MonPS29

Saddle Antenna Radio Frequency Ion Sources

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In this paper we present an overview of the positive and negative ions production in saddle antenna (helicon discharge) radio frequency (SA RF) ion sources. An efficiency of H^- ion production in recently developed RF surface plasma sources (SPS) with solenoidal antennas was improved to 1-1.5 mA/kW. The efficiency of positive ion generation in these RF ion sources was up to 2 mA/kW. About 60 kW of RF power is typically needed for 50 mA beam current production from a 7 mm emission aperture. This efficiency is relative low because in the RF discharge with solenoidal antenna, the plasma is generated near the coil and diffuses to the axis creating a nearly uniform plasma density distribution in all cross sections of the discharge chamber, when the plasma flow is necessary only near an emission aperture. The efficiency of the extracted ion generation was improved significantly with using of the saddle antenna. In the RF discharge with the saddle antenna the plasma is generated near the axis and the magnetic field suppress the plasma diffusion from the axis, creating a peaked plasma density distribution on the emission aperture. With the SA the efficiency of positive ion generation in the plasma has been improved up to 200 mA/cm^2 per kW of RF power at 13.56 MHz. After cesiation, the current of negative ions to the collector was increased from 1 mA to 10 mA with RF power 1.5 kW in the plasma (6 mm diameter emission aperture) and up to 30 mA with 4 kW RF power in the plasma and 250 Gauss longitudinal magnetic field. In the tested version of the SA RF SPS the specific efficiency of H^- production was increased a factor of 7, up to 20 mA/cm^2-kW. Continuous wave (CW) operation of the SA SPS has been tested on the small test stand. The general design of the CW SA SPS is based on the pulsed version. Some modifications were made to improve the cooling and cesiation stability. CW operation with negative ion extraction was tested with RF power up to 1.8 kW from the generator (~1.2 kW in the plasma) with production up to Ic=7 mA. Stable generation of H^- beam without intensity degradation was demonstrated in the AlN discharge chamber for a long time (~40 days) with high RF power in the RF SPS with external antenna. Features of SA RF discharges and ions generation will be discussed.

The work was supported in part by US DOE Contract DE-AC05-00OR22725 and by STTR grant, DE-SC0011323.