Bare-tether cathodic contact through thermionic emission by low-W materials

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In the absence of an active cathodic device, the current flowing along the tether vanishes at both ends and the tether is said to be completely passive and electrically floating. In the absence of effective thermionic emission, current is emitted through ion collection along the negatively biased (cathodic) segment. Under OML collection throughout the entire tether, the anodic-to-cathodic length ratio is very low because ions are much heavier than electrons, which results in low average current and drag.

The electride C12A7 : e\(^{-}\), which might present a possible work function as low as 0.6eV and moderately high temperature stability, was recently proposed as coating for floating bare tethers. Thermionic emission along the thus coated cathodic segment, arising from heating under space operation, might be more efficient than ion collection.

Each point of the cathodic segment of a bare tether would emit current as if it were part of a cylindrical probe uniformly polarized at the local tether bias. Around a negatively biased probe with intense thermionic emission, immersed in plasma, a double layer (DL) would be established. The thermionic current might follow two distinct laws under different conditions. When the plasma-to-probe bias reaches some high enough value, the current is limited by the emitter temperature and follows the Richardson-Dushman’s law with Schottky effect. At a lower plasma-to-probe bias, the electron emission at the emitter surface is space-charge-limited (SCL); a preliminary study on this SCL double layer is presented using Langmuir’s SCL electron current between cylindrical electrodes and OML ion-collection sheath.

Assuming OML electron collection along the anodic segment, a detailed calculation of current and bias profiles along the entire tether length is carried out, with ohmic effects included. In the simplest drag mode, under typical orbital and tether conditions, thermionic emission through an ultra-low-W material does result in a short cathodic section. When compared to ion collection, thermionic emission leads to much higher drag values and may eliminate the need for an active cathodic device and its corresponding gas feed requirements and power subsystem, which results in a truly “propellant-less” tether system, for such basic applications as de-orbiting LEO satellites.