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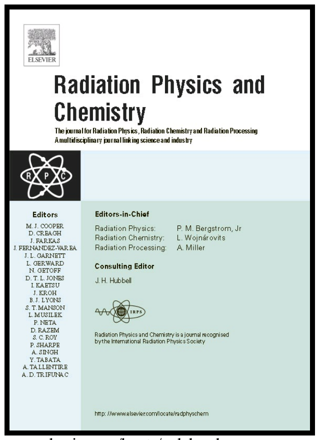

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Improvement of extracted ion beam from cold cathode Penning ion source

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Abstract

A D.C. cold cathode Penning ion source is operated at the optimum parameters at pressure equal to 7 x 10^{-4} mmHg using argon gas. It consists of a copper cylindrical hollow anode and two movable molybdenum discs cathodes are placed symmetrically at two ends of the anode. Argon ion beam is extracted from the ion source by using extractor of different aperture diameter equal to 2.5, 3, 3.5, 4 and 4.5mm respectively. The extractor is placed at different distances from the ion exit aperture equal to 5, 10, 15 and 20mm respectively. It is found that at extractor aperture diameter equal to 3.5mm, ion exit aperture - extractor distance equal to 10mm and extraction potential applied on the extractor is equal to -500V, the optimum extracted ion beam current equal to 543μA can be obtained. A comparison for Penning ion source without and with the extractor is made at the same optimum operating parameters, it is found that the extracted ion beam current from Penning ion source with the extractor increases about twice its initial value of Penning ion source without the extractor.

Key Words: Cold Cathode Penning Ion Source; Extractor; Ion Beam Current; Extraction potential.

Introduction

The Penning geometry was first reported as a positive ion source by Louis Maxwell working at the Franklin Institute in Philadelphia in 1930 [1]. However, the Penning electrode geometry gets its name from Frans Penning, a researcher working at Philips Physics Laboratory in Eindhoven, The Netherlands. In 1937, he developed the Penning ionization gauge or Philips ionization gauge (PIG) [2]. By measuring the discharge current in the electrode geometry, he was able to measure accurately and reliably very low pressures in gases, a technique that is still widely used today.

Cold cathode Penning type ion source is compact in size, no filament and maintenance free long life. It has been used for a variety of applications, such as sputtering [3], materials surface modification [4], ion implantation [5,6], thin films deposition of different materials [7], electromagnetic separation of isotopes and fusion applications [8-11]. Ion beam sources are widely used in fusion technologies [12–14]. In a typical ion source, the electrons oscillate between two cathode electrodes inside a hollow anode to establish a high voltage with low pressure plasma discharge. An axial magnetic field increases the path length of ionizing electrons, making plasma production more efficient. The special limitation in the central region makes the size of the plasma chamber only about a few centimeters.

The ion source extraction consists of the front plate of the ion source, which is known as the plasma electrode, and at least one other electrode, the puller (or extractor) electrode, which provides the electric field for accelerating the charged particles from the ion source to form an ion beam. The surface which forms the source of ions can be either of fixed geometry (surface ionization and field ion sources) or it can be the boundary of the plasma (plasma ion sources), in which the shape of the surface is fluid depending on the current density, ion supply rate and the applied electric field [15]. The design of an extraction system must take into account the nature of this system and must initiate the ion beam as free of aberrations as possible. The extraction of ions and ion beam formation process