Temperature Distributions in Hollow Cathode Emitters

James Polk and Colleen Marrese
MS 125-109
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Dr
Pasadena, CA 91109
james.e.polk@jpl.nasa.gov

Lisa Dang
Northrup Grumman Space Technologies

Ben Thornber
Imperial College

Lee Johnson
Jet Propulsion Laboratory

Hollow cathodes used as electron sources in ion engines and Hall thrusters rely on the maintenance of a low work function barium adsorbate layer on the interior surface of the emitter. The life of these cathodes is limited by degradation of the emitting surface. There are four main processes that degrade the barium adsorbate layer and can lead to insert failure:

1. Depletion of the barium source material.
2. Insufficient production of Ba and BaO because of reaction product buildup at the interface between the impregnant and the tungsten matrix.
3. Inadequate transport of Ba and BaO from impregnant deep in the matrix through the pores to the surface.
4. Closure of the surface pores by deposition of tungsten. The tungsten is likely transported as tungsten oxide vapor, which then dissociates in the emission zone.

The rate of all four of these processes is strongly dependent on the temperature of the emitter. An experimental apparatus designed to measure the internal axial temperature distribution on cathode inserts has been used to characterize the thermal characteristics of hollow cathodes.

The apparatus consists of a fiber optic probe which is driven into the insert region by a high speed positioning system. Radiation collected by the fiber optic probe is split into two paths which are filtered to narrow bands around 1200 and 1500 nm. These two light signals are measured with photodiodes. The ratio of the two photodiode signals is used to determine the insert temperature distribution. The use of two color pyrometry eliminates the sensitivity to detector-source geometry. The system is calibrated using an externally heated source with the same surface chemistry as the actual inserts which is instrumented with high temperature thermocouples.

The experiments are focused on determining insert temperature distributions over a range of operating conditions (flow rates and currents) for various cathode geometries (orifice and insert diameters) and insert materials. The measurements will be performed on conventional hollow cathodes with impregnated tungsten and tungsten-iridium inserts

and in reservoir cathodes. The results will be used to determine how geometry, materials and operating conditions affect the size of the emitting region, emission current density and cathode insert life. In particular, these results will be used to guide the development of hollow cathode performance and life models.