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Kinetic effects in low-pressure discharges with secondary electron emission[1]

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Secondary electron emission (SEE) from material surfaces can result in efficient plasma cooling and large energy losses from the plasma. This is relevant to Hall thrusters and divertors, where the electron temperature is high enough to provide strong SEE. The SEE reduces negative charge of a wall immersed into a plasma and increases the flux of plasma electrons to the wall. If the plasma is hot enough to produce intense SEE, the plasma potential relative to the wall can be several times lower than that without the SEE. Then the electron heat flux to the wall will be extremely high provided the plasma electron velocity distribution function (EVDF) is Maxwellian, with a large number of electrons flying toward the walls and capable to penetrate the sheath potential barrier. This is the case if the electron mean free path is small compared to the plasma dimensions. Further increase of the electron temperature saturates the wall losses once the space charge limited (SCL) regime of the sheath establishes. In low-pressure plasmas, however, amplification of the electron heat flux to the wall due to the SEE is much weaker because the electron mean free path is large compared to the plasma dimensions. In such plasmas, the EVDF is depleted of the energetic electrons flying toward the walls. This considerably reduces the flux of hot electrons to the walls. The secondary electrons propagate freely between the walls forming electron beams that do not mix with the plasma electrons. The presence of these secondary electron beams with intense current and relatively low energy prevents the occurrence of a steady SCL sheath. Instead, relaxation oscillations of the sheath between the SCL and non-SCL states may occur under conditions with intense anisotropic heating.

[1]In collaboration with I. Kaganovich, Y. Raitses, PPPL, and A. Smolyakov, University of Saskatchewan.