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Development of a 1 MeV electrostatic accelerator for fusion application at JAEA

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This paper reports the activities on the development of negative ion accelerators for fusion applications at Japan Atomic Energy Agency (JAEA). In International Thermonuclear Experimental Reactor (ITER) and JT-60 Super Advised (JT-60 SA), high-current and high-energy negative ion beams are required to be produced. The beam currents and energies for ITER and JT-60SA are 40A (200A/m2), 1 MeV for 3600 s and 22A (130A/m2), 0.5 MeV for 100 s, respectively. In order to realize those accelerators, an electrostatic accelerator with multiple acceleration stages and apertures has been proposed by JAEA and adopted as the reference accelerators for those.

The accelerator is featured by the use of a large grid with > 1000 apertures for high-current and multiple acceleration stages for high-energy. The major issues are a stable vacuum insulation and a suppression of direct interception loss of the negative ions. A careful experimental studies on the vacuum insulation clarified that the voltage holding is varied with a square root of the gap length between the grids and with a power law scaling of number of the apertures. From the result, the structure of the accelerator has been designed. As for the suppression of the direct interception, the beamlet deflection due to residual magnetic field and space charge are suppressed by an off-set aperture displacement and a "Kerb plate"forming a local compensation electric field. In the test with the ITER mockup accelerator with 9 apertures, a 980 keV, 185 A/m2 has been successfully accelerated for 0.4s in 2011.

Since 2011, JAEA has concentrated on the extension of the pulse duration time. One of the issues is a reinforcement of the extraction grid (EXG), where the extracted electrons are dumped. For this, the cooling channels in the EXG are moved from the previous backside to the front side of the heat receiving surface. This new EXG allows the surface temperature to be reduced to 150 oC of allowable level. In addition, the power loading of the acceleration grids is reduced. The measurement of the power loading in the acceleration grids reveals that the secondary electrons induced by the direct interception of the negative ions with the EXG is one of the origins of the power loading of the acceleration grids in downstream. The EXG is further modified with enlargements of the aperture size and off-set displacement distance.

Taking these measures for the long pulse duration time, the pulse duration time has been successfully extended to 60 s at 0.97 MeV and 190 A/m2. This is the first demonstration of long-pulse acceleration for the ITER- and JT-60SA-relevant intense negative ion beams in the world. The achieved pulse duration time is limited by the capability of the power supply. There is no limitation to extend the pulse duration, namely, no degradation of the voltage holding and beam acceleration have been observed up to 60 s. The further test is planned after the upgrade of the power supply.

If a proceedings is prepared,
</br> will you submit a contribution?

yes

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