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Ion beam extraction from a matrix ECR plasma source by discrete ion-focusing effect

Eugen Stamate[1], Mihai Draghici[1]

[1]Technical University of Denmark, Roskilde, Denmark

eust@risoe.dtu.dk

Positive or negative ion beams extracted from plasma are used in a large variety of surface functionalization techniques such as implantation, etching, surface activation, passivation or oxidation. Of particular importance is the surface treatment of materials sensitive to direct plasma exposure due to high heath fluxes, the controllability of the ion incidence angle, and charge accumulation when treating insulating materials. Despite of a large variety of plasma sources available for ion beam extraction, there is a clear need for new extraction mechanisms that can make available ion beams with high current densities that can treat surfaces placed adjacent to the extraction region. This work introduces a new phenomenology for ion beam extraction using the discrete ion-focusing effect associated with three-dimensional plasma-sheath-lenses [1, 2]. Experiments are performed in a matrix-ECR plasma source [3] with transversal magnetic filter for electron temperature control. 12 ECR plasma cells are placed 7.5 cm apart on the top of a cubic chamber 40x40x40 cm^3. Each cell can be controlled independently by tuning the injected microwave power. The discharge is operated at pressures below 1 mTorr and plasma densities around 10^{16} m^{-3}. A rectangular plasma-sheath-lens is created by an electrode-insulator interface designed by finite element simulations. The discrete ion-focusing effect deflects the ions to and extraction aperture on the electrode. A linearly distributed positive ion beam is extracted behind the electrode in different gas mixtures, including Ar/SF_6, CF_4 and O_2. By creating an electronegative discharge with a density ratio of negative ion to electron close to 100, it is also possible to extract negative ions when the extraction electrode is biased positively.

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