid (ESG) in order to correct the beam deflection. The aperture displacement of ESG was designed to be 0.5 mm by the 3D beam trajectory simulation. This allowed to suppress the beam deflection angle within 1 mrad and the beam displacement from aperture center at grounded grid within 1 mm.

Then the displaced ESG of 0.5 mm was fabricated and tested in the MeV accelerator. In figure 1, the total heat load of five acceleration grids with the displacement of ESG are compared with that without the displacement. Grid heat load extrapolating to zero of source pressure, which corresponds to a direct interception loss of the negative ions, has been dramatically reduced from 23 % to 15 %.

The reduction of the grid heat load leads to the extension of the pulse duration time. Figure 2 shows the results of long pulse beam acceleration. Pulse duration time of the negative ion beams with the power density over 100 MW/m^2 has expand to 10 s. This is the first long pulse acceleration at high power density negative ion beam. Each acceleration grid heat load in these beam acceleration test is about 3 %, which is enough low compared to the design value of 5% of ITER beam source.

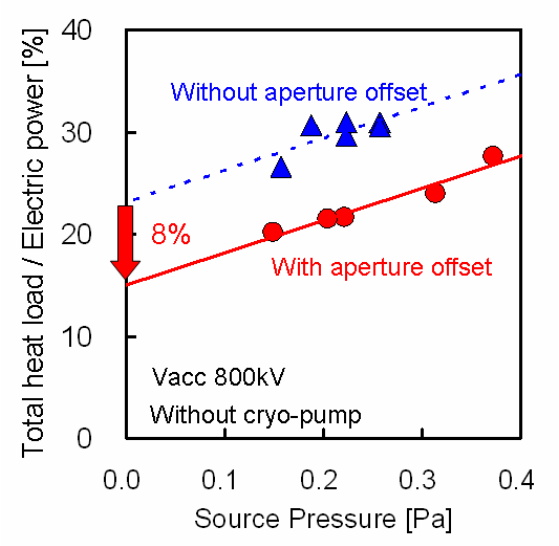

Figure 1 Total acceleration grids heat load with and without aperture displacement of ESG.

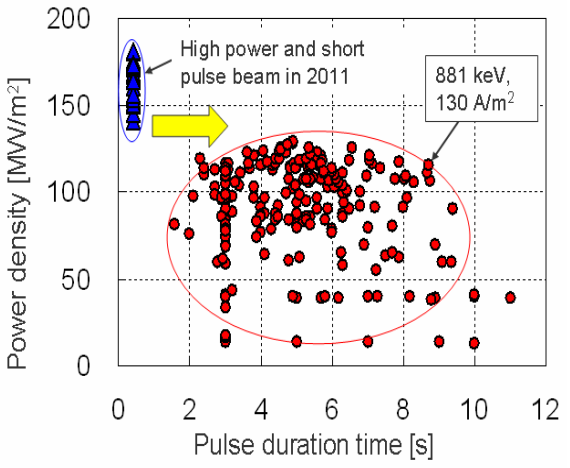

Figure 2 Long pulse acceleration at high power density negative ion beam.