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Non-self-sustained regimes of Hall thruster discharges[1]

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Interesting discharge phenomena are observed between magnetized Hall thruster plasma and the neutralizing cathode, which are highly correlated with the thruster performance. In a typical Hall thruster, a steady-state cross-field discharge is self-sustained between the anode and a hollow cathode placed outside the thruster channel. It is commonly assumed that the thruster discharge current is limited by the ionization of the working gas, wall losses and electron transport across the magnetic field, and not by the supply of electrons from the cathode. We report that for Hall thrusters operating with a high ionization of working gas, the enhancement of the cathode electron emission can lead to a dramatic (up to 20-30% at 50-300 W) narrowing of the plasma plume and a nearly twofold increase in the fraction of high-energy ions [1]. The measured variations of the plasma properties suggest that the electron emission from the cathode can affect the electron cross-field transport and the ionization in the thruster discharge, including generation of multicharged ions. An apparent cooling of plasma electrons observed in these regimes may support recent theoretical predictions [2] of electron kinetic effects in E x B rotating thruster plasmas. As the voltage drop between the cathode and the near-field plasma plume reaches an apparent threshold, these effects on the discharge current and plasma plume parameters finally reach saturation. Thus, it now appears that the maximum available supply of electrons from the cathode to the thruster discharge and the plasma plume can limit efficient generation of the focused plasma flow in Hall thrusters, especially at low powers. [1] Y. Raitses, A. Smirnov and N. J. Fisch, Appl. Phys. Lett. , 221502 (2007). [2] N. J. Fisch et al., in preparation (2008).

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