DPP08-2008-000024

Abstract for an Invited Paper
for the DPP08 Meeting of
the American Physical Society

Permanent-magnet helicon sources and arrays: a new type of RF plasma

FRANCIS F. CHEN, UCLA

Among radiofrequency (rf) plasma sources used for materials processing in industry, helicon sources are well known for their high density but seldom used because they require a large dc magnetic field, making the source larger, heavier, more complex, and costlier than other available sources. Placing the plasma inside an annular permanent magnet (PM) does not work because the field lines carry the plasma into the wall before it can be ejected towards a substrate. However, a ring magnet has a stagnation point below which the field is weaker but almost straight. Use of a "low-field peak" partly compensates for the weak field by spacing a back plate so that the reflected wave constructively interferes. Strong PM helicon discharges were produced in a proof-of principle experiment.[1] The discharge tube was optimized using the HELIC code,[2] resulting in 2" diam by 2" high, with a three-turn m = 0 antenna at the bottom end. The NeFeB magnet is 3" ID x 5" OD by 1" high. To cover large substrates, an 8-tube array was constructed with 7" between tubes. Array sources have three problems: 1) the power must be distributed equally, 2) all tubes cannot be the same distance from the matching circuit, and 3) the transmission lines have to handle the voltage at startup and the current in CW operation. These have been solved in the Medusa 2 experiment which is in a "sweet spot" in which the small antennas have the right inductance for the rf system. With 3kW total @ 13.56 MHz, at 7" below the sources, the density is $\sim$5 x 10^{11} cm^{-3} at 1.3 eV in 15 mTorr of argon, uniform to 3% over the area covered by the tubes. Possible applications are to optical coating, roll-to-roll web processing, flexible and OLED displays, solar cells, and "smart windows" with organic solar cells.

[1]F.F. Chen and H. Torreblanca, Plasma Phys. Control. Fusion 49, A81 (2007).
[2]D. Arnush, Phys. Plasmas 7, 3042 (2000).