NSF GRANT #DMI-0115570
NSF PROGRAM: Manufacturing, Machines, and Equipment

A Novel Helicon Plasma Source for Large-Area Displays

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Abstract: Helicon wave sources are known for the dense, remote plasmas they create for etching. Recently they have been found to also deposit high-quality oxide layers. By using an array of multiple sources, we hope to create a uniform plasma of arbitrary size for processing flat-panel displays. The dc magnetic field *B* that helicons require can hopefully be supplied by permanent magnets, thus avoiding the cost and complexity of large electromagnetic coils. The size, shape, and placement of each source will be optimized, as well as the antenna and rf frequency.

1. Source design: Previously [1] we have shown that an array of seven stubby tubes can cover a 400-mm substrate uniformly with density up to 10^{12} cm^{-3}. The short-tube effect has been explained by constructive interference from the wave reflected at the back. To optimize this effect at low B-fields we use the HELIC code developed by D. Arnush [2]. Guided by computations, we construct tubes of the type shown in Fig. 1. Sample computational results [3] are shown in Figs. 2 and 3. In Fig. 2, the distance *d* between the antenna and the back plate is varied, and a density peak is observed at varying B-fields. In Fig. 3, the antenna type is varied, and it is seen that a simple loop antenna, as shown, is more efficient than a half-helical (HH) or Nagoya-type antenna. The antenna position can be optimized for a given range of densities and B-fields. Studies of the tube diameter [4] show that the rf absorption efficiency increases with diameter. Thus, a compromise has to be made, since large diameters could lead to lower uniformity for an array.

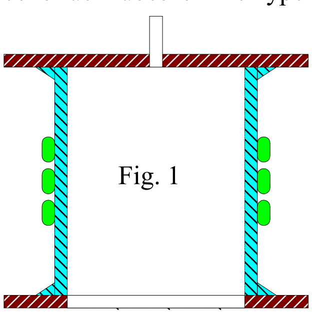
Fig. 1

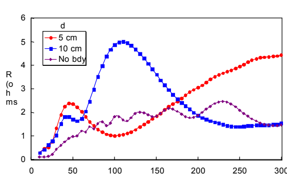
Fig. 2

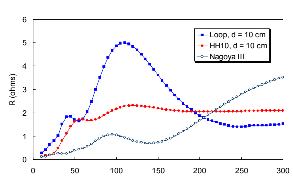
Fig. 3

2. Array design: The optimal spacing of individual tubes depends on how fast the plasma diffuses laterally as it drifts down from the sources. This spreading has been observed to be much faster than classical theory would predict, as shown in Fig. 4. These are radial density profiles 3 and 10 cm downstream from the source, whose radius is shaded at the left. The rapid spreading could be caused by the structure of the source, shown in Fig. 5. The plasma exits through an insulating aperture, which can charge up negatively, pulling ions out radially as they leave. This effect can make the array more compact vertically.

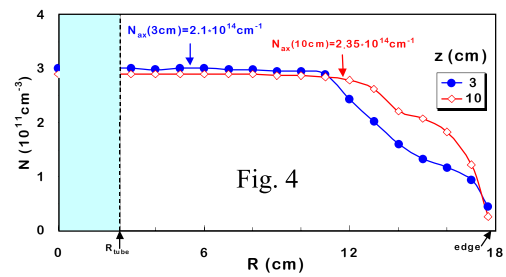

Fig. 4

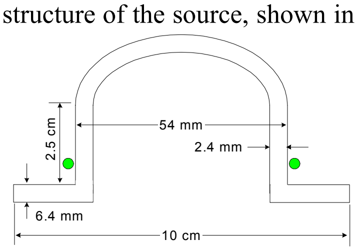

Fig. 5

3. Permanent magnets: Fig. 6 shows a conceptual design for a tube with a permanent-magnet B-field. The flange is an iron plate to extend the field past the aperture.

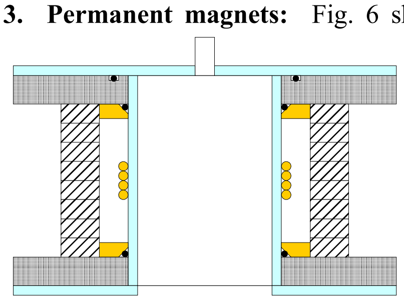
Fig. 6

NSF Grant DMI-0115570 supported this work.

4. References:

[1] Chen, Evans, and Tynan, PSST **10**, 236 (2001).
[2] D. Arnush, Phys. Plasmas **7**, 3042 (2000).
[3] F.F. Chen, Phys. Plasmas **10**, 2586 (2003).
[4] F.F. Chen, UCLA Report LTP-202 (Feb. 2002).