Hydrogen pair-ion production by catalytic ionization

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Pair plasmas consisting of only positive- and negative-charge particles of equal mass have attracted special attention because they maintain space-time symmetry. A fullerene pair-ion plasma, consisting of positive and negative ions of equal mass (C_{60}^+ and C_{60}^-), has been generated and its collective phenomena have been investigated experimentally [1]. In order to investigate more extensive physical properties of pair plasmas, particularly wave-propagation characteristics up to higher frequencies, a hydrogen pair-ion plasma source is developed [2], because atomic hydrogen ions (H^+ and H^-) are the lightest ions and have high response frequencies to electromagnetic fields. Moreover, the research and development of negative-ion sources have been extensively performed in connection with neutral-beam-injection (NBI) heating for fusion-oriented plasmas. For the H^- production, a cesium-seeded multicusp type of ion source is the most successful ion source at present. However, alkali metals, such as Cs, with low evaporation temperatures cannot be used for the generation of the pair-ion plasma because there is the possibility of impurity interfusion.

A Penning ionization gauge (PIG)-discharge plasma is generated and irradiated to porous metals (Ni or Cr,Cu,Pt,Pd-Ni alloys) under a uniform magnetic field [3]. The hydrogen pair ions are produced from the backside of the plasma irradiated surface. The amount of the pair-ion production depends on the irradiated plasma density and the porous temperature/material. As a result, atomic hydrogen on the porous surface produced by chemical adsorption and the ionization energy higher than the thermal energy need for the production of the pair ions. The Ni-based porous metals properly act as catalyst, and the ionization energy is supplied by the plasma (ion) irradiation. The production balance between H^+ and H^- depends on the catalyst temperature and the difference of Pauling-scheme electronegativity between atomic hydrogen and the metal atom. We suggest the production mechanism as catalytic ionization comprised of dissociative adsorption, surface migration, and desorption ionization.

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[3] W. Oohara, K. Tokuhiro, O. Fukumasa, Proc. PSS2009/SPP-26 (2009) 328.