Application of microplasmas for satellite propulsion

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We report the operation of a multi-electrode microhollw cathode discharge, operated in a pulsed mode with the discharge region being cycled along the electrode structure. Electrical and optical measurements were made to characterise discharge behaviour and indicated that a stable discahrge with a high gas temperature could be sustained at power of ~ 1 W. Such a discharge may be suitable for application as a microthruster for small-scale satellites.

Satellite thrusters based on microplasmas have been proposed as a novel alternative to conventional designs for thrust engines with sub milli-newton thrust levels. Such thrusters are required for so-called micro- and nano-satellites: devices with total mass of around 50 kg or less. The thruster uses a microdischarge to heat gas that is then ejected from the satellite. Prototype designs have been developed accompanied by modelling studies [1-3]. A thruster designed by the University of Texas at Austin is currently being tested on the FASTRAC satellite, a mission devoted to testing novel instruments and device [4]. The purpose of the study reported here is to understand the physical mechanisms that underlie a thruster design based on a multi-electrode microhollow cathode geometry.

Figure 1 is a schematic diagram of the multi-electrode device tested in this study. In the device, metal electrodes are sandwiched between 200 μm glass insulators to make a six electrode microhollow cathode structure. The electrode structure is placed at the end of a gas tube, through which argon gas is flowed. Voltage applied to electrode pairs excites a discharge inside the channel, with the voltage being switched between the electrode pairs at kHz-order frequency. This generates a pulsed dc discharge between each pair of adjacent electrodes, with the voltage pulse used to generate the discharge being cycled along the electrode structure.

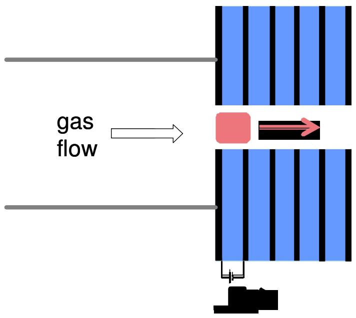

Fig. 1: Geometry of the multi-electrode microplasma device.

Electrical and optical measurments were made to characterise the discharge behaviour. The system had a breakdown voltage of ~400 V and sustained operation with power input of ~1 W. Current and voltage measurements indicated high frequency oscillations that are frequently observed for this discharge geometry appear to be suppressed in this multi-electrode structure. Measurements of emission from trace amoutns of nitrogen molecules in the gas flow were used to determine the gas temperature in the channel. These measurements indicate that the pulsed microhollow cathode operation leads to gas temperatures of more than 1000 K.

This preliminary study indicates that the multi-electrode microhollow cathode discharge may be an effective and efficient plasma thruster. More focused studies are planned. From a discharge physics viewpoint, the multi-electrode structure appears to allow a way to control oscillations that occur similar two-electrode structures. This may be due to the presence of narrow “interior” electrodes. Modelling and experimental studies are planned.

References

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