MODELLING OF THE POSITIVE SPACE CHARGE PLASMA LENS

I. Litovko[1], A. Goncharov[2], A. Dobrovolskiy[2], V.Gushenets[3], E. Oks[3]
[1]*Institute for Nuclear Research NAS of Ukraine, Kiev, Ukraine*
[2] *Institute of Physics NAS of Ukraine, Kiev, Ukraine*
[3]*High-Current Electronics Institute of SB RAN, Tomsk, Russia*

The electrostatic plasma lens is a well-investigated tool for focusing high-current, large area, energetic, heavy ion beams, providing a convenient, simple and quick way of carrying out high-dose ion implantation. The fundamental concept of this kind of lens is based on plasma optical principles of magnetic insulation electrons and equipotentialization magnetic field lines for the control of over thermal electric fields introduced into the plasma medium. The crossed electric and magnetic fields inherent the plasma lens configuration provides the attractive method for establishing a stable plasma discharge at low pressure. Using plasma lens configuration in this way several low cost, low maintenance, high reliability plasma devices using permanent magnets and possessing considerable flexibility towards spatial configuration were developed. These devices can be applied both for fine ion cleaning, activation and polishing of substrates before deposition and for sputtering. One particularly interesting result of this background work was observation of the essential positive potential at the floating substrate. This suggested to us the possibility of an electrostatic plasma lens for focusing and manipulating high-current beams of negatively charged particles, electrons and negative ions that is based on the use of the dynamical cloud of positive space charge under condition of magnetic insulation electrons. The preliminary experimental and theoretical results had shown an attractive possibilities of perspective application dynamical positive space charged plasma lens with magnetic electron insulation for focusing and manipulating wide-aperture high-current no relativistic electron beams.

Here we describe further elaboration of the numerical model based on the PIC-method for positive space charge plasma lens and negatively charged particle beams passing through the lens. Found plasma-dynamical conditions for stable operation of the space charge plasma lens. It was shown that plasma lens significantly improve of electron beam focusing in low-current mode. In case of high-current mode while as electron beam space charge much more than space charge plasma lens the lens operates in plasma mode to create transparent plasma accelerating electrode and producing additional plasma density required for the formation and stable transport of the intensive electron beam.

The work was supporting in part due to by the grant of SFFR F53.2/013 and RFBR 13-08-90416.