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# Development of a Miniature Microwave – Multicusp Plasma Source as Electron Neutralizer: Experimental Study of Boundary Conditions


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The advent of micro and nano-satellites has prompted the development of miniature plasma based electric thrusters for propulsion. An electron neutralizer is required to neutralize the ion thruster exhaust and prevent space-craft charge up. Since wave based plasma sources offer better operational lifetime than filament sources, the development of a microwave (MW) plasma source operating at low power is important for future applications.[1]

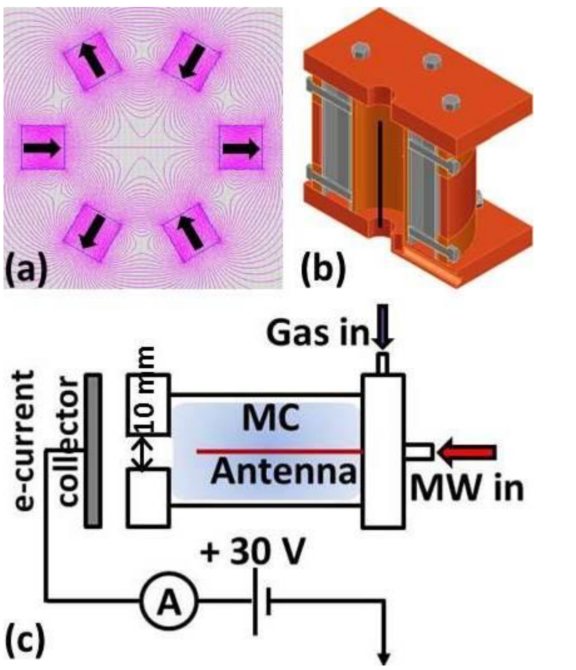


**Fig. 1: (a) Magnetic field lines in the MC cross-section. (b) Neutralizer design. (c) Schematic of the setup.**

A miniature (diameter ~ 21 mm, length ~ 41 mm) cylindrical multicusp (MC) plasma source has been developed for application as a neutralizer (cf. Fig. 1).[2] Xenon plasma was generated via antenna launch of low MW power ($P_{in}$ ~ 2 – 10 W) and small gas mass flow rate ($mfr$ ~ 5 – 40 μg/s) by electron cyclotron resonance and confined by a magnetic well. Electron current, $I_e$ ~ 6 – 45 mA was obtained using a checkered MC configuration.

In this work, the effect of reducing the axial electric field boundaries is investigated. A 9 mm aluminum block is fixed on the back plate of the neutralizer to reduce the axial chamber length (CL) to 32 mm. Fig. 2 (a) and (b) show the magnetic field lines in the axial plane of the neutralizer and the position of the block. $I_e$ is measured as a function of frequency (800 – 1600 MHz) and power, at various flow rates.

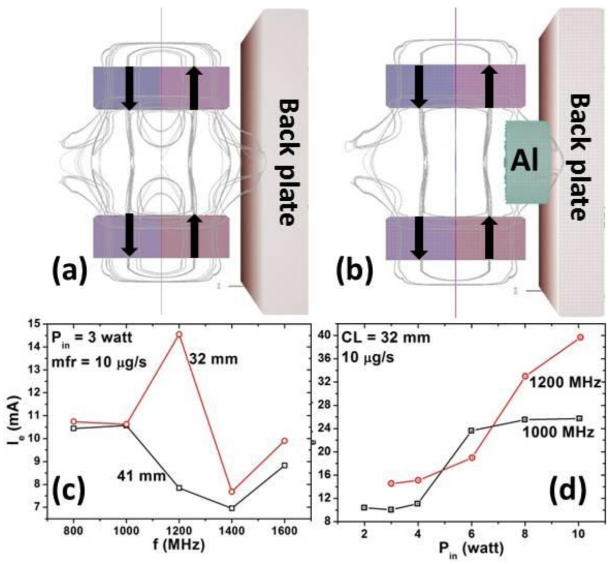


**Fig. 2: Magnetic field lines for axial length (a) 41 mm, (b) 32 mm. $I_e$ vs MW (c) frequency, (d) power.**

It is observed that $I_e$ is enhanced due to increased electric field resulting from shortening of CL [Fig. 2 (c)]. At 1200 MHz, there is two fold increase of $I_e$, which may be explained by noting that CL ~ 32 mm is very close to $\lambda/8$ (~ 31.25 mm) dimension for 1200 MHz. However, the plasma is not sustained below 2.5 W in this case. Also there are notable jumps in $I_e$ with change in $P_{in}$ [Fig 2 (d)]. A simulation model is under development for better understanding of the above microwave-plasma coupling, and is expected to help in further optimization of the performance.


[1] N. Yamamoto, et. al., Plasma Sources Sci. Technol. **19**, 045009 (2010).

[2] I. Dey, et. al., Phy. Plasmas **18**, 022101 (2011).