Advanced Plasma Optical Devices (Status and New Developments)
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This is to review the current status of ongoing research and development of the new generation plasma devices based on the cylindrical electrostatic plasma lens configuration attractive for application in the state-of-the-art ion-plasma technologies for surface treatment and synthesis new materials by intense electron and ion beams. 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 first experimental and theoretical investigations of high-current wide-aperture no relativistic electron beams focusing due to plasma lens with positive space charge cloud are presented. We describe also the original approach for effective additional elimination of micro droplets in a density flow of vacuum arc plasma. This approach is based on application the cylindrical plasma lens configuration for introducing at volume of propagating along axis’s dense low temperature plasma flow convergent radially energetic electron beam produced by ion–electron secondary emission from electrodes of plasma optical tool. The first experiments and theoretical estimations demonstrate the workability an idea application new plasma-optical system with convergent and oscillating fast electrons for effective additional evaporation, destroying and elimination of liquid metal droplets in a flow of arc plasma.