Development of high-power-density ion beam system with high repetitive pulse operation

H. Sakakita, S. Kiyama, H. Koguchi, Y. Hirano, T. Shimada,
M. Tokitani[a], N. Yoshida[b], K. Tokunaga[b]

National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba central 2, 1-1-1 Umezono, Tsukuba 305-8568, Japan
[a]National Institute for Fusion Science,322-6 Oroshi-cho, Toki 509-5292, Japan
[b]Kyushu University, 6-1 Kasuga-kouen, Kasuga 816-8580, Japan

h.sakakita@aist.go.jp

High-power-density ion beam system with high repetitive pulse operation was successfully developed for the first time. For the purpose of hydrogen neutral beam injection (NBI) through a narrow port in the vacuum vessel of fusion plasma devices, a high-current and high-current-density ion beam system with strong focusing characteristics was developed [1,2]. A considerable amount of ion beams of various elements (hydrogen, deuterium, helium and nitrogen) can be extracted in this system, which has multi aperture (~3700 holes) concave-type electrodes with a diameter of 345 mm and a bucket-type ion source. The beam is strongly focused into a diameter of ~36 mm around the focal point, with a divergence angle of about ±0.8 deg. A power-density as high as ~1 GW/m^2 was attained around the focal point of the beam. One of applications of this focused beam is the irradiation experiments to the materials, especially to the inner wall candidate material (ex., tungsten) in ITER (International Thermonuclear Experimental Reactor) [2]. It was found that high energy and high flux helium irradiation effects in tungsten indicate that serious consideration should be given to the surface erosion of tungsten walls [3]. In ITER, intermittent thermal flux due to the edge localized mode (ELM) to the plasma facing materials can cause severe damage on mechanical properties etc. Therefore, it is very important to study the effect of ELM, and recently pulsed electron beam or laser have been used to demonstrate ELM behavior. However, in order to imitate intermittent high-power-density He^+ pulse, namely, 'ELM simulator', the operation method and power supplies of our beam system were modified. Figure 1 shows a time evolution of extracted He^+ beam power with 2 ms of each beam width and every 6 ms. Waveform of each beam pulse is completely controlled. The gradual reduction of beam power is due to the limitation of the capacity of the condenser bank. In this case, beam energy, beam current, beam power and power density are 25 keV, ~36 A, ~0.9 MW and ~250 MW/m^2,(around 1530 mm from the electrode) respectively. This type of beam source not only has the capability of producing a strongly focused beam of high current and high current density, but also has the characteristics of high reliability and an excellent beam control property. In the conference, beam system and characteristics will be presented in detail.

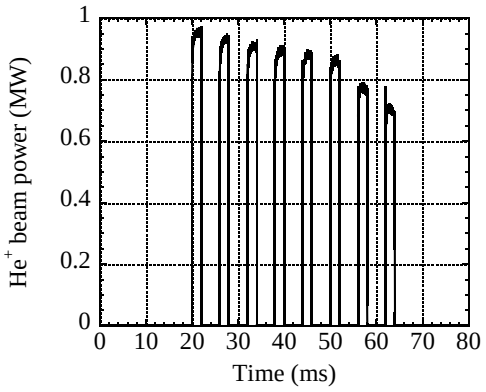

Fig. 1. Time evolution of He^+ beam power.

[1] H. Sakakita, et al., Proc. 30th Eur. Phys. Conf. on Control. Fusion and Plasma Phys., **27A**, St Petersburg, P2-173 (2003).
[2] H. Sakakita, et al., Proc. 21st IEEA Fusion Energy Conf., Chengdu, **FT/P5-2** (2006) 1.
[3] M. Tokitani, et al., Proc 18th Int. Toki Conf., Toki (2008).