Seminar

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Institute for Plasma Research

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Title: Studies on extraction of an ion beam and its transport from a multi-cusp gridded ion source

Speaker: Mr. Bharat Singh Rawat
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Date: 13th March 2023 (Monday)

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Venue: Seminar Hall, IPR

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Abstract

Multicusp gridded ion sources have a variety of applications, including electrical thrusters, surface modification, and neutral beam injectors for fusion research. The typical beam energy and current of the ion source used for electrical thrusters and surface modifications studies are 1 – 2 keV and hundreds of mA, respectively. Plasma chamber, extraction system, neutralizer, and beam transport systems are the essential components of these ion sources. The electrical efficiency of these ion sources depends on the confinement of primary electrons in the plasma chamber with a suitable magnetic multicusp configuration and processes of ion extraction using a set of thin multi-aperture grids. Sufficient space charge neutralisation of the ion beam is also important to confirm a proper extraction and transport of the beam. The measurement of ion current density at various axial or radial locations is essential to estimate the beam divergence and to assess the extent of beam-spread required to be known for various applications. Measurement of other parameters like distribution of neutralizing electrons, charge exchange ions, electric-potential in the beam and neutralisation efficiency are also important to utilize the maximum capabilities of the ion source.

In the present research work, a ring cusp ion source has been designed and developed for producing Ar^+ ion beams of energy in the range of 1- 2keV and currents of about 100 mA. The magnetic cusp configuration of the plasma chamber is optimized for the maximum confinement of primary electrons via simulation using CST-Studio. The ion trajectory simulation using OPERA-3D is used to design the ion extraction system for minimum beam divergence. Theromostructural analysis is also carried out to minimize the grid deformation due to thermal loads. The characterization of the developed ion source is carried out by the measurement of beam profiles, ion beam divergence and total beam currents at different locations along the beam path using an eleven channel Faraday cup array (FCA) and a nine channel Fixed wire array (FWA). The Faraday cup array is developed with multiple electrodes for filtering out the primary electrons and slow moving charge exchange ions and also suppressing the secondary electrons to improve the measurement accuracy. A mathematical model, in which the beam is considered as a superposition of multiple beam-lets directed towards a focal point, has been used to estimate the beam divergence and focal length using the analysis of measured radial profiles of ion current density. Measurements of beam attenuation, fluxes of slow moving charge exchange ions and neutralizing electrons have also been carried out for studying the beam transport and neutralization processes. The radial distribution of neutralizing electrons in the ion beam could be measured using the faraday cup array by applying appropriate potentials at its filtering electrodes. The measurement of radial flux of charge exchange ions outside of the ion beam is carried out using a single channel faraday cup. Experimental results on extraction of ion beam and its transportation will be discussed.