Optimization of a Low Power ECR Thruster Using Pulsed Heating

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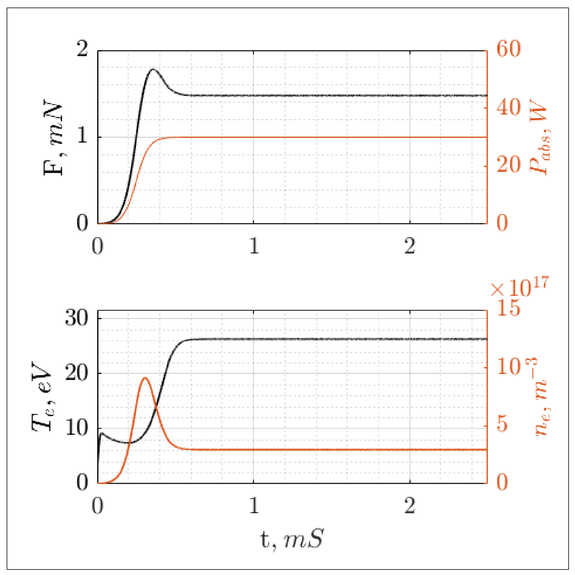
Motivation

Magnetic nozzles enable simple thruster designs, low system masses, and can use a variety of propellants, making them well suited for small satellite applications [1]. Efficiency at low powers has typically been worse than existing systems such as gridded ion and Hall effect thrusters [2].

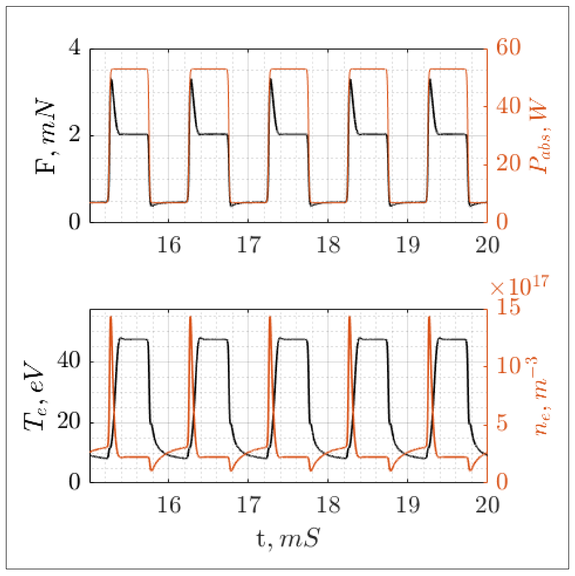
While previous studies have optimized these thrusters by modifying geometry and magnetic field topology, in this experiment we use custom input waveforms to improve performance. This enables rapid iteration through many test points.

For this test, we aim to improve thrust efficiency using pulsed power waveforms. By pulsing the input power, we drive the plasma to electron temperatures and densities that are unattainable with CW waveforms.

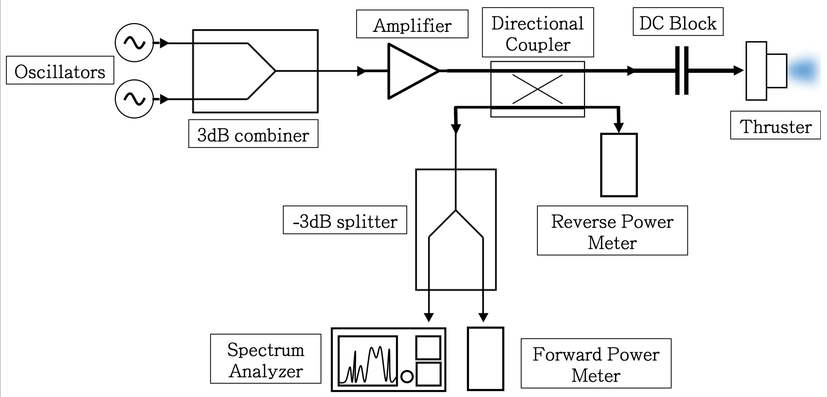
CW



Pulsed

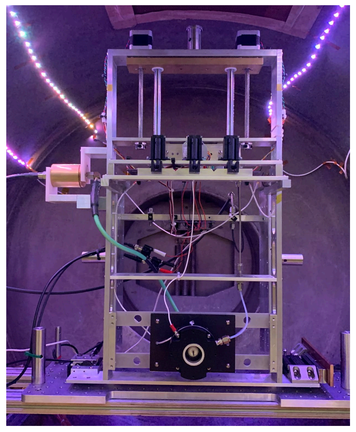


Experimental Setup



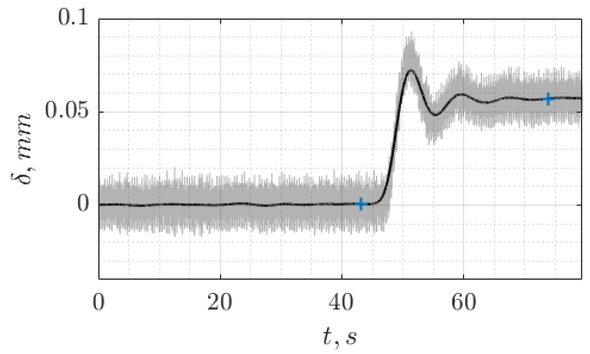
Schematic of the microwave setup

We use a coaxial ECR thruster based on experiments at ONERA [2]. The input signal is a microwave signal generators controlled by a computer interface. Power is read by RMS power meters and a spectrum analyzer. Absolute thrust is measured using a custom-built thrust stand. The signal generator and amplifier limit our experiments to 50% duty cycle and pulse frequencies under 100 kHz

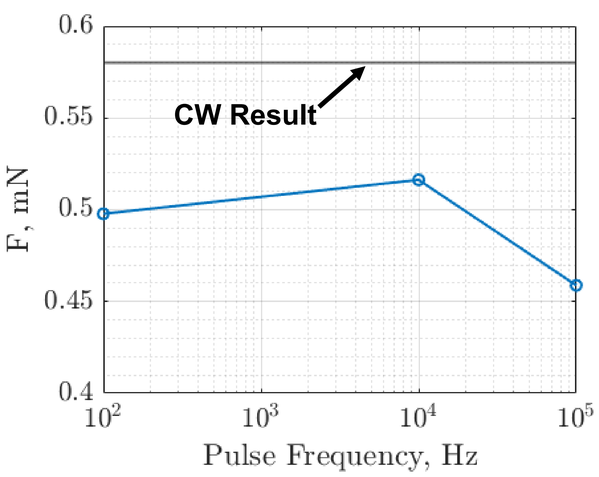


ECR Thruster on PEPL Thrust Stand

Results



Thrust Measurement Output



Thrust stand measurements for 30 W, 2 sccm xenon test using 0.1, 10, and 100 KHz pulsing at 50% duty cycle

Conclusions & Future Work

Initial pulsed power results show worse thrust output than CW performance. This performance drop can partially be explained by more neutral gas leaking out of the thruster during off times. Future experiments will focus on optimizing pulse frequency and duty cycle.

Acknowledgments

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[1] S. N. Bathgate, M. M. M. Bilek, and D. R. Mckenzie, "Electrodeless plasma thrusters for spacecraft: a review," *Plasma Sci. Technol.*, vol. 19, no. 8, p. 083001, Aug. 2017.

[2] F. Cannat, T. Lafleur, J. Jarrige, P. Chabert, P.-Q. Elias, and D. Packan, "Optimization of a coaxial electron cyclotron resonance plasma thruster with an analytical model," *Phys. Plasmas*, vol. 22, no. 5, p. 053503, May 2015.

[3] Alton, G. D., "Future prospects for ECR ion sources with improved charge state distributions," Tech. rep., Oak Ridge National Lab., TN, 1995.