Effect of miniaturization on ring-type plasma actuators

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ABSTRACT

This paper presents an investigation of the effects of miniaturization on ring-type plasma actuators. These devices have wide-reaching applications in areas spanning gas conversion [1] to surface sterilization and decontamination [2]. The motivation for a ring-type structure is to induce a body force perpendicular to the surface, produced as a result of the interaction of the radially tangential ionic wind. In its miniaturized form, this device serves the aerospace industry by acting as a source of active flow control and virtual surface roughness, offering advantages such as no moveable parts, fast response times, and low power consumption [3]. Additionally, this geometry is attractive from a diagnostics point of view, since its radial symmetry inherently eliminates edge effects and fringe fields, which inevitably distorts signals and complicates the analysis [4] – an effect that becomes appreciable when the dimensions are reduced.

Our findings indicate that power dissipation, normalized with respect to the actuator's surface area, decreases with size reduction, with the 1 mm diameter sample dissipating five times less power than an actuator twice its size. Surprisingly, a further reduction in size leads to an increase in power dissipation, exceeding that of the 2 mm sample. Furthermore, an effect novel to the ring-type geometry was observed in the form of current oscillations for ring diameters between 1.2 mm and 2.0 mm (Figure 1). Finite Element Analysis (FEA) simulations revealed that the origin of the oscillations can be traced to charged particle dynamics (Figure 2). Based on this, we propose further research into the mechanism and control of this phenomenon, paving the way for the realization of new technologies.

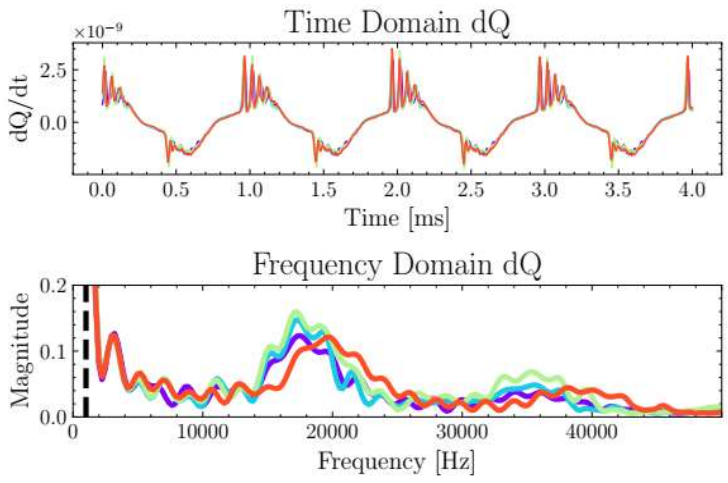

Figure 1: Several measured current oscillations for 2 mm diameter actuator

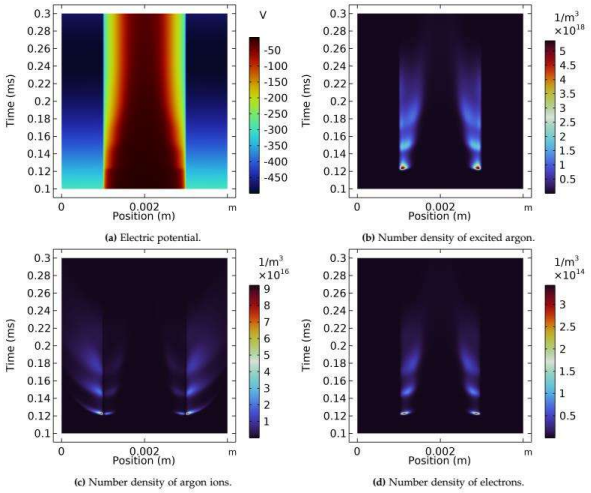

Figure 2: Simulation of the time-evolution of the potential and number densities of species along a horizontal slice above the surface of the actuator

References

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[4] S. PAVON *et al.*, Journal of Physics D: Applied Physics (2007) 40(6)