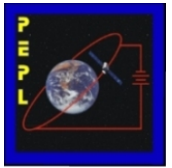


Breakdown and Ignition Limits in LaB_6 Hollow Cathode Discharges

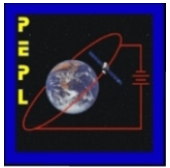
Ricky Tang, Sonca Nguyen, Timothy B. Smith, and Alec D. Gallimore
University of Michigan, Ann Arbor, MI 48109

International Conference on Plasma Science
Traverse City, MI
June 4-8, 2006



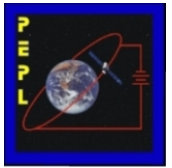
Contents

- Motivation
- Cathode Assembly
- Experimental Setup
- Results
 - Breakdown Voltage Characteristics
 - Current Profile
 - Frequency Spectrum
- Conclusion & Future Work
- References

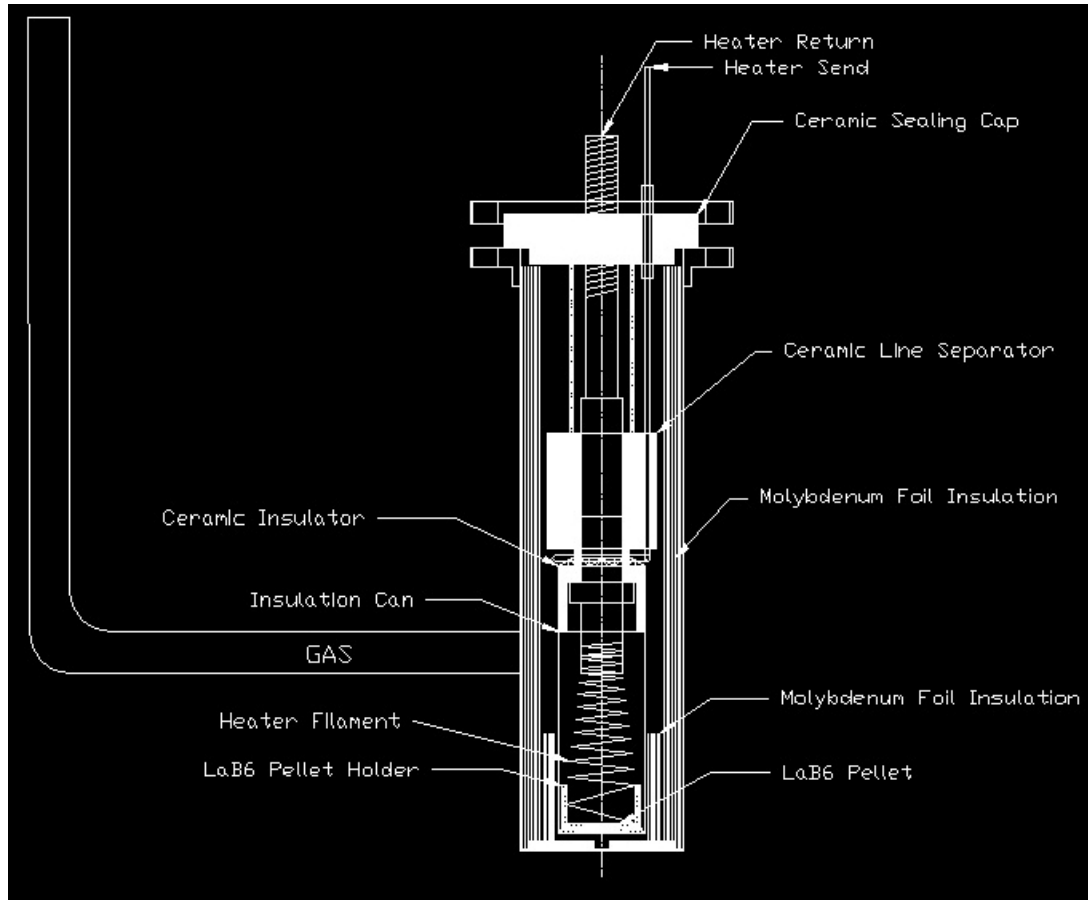


Motivation

- Two major failure modes for conventional hollow cathode – emitter poisoning and heater failure
- LaB_6 is two orders of magnitude less sensitive to oxygen poisoning¹
- Erosion rate for LaB_6 is lower for emission currents below 13 A/cm^2 (Ref. 2)
- LaB_6 operation temperature is higher to attain similar emission current densities¹ due to higher low-temperature work function
 - Heater elimination increases robustness and simplicity
- As a first attempt toward testing the feasibility of heaterless LaB_6 operation, we performed a series of experiments with a LaB_6 hollow cathode to assess its breakdown and ignition characteristics

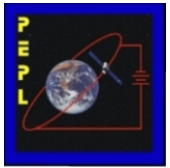


MAI Cathode Assembly

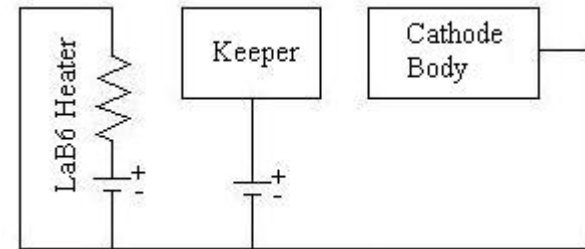


Orifice diameter: 4.25mm

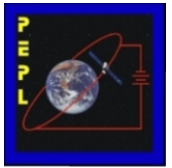
Keeper-orifice distance: 9.0mm



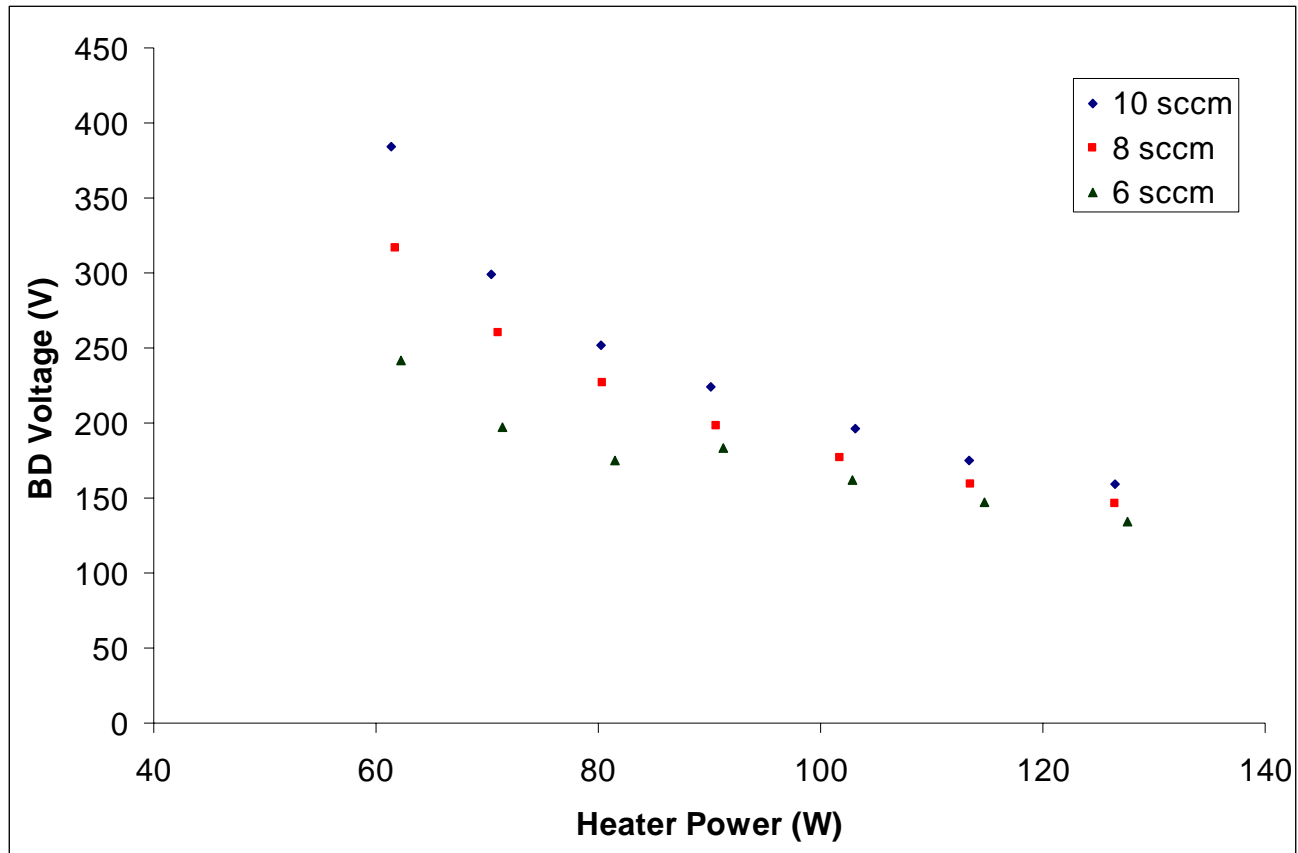
Experimental Setup

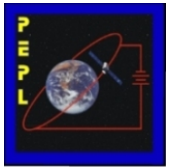


1. All testing done in a 2-meter-long by 0.6-meter-diameter cathode test facility (CTF) at PEPL
2. Cathode conditioned by initiating a Xe flow of 10sccm and heating the LaB_6 pellet first at 6A for 5 mins followed by 12A for 10 mins
3. Keeper operates at a current limit of 1A

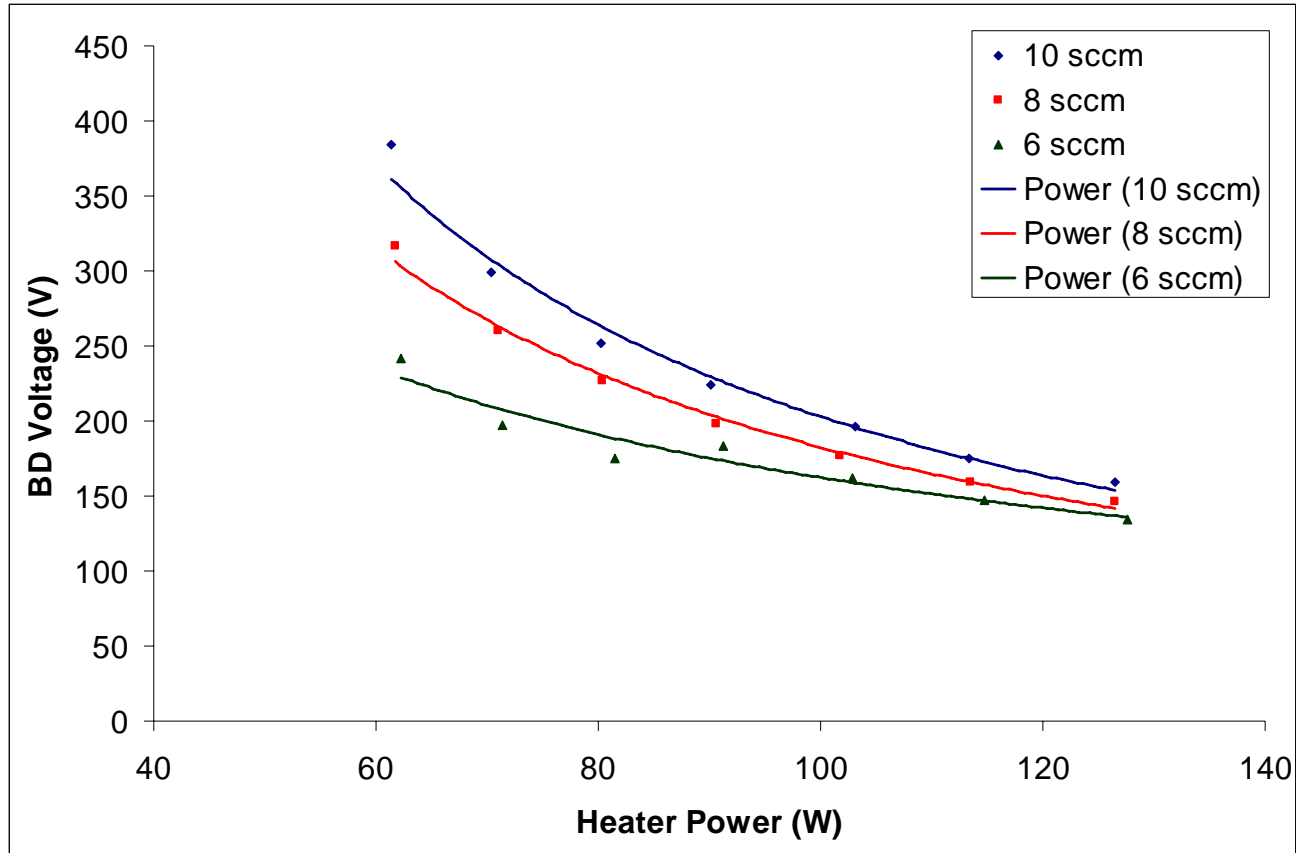


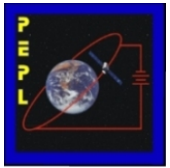
Breakdown Voltage



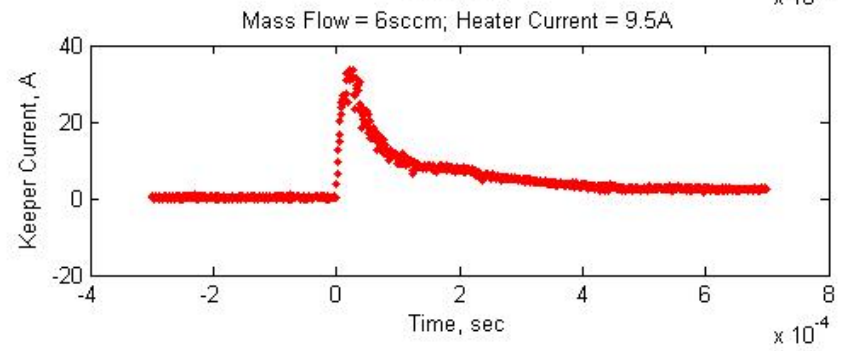
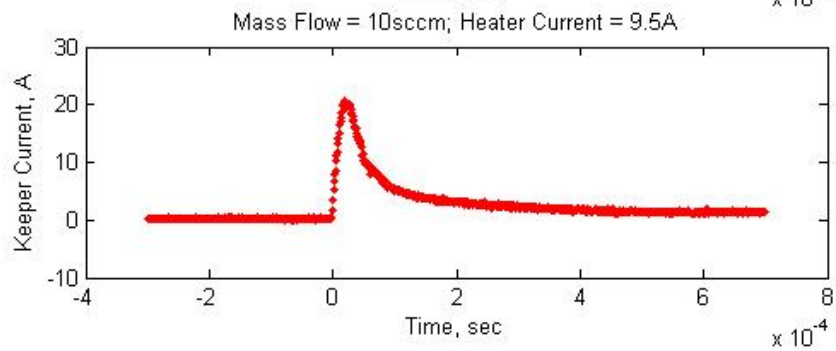
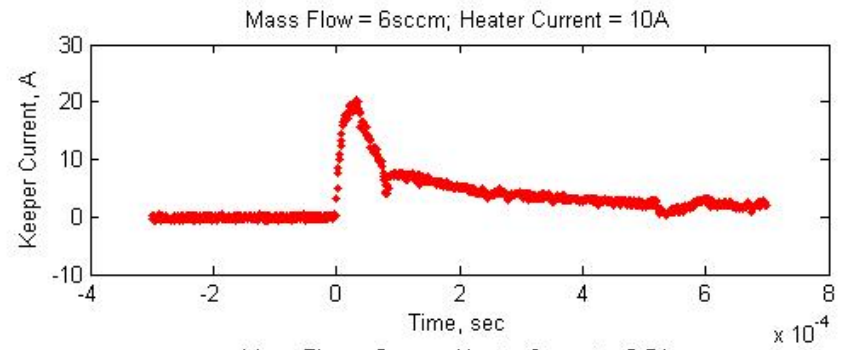
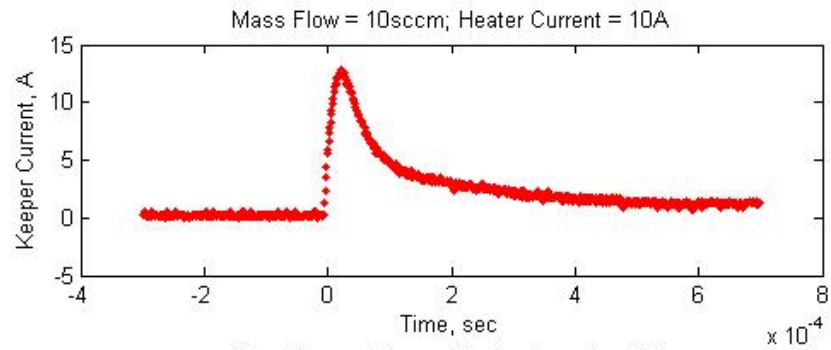


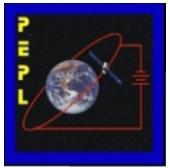
Breakdown Voltage



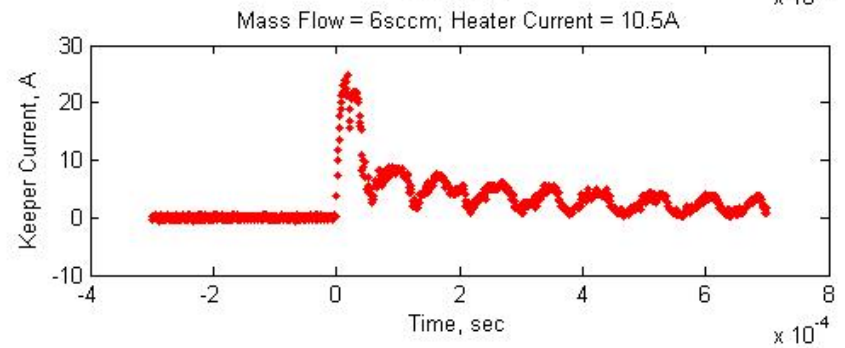
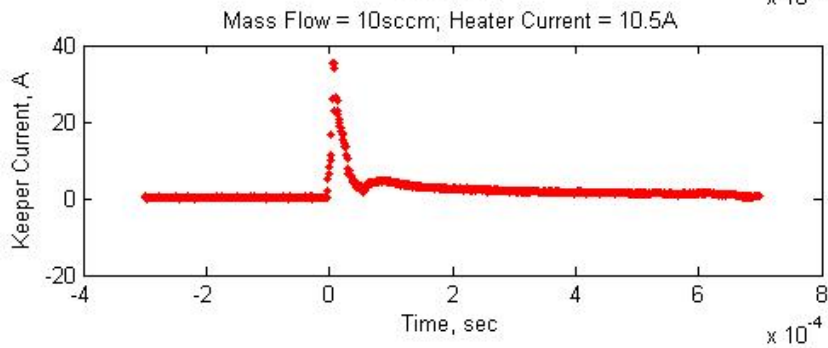
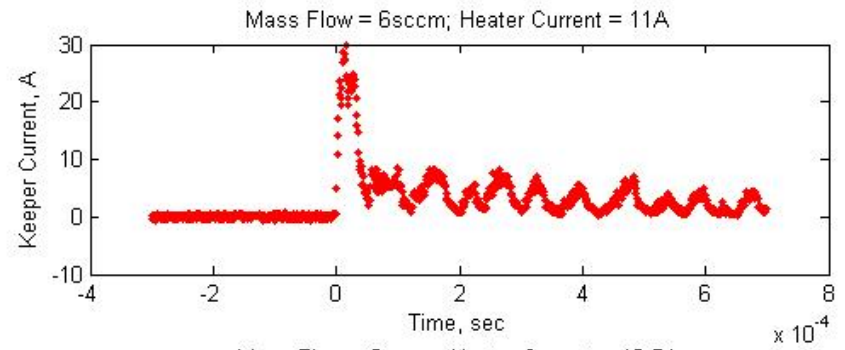
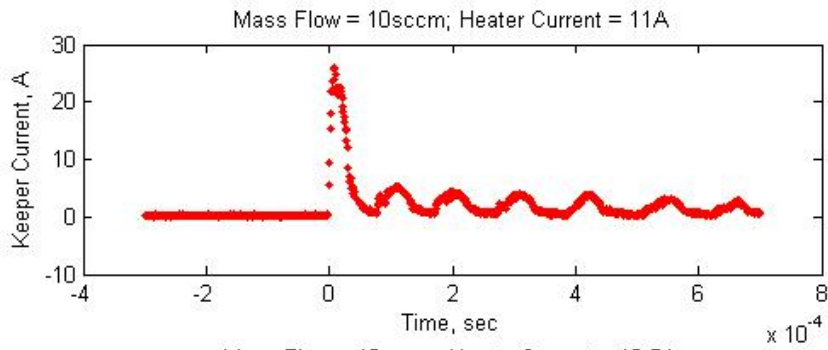


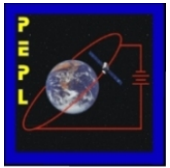
Current Profile



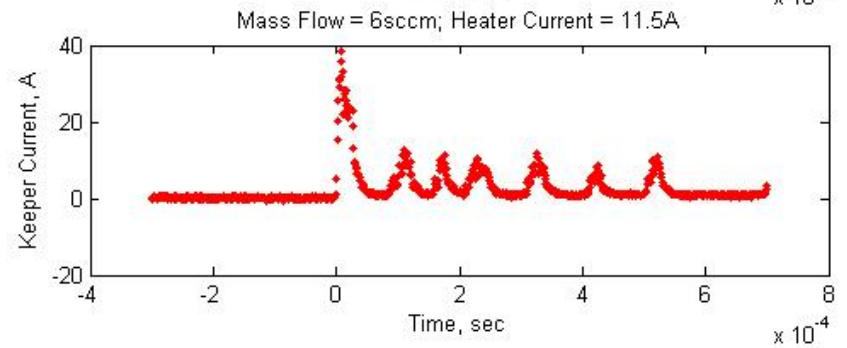
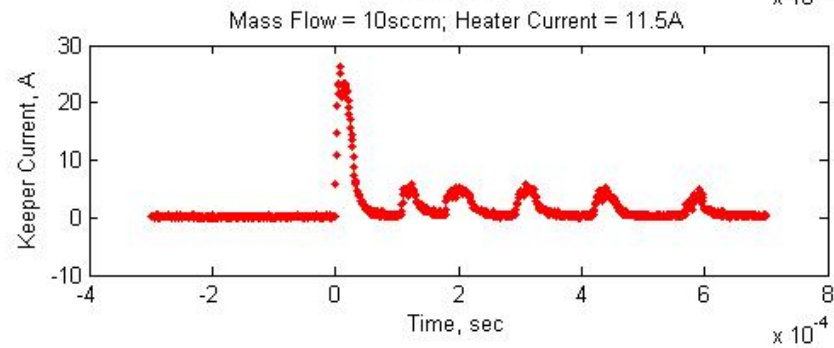
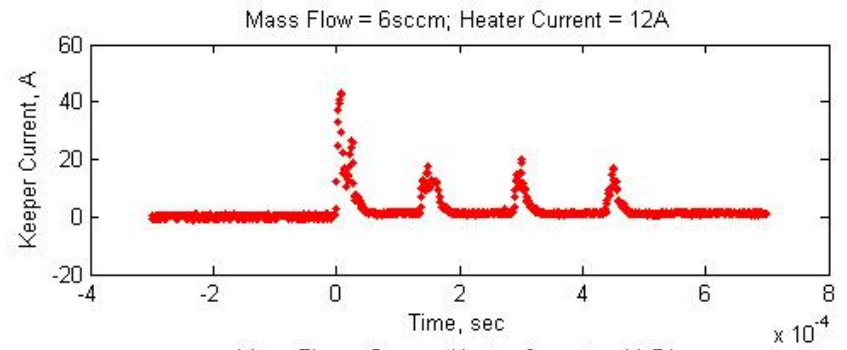
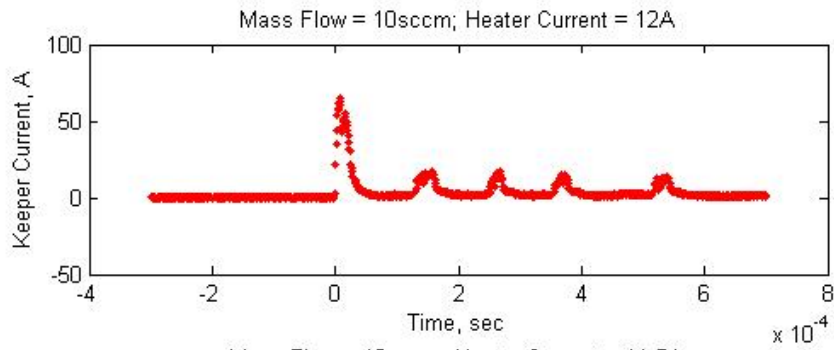


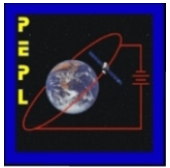
Current Profile (cont.)



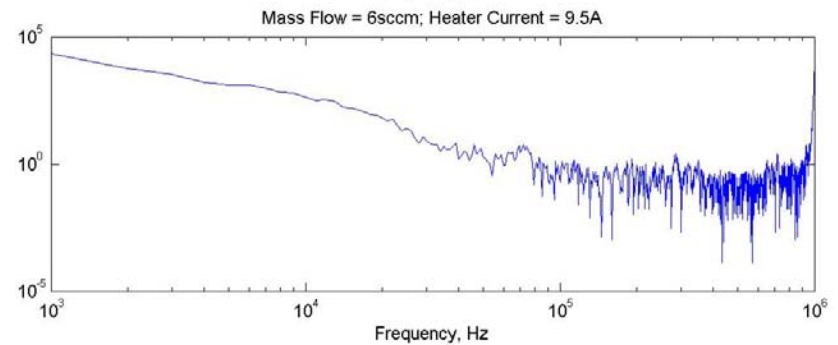
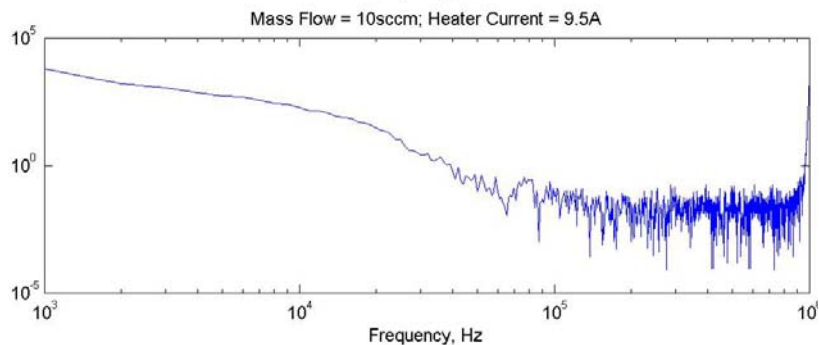
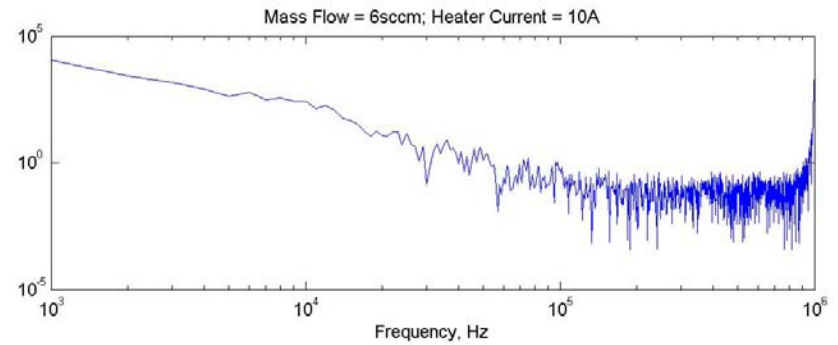
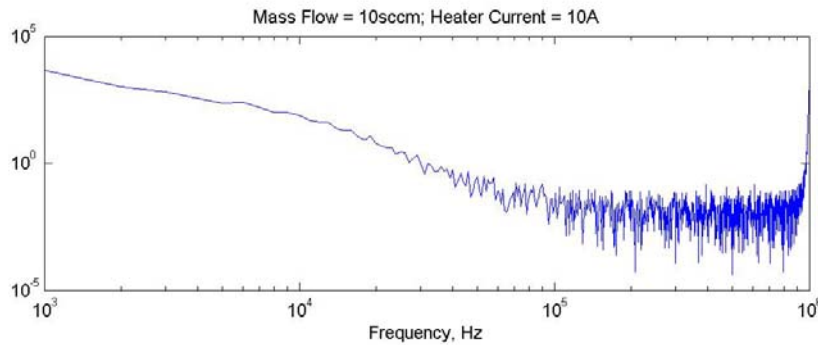


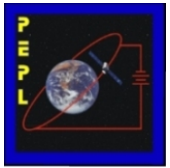
Current Profile (cont.)



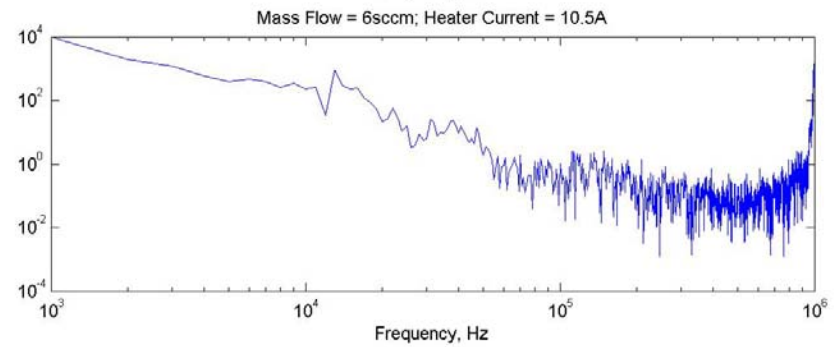
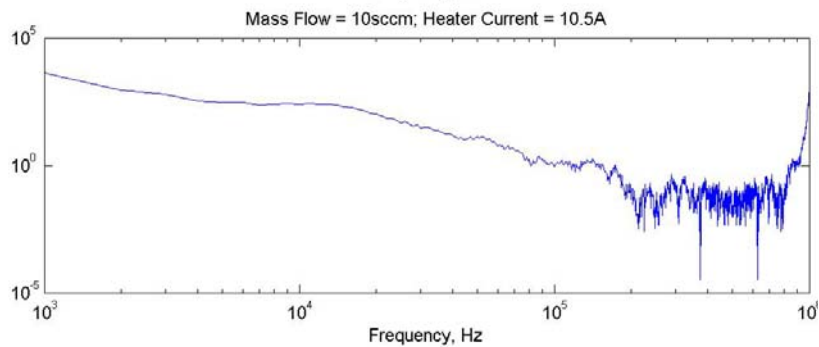
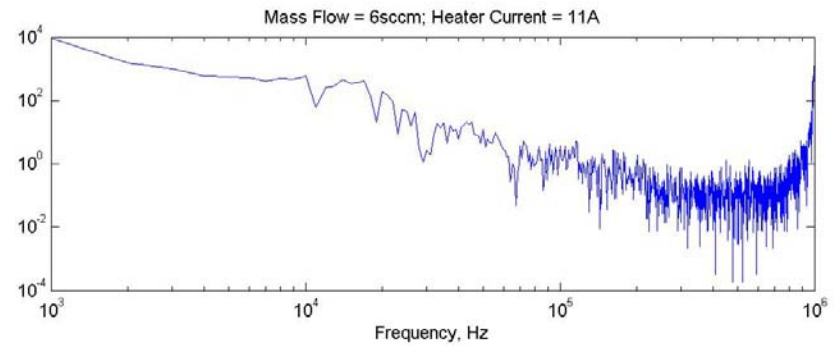
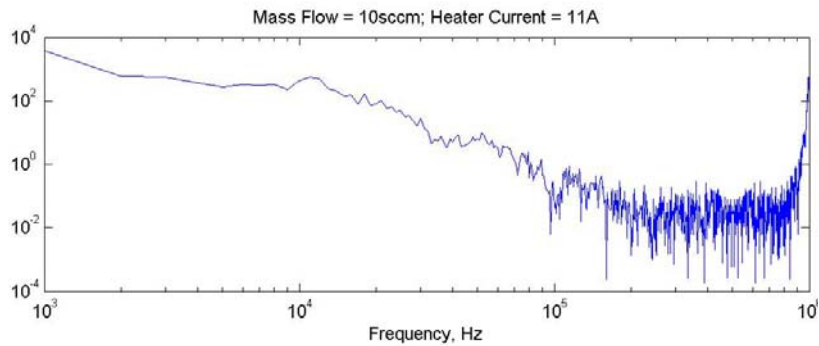


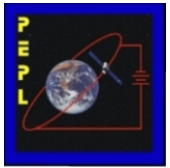
Frequency Spectrum



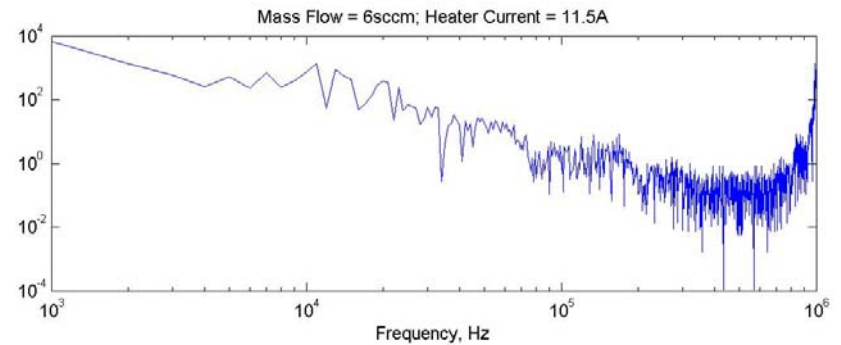
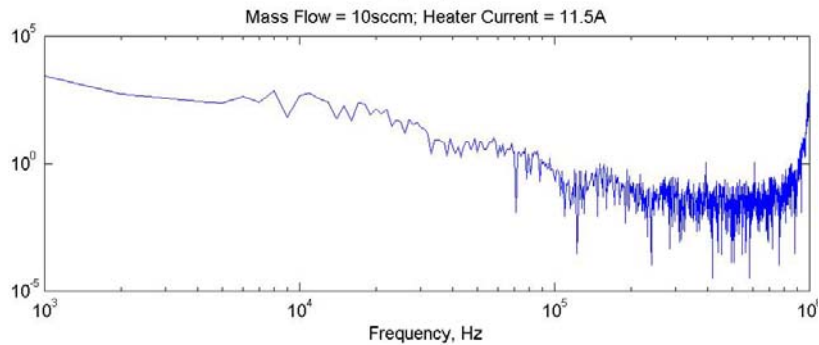
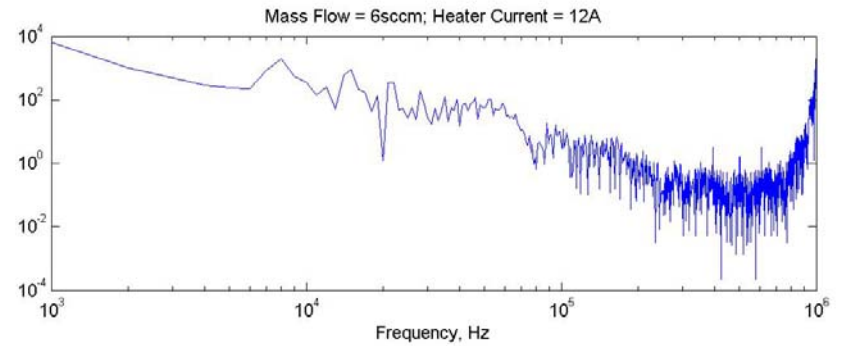
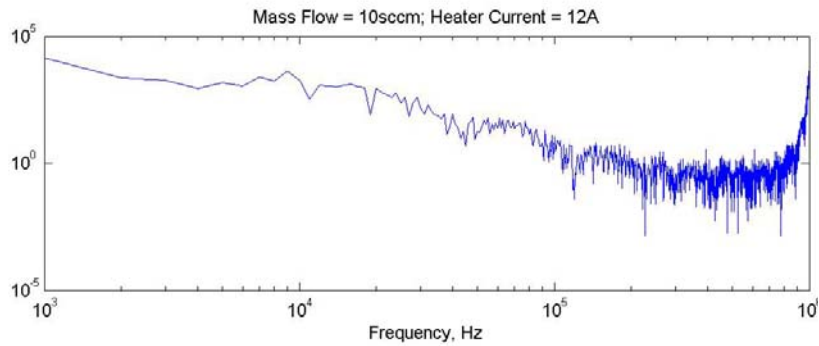


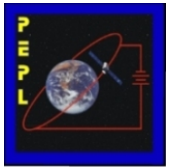
Frequency Spectrum (cont.)





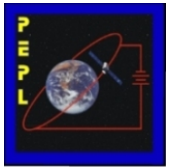
Frequency Spectrum (cont.)





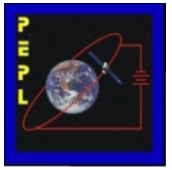
Conclusion & Future Work

- Breakdown voltage as a function of heater power follows the power law and increases with higher mass flow and lower heater power
- Initial current growth rate does not vary with heater power and mass flow
- Current decay (to steady state level) shows interesting oscillation at $\sim 10^4$ Hz for higher heater currents
- Frequency spectrum shows no noticeable peaks otherwise
- Incorporate an anode to shift the discharge current from the keeper and leave the keeper floating to study steady-state characteristics
- A full investigation of the LaB_6 pre-ignition temperature via disappearing-wire pyrometry
- Study the feasibility of heaterless breakdown

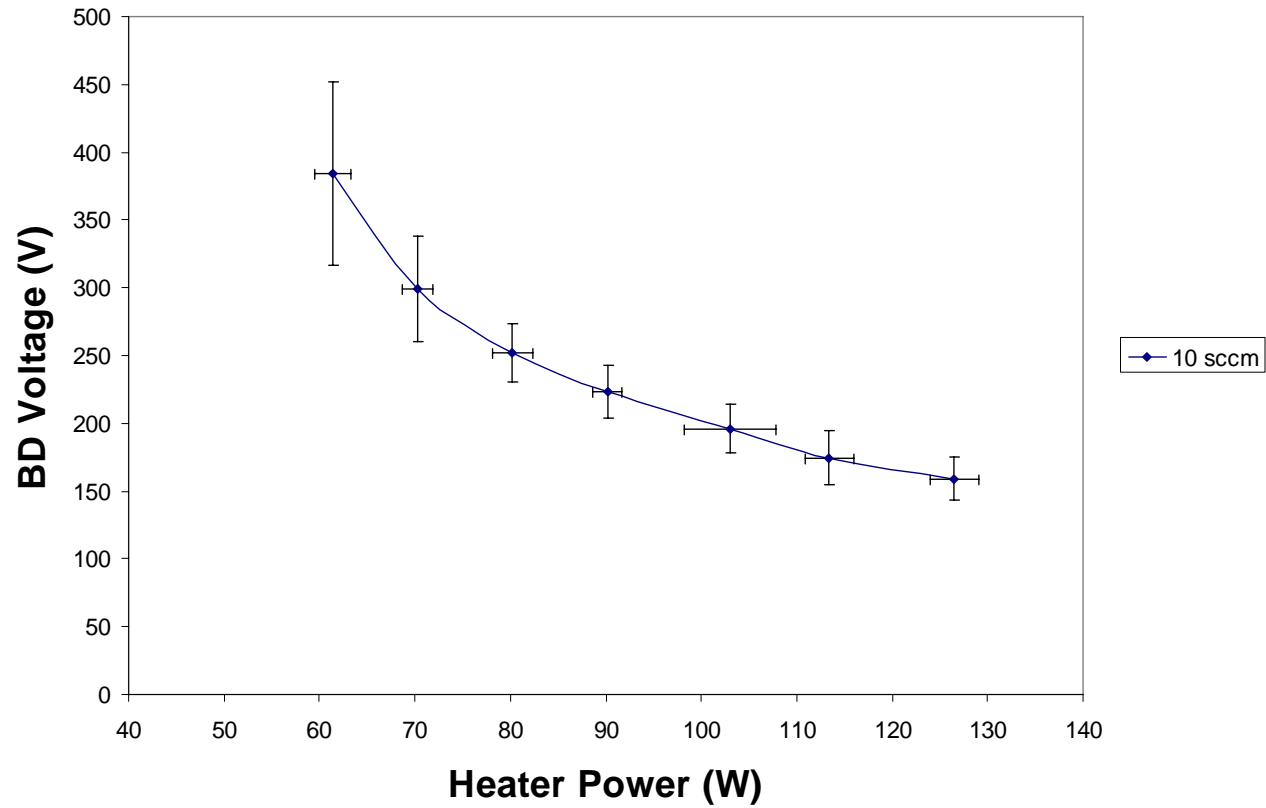


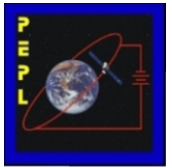
References

- 1) D.M. Goebel and R.M. Watkins, "LaB₆ Hollow Cathodes for Ion and Hall Thrusters," AIAA-2005-4239, *41st Joint Propulsion Conference*, Tucson, AZ, Jul 2005.
- 2) K.N. Leung, P.A. Pincosy, and K.W. Ehlers, "Directly Heated Lanthanum Hexaboride Filaments," *Rev. Sci. Instrum.*, Vol. 55, pp. 1067-1068 (1984).

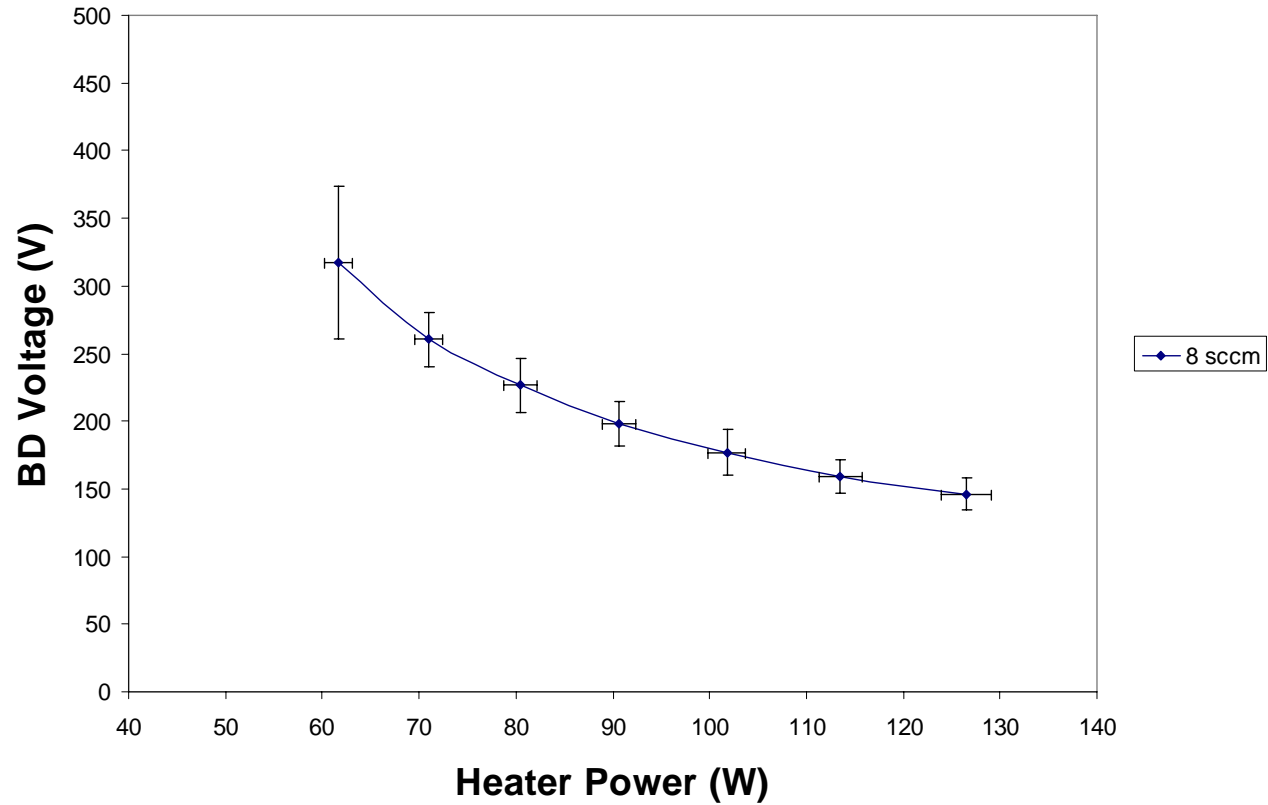


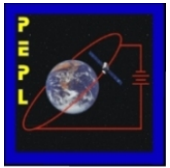
Breakdown Voltage



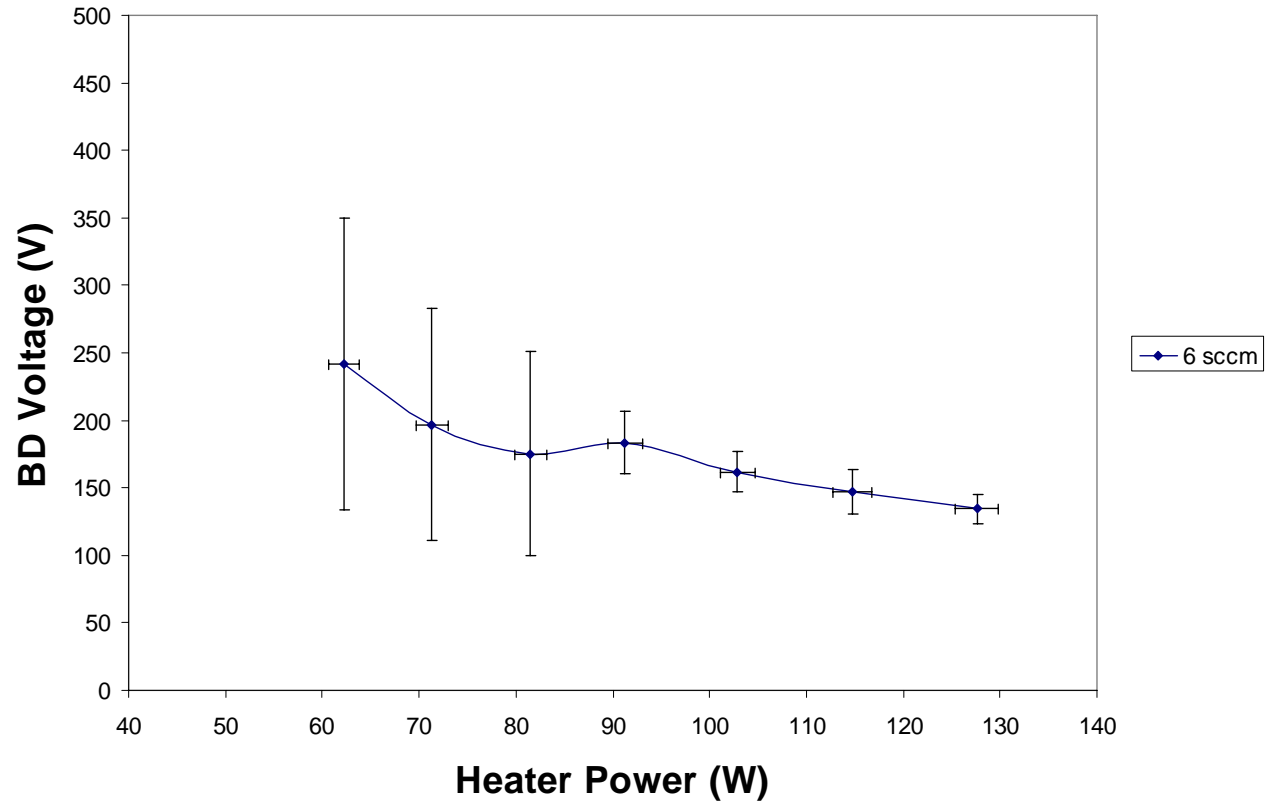


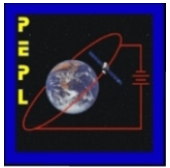
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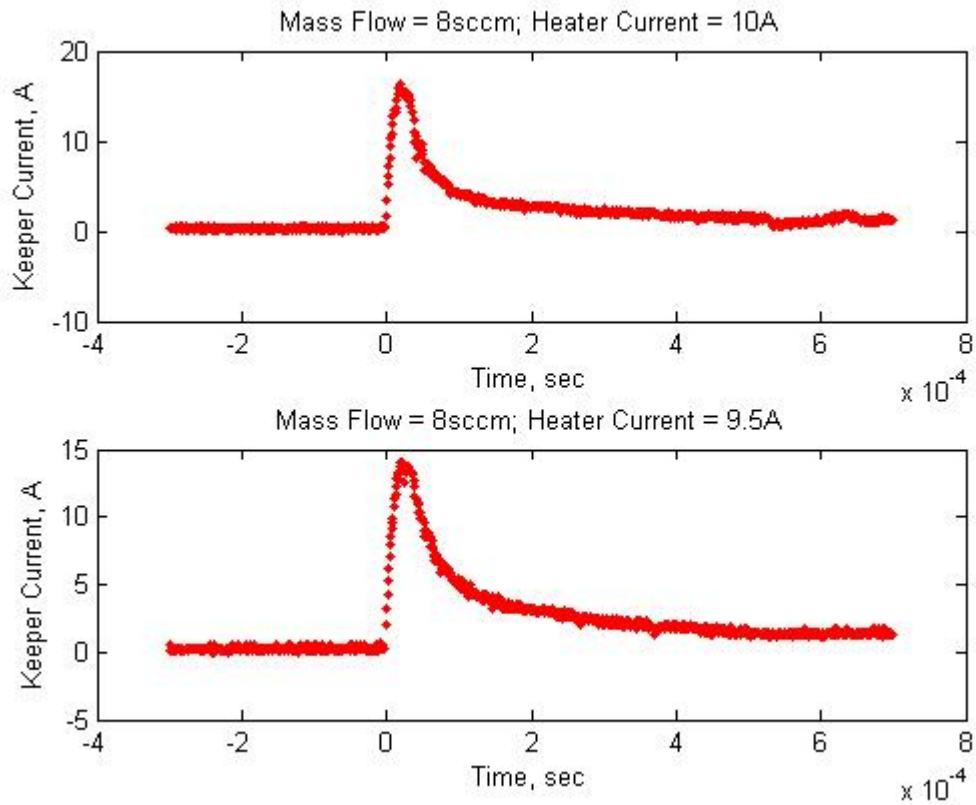


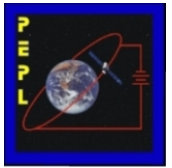
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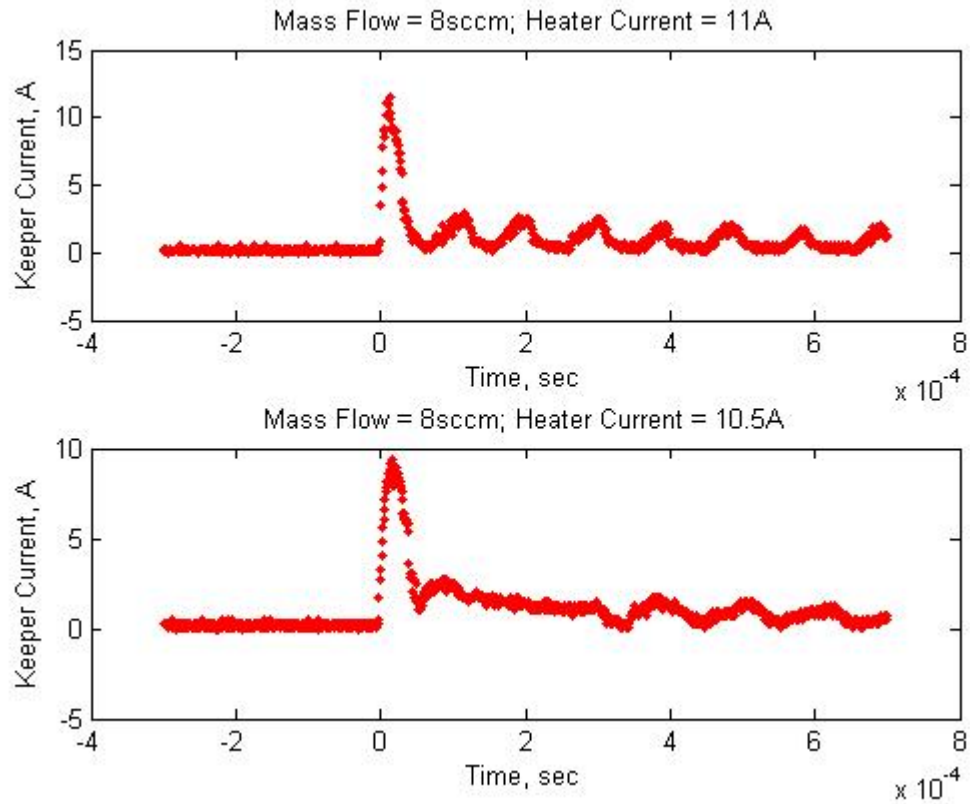


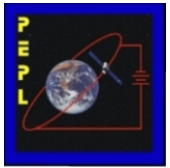
Current Profile





Current Profile (cont.)





Current Profile (cont.)

