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２次粒子挙動解析によるMeV級加速器の電極熱負荷低減の検討

Study on suppression of grid heat load by secondary particle analysis for MeV accelerator

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ITER neutral beam injector (NBI) requires an accelerator which can produce 1 MeV, 40 A negative ion beam for 3600 s. To demonstrate the acceleration of such a high power beam, JAEA has developed the MeV accelerator. For the long pulse operation of the negative ion accelerator, suppression of heat load on acceleration grids is one of key issues. A major source of the grid heat load is i) direct interception of the H^- ion beam and ii) incident of secondary particles such as electrons, neutrals, and positive ions. The secondary particles are generated by several processes such as stripping of negative ions, ionization of residual gas and emission of secondary electrons. The EAMCC (Electrostatic Accelerator Monte Carlo Code) analyses the trajectory of these secondary particles in the accelerator and calculates the heat load during the beam acceleration. Figure 1 shows the trajectory of secondary particles and the grid heat load in the MeV accelerator during the beam acceleration at 900 keV, 170 A/m^2. It was found that not only the direct interception of the H^- ion on the grid, but the stripped electrons and secondary electrons produced during the beam acceleration causes the high heat load. The electrons stripped near the extraction region are deflected by the electron suppression magnet and impinges on the acceleration grids to cause high heat load.

To decrease the grid heat load, following modifications of the grid structure were investigated; i) diameter of the aperture for A1G and A2G was decreased from ϕ16 mm to ϕ14 mm. By this modification, most of the stripped electrons produced in the extraction region are intercepted with A1G and A2G before acceleration to full energy. ii) thickness of the grid was decreased from 20 mm to 10 mm. This was effective to decrease the generation of secondary electrons by H^- collision on inner wall of aperture. An EAMCC calculation including these modifications suggests reduction of total heat load from 49 kW to 35 kW by these modifications. Maximum heat load appears in GRG (9.8 kW). By extrapolating this result to the ITER accelerator (1280 apertures), heat load of GRG is estimated to be 0.84 MW (1280/15 x 9.8 kW). This heat load is considered to be sufficiently low compared with the capacity of ITER cooling system.

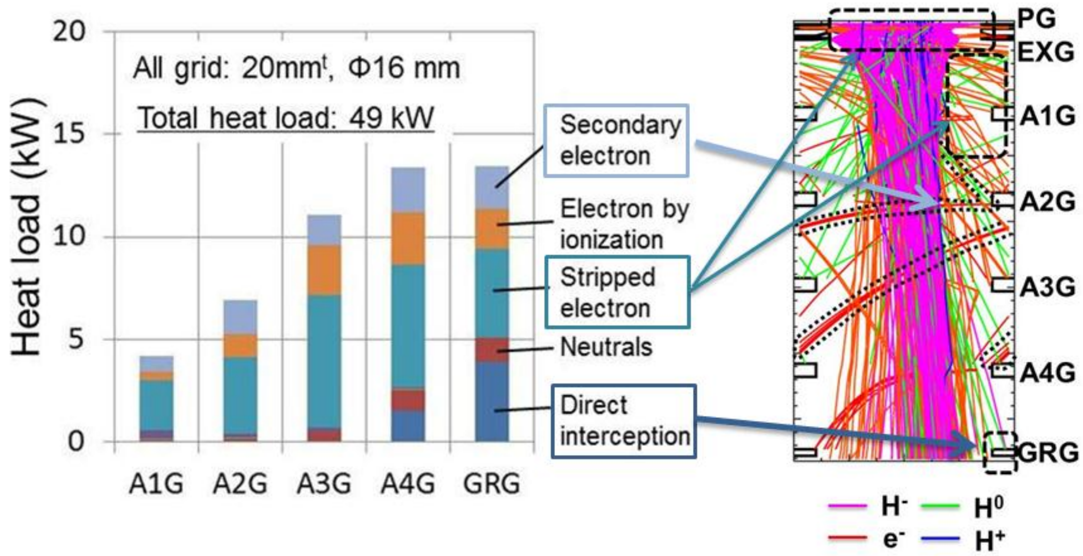

Figure 1 Grid heat load and secondary particle trajectory in a MeV accelerator.