ElectroDynamic Applications, Inc.

PENNSTATE

Hybrid Chemical-Electric Propulsion (HCEP)

Phase I STTR

Principal Investigator: Christopher Davis, PhD
ElectroDynamic Applications, Inc.
Ann Arbor, Michigan

University Principal Investigator: Professor Michael Micci
Penn State University

Space Power and Propulsion Program Review, September 12th, 2012

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
22 SEP 2012		**00-00-2012 to 00-00-2012**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Hybrid Chemical-Electric Propulsion (HCEP)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **ElectroDynamic Applications, Inc,3600 Green Court Ste 300,Ann Arbor,MI,48105**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at the 2012 AFOSR Space Propulsion and Power Program Review held 10-13 September in Arlington, VA. U.S. Government or Federal Rights License

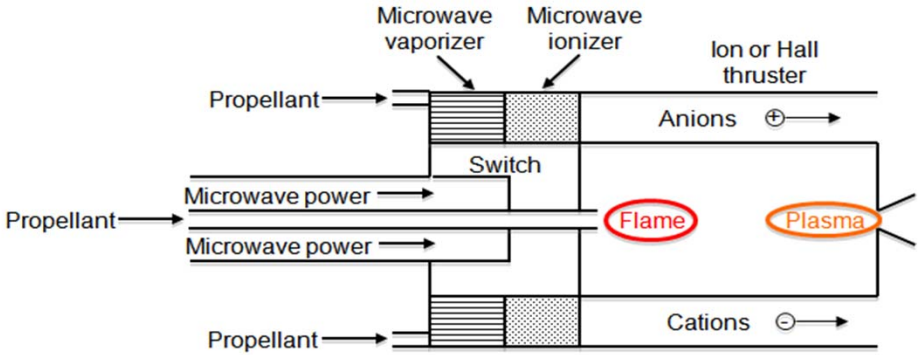
14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

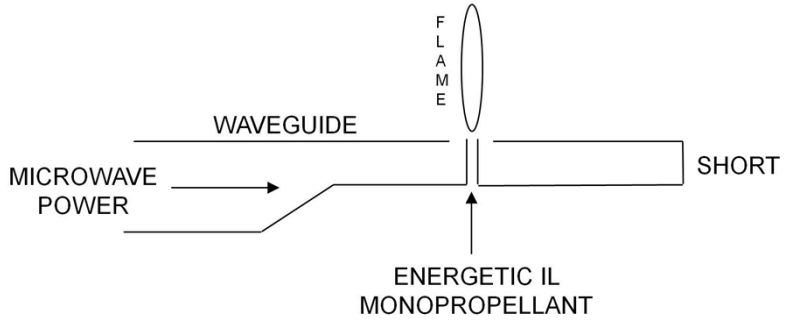
HCEP Thruster Concept

- Can be operated as a chemical thruster and a low or high I_{sp} electric thruster using same ionic liquid (IL) propellant
  - *Chemical, high thrust mode* – Ignite and bring to complete combustion using microwaves in central chamber
  - *Low electric I_{sp} mode* – Electrothermal heating of combustion products to ~ double I_{sp} (<1000 s)
    - Estimated 3-N thrust with 25 kW, 50% thruster efficiency
  - *High electric I_{sp} mode* – microwave energy used to ionize IL propellant; ions then accelerated electrostatically
    - Estimated I_{sp} of ~3000 s

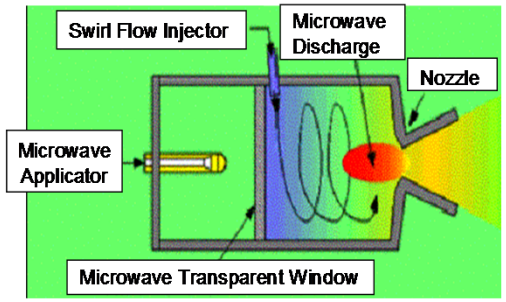


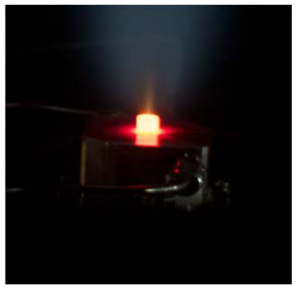
Phase I Tasks (1 of 2)

- Characterization of IL (ionic liquid) ignition and sustainability
  - Measure microwave ignition as a function of flow rate and power
  - Testing performed at PSU facilities using available AF-315E



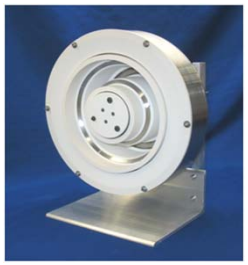
- Demonstration of microwave electrothermal heating of representative combustion products
  - Characterization of mixtures of CO_2, H_2O, N_2, N_2O, etc.

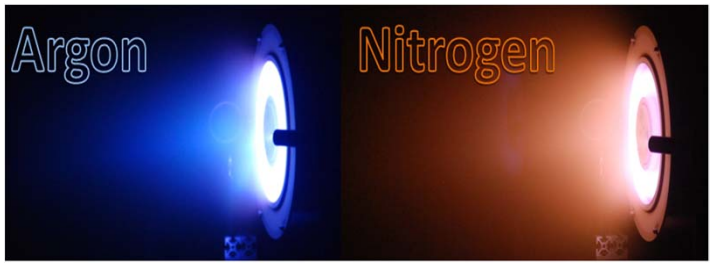




Phase 1 Tasks (2 of 2)

- Validation of electrostatic acceleration of simulated ionic liquid components
  - Run well-characterized Hall thruster using representative IL components (CO_2, N_2O, H_2O, and N_2)
  - Compare results to Xenon performance
  - Testing performed at University of Michigan's Plasmadynamics and Electric Propulsion Laboratory (PEPL) Large Vacuum Test Facility (LVTF)





- Development of conceptual design of a HCEP thruster
  - Electrostatic acceleration design
  - Neutralizer design and integration
  - Method for switching of microwave power between igniter or ionizer
  - Thruster design to operate in 30 kW power range