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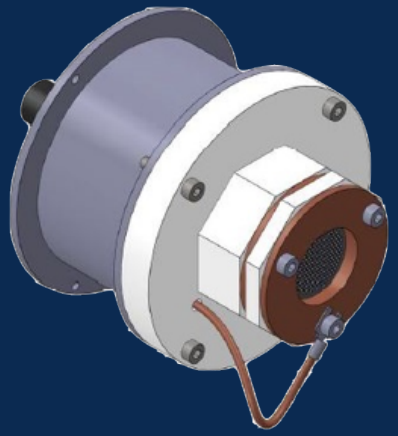
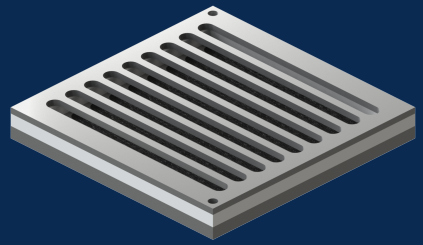
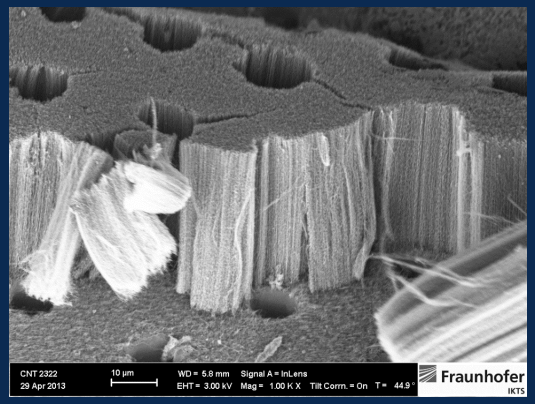
Mechanical Engineering Institute of Aerospace Engineering, Chair of Space Systems

MEMS Ion Thruster Chips to Significantly Enhance Cold Gas Thruster Lifetime for LISA







M. Tajmar, D. Bock, P. Laufer

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Micropropulsion Candidates

FEEP Thrusters (Previous Baseline)

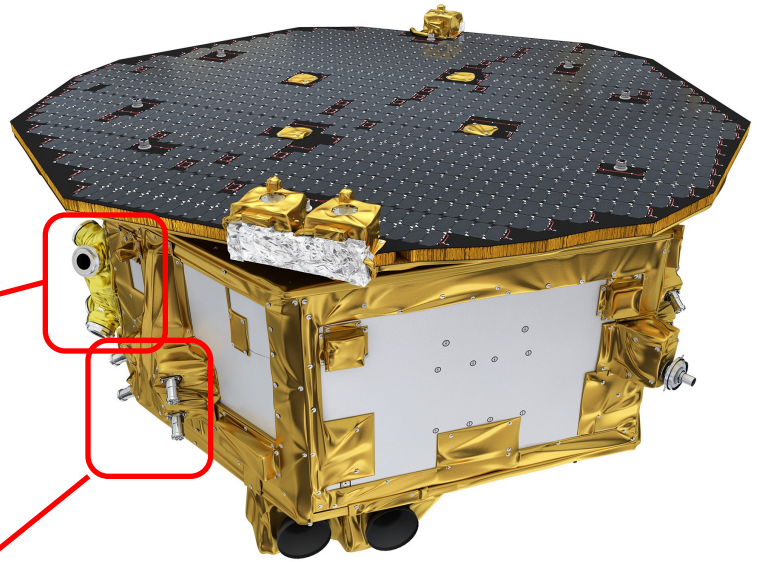
Pro: High Specific Impulse

Con: Lifetime/Liquid Metals, Complexity (Neutralizer, Electronics), Costs

Colloid Thrusters (Experiment on Lisa-PF)

Pro: No liquid metal (easy wetting)

Con: Lifetime (2000h), Low Thrust (<30 µN)

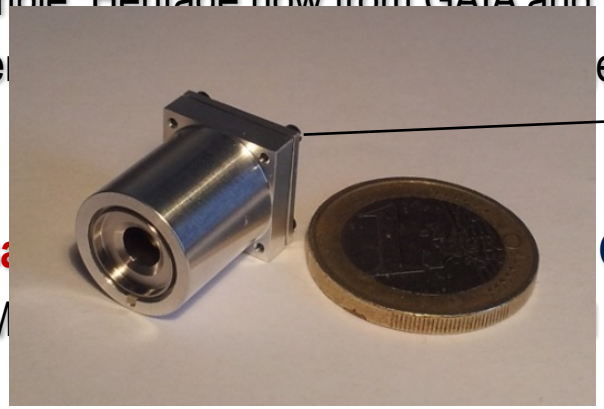


Source: ESA/Spaceflight101.com

Cold Gas Thrusters (Present Baseline on Lisa-PF)

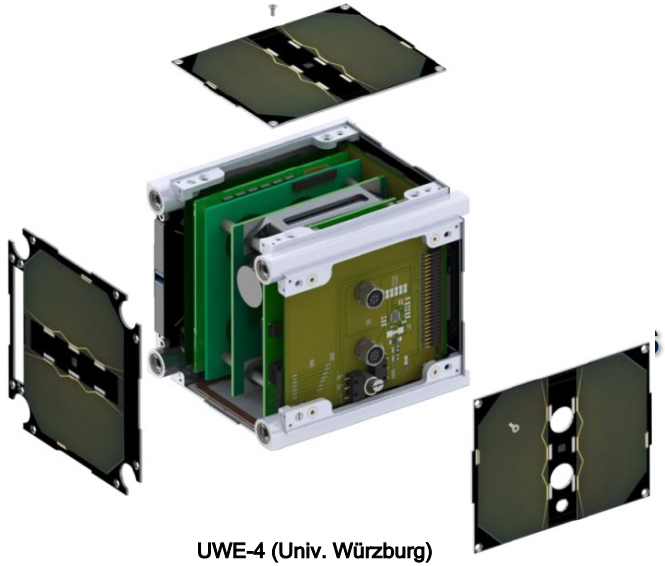
Pro: Simple, Heritage now from GAIA and LISA-PF

Con: Ve e tanks – pos



Proposa Gas System

⇒ MEM Emission Pe



UWE-4 (Univ. Würzburg)

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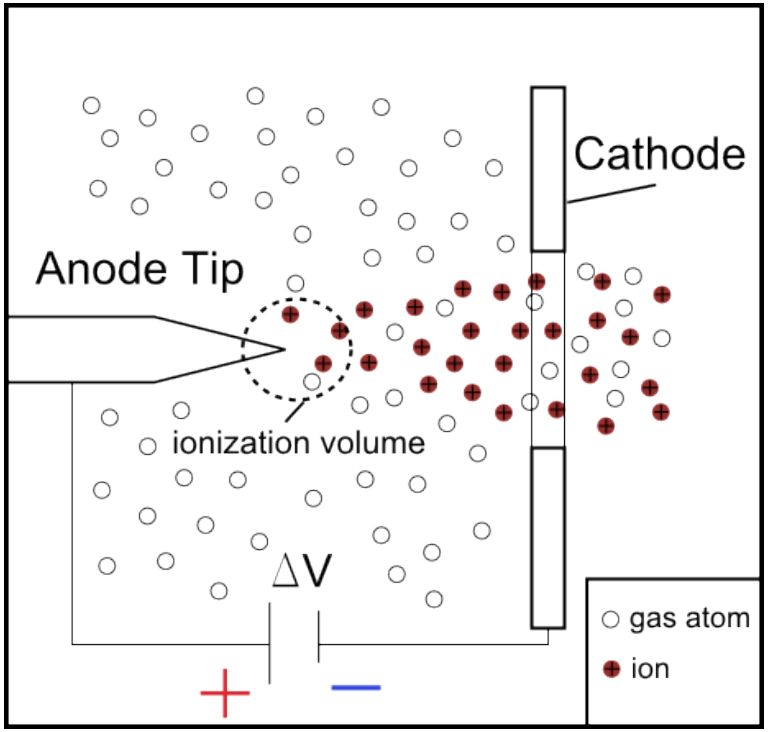
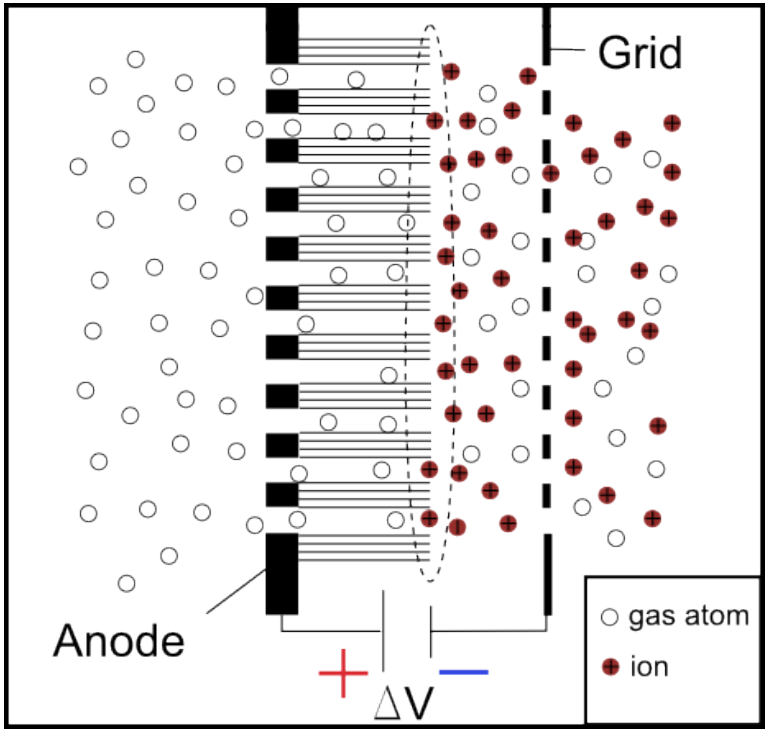
Gas-Field-Ionization Source

Basic Gas-Field-Ionization-Source



- Invented by Müller in 1951
- Ion Microscope (Atomic Resolution)
- FIB (Nano/Micro Manufacturing), …

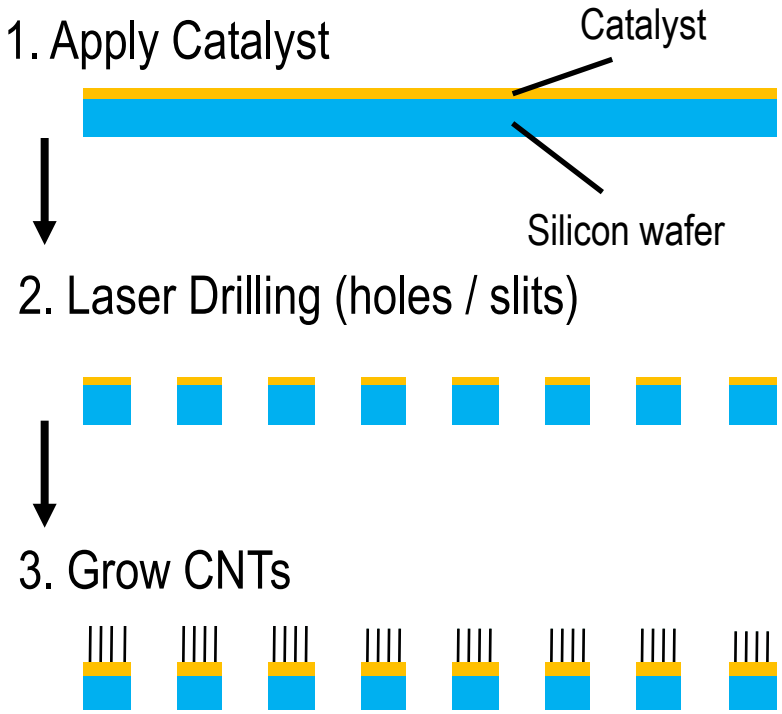
Advanced Gas-Field-Ionization-Source

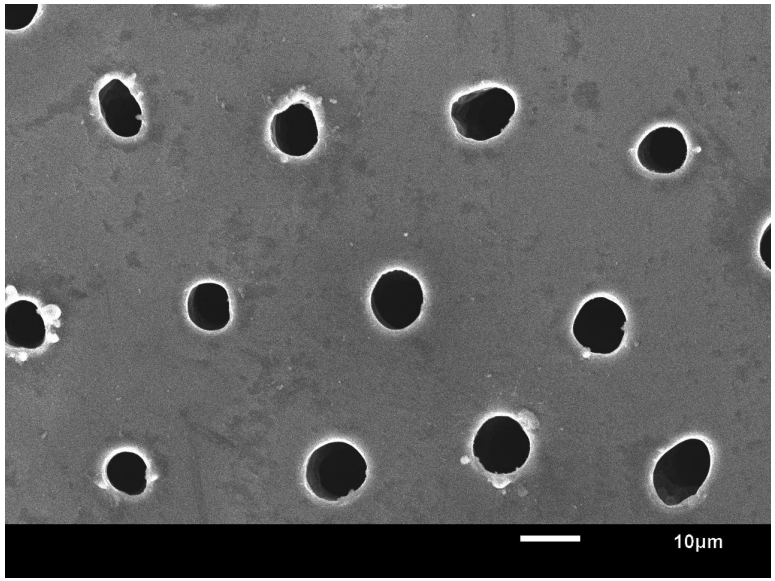


- Potentially higher ionization efficiency
- Compact high current source
- Works bipolar (!) – no sep. e^- source
- Microthrust, low thrust noise as with FEEPs
- No liquid metal, simple

Novel Chip Manufacturing Process

Manufacturing Process





10 µm diameter, 450.000 holes,
aspect ration 50:1 (!)

Cooperation: Fraunhofer IKTS (CNTs), Laserzentrum Mittweida

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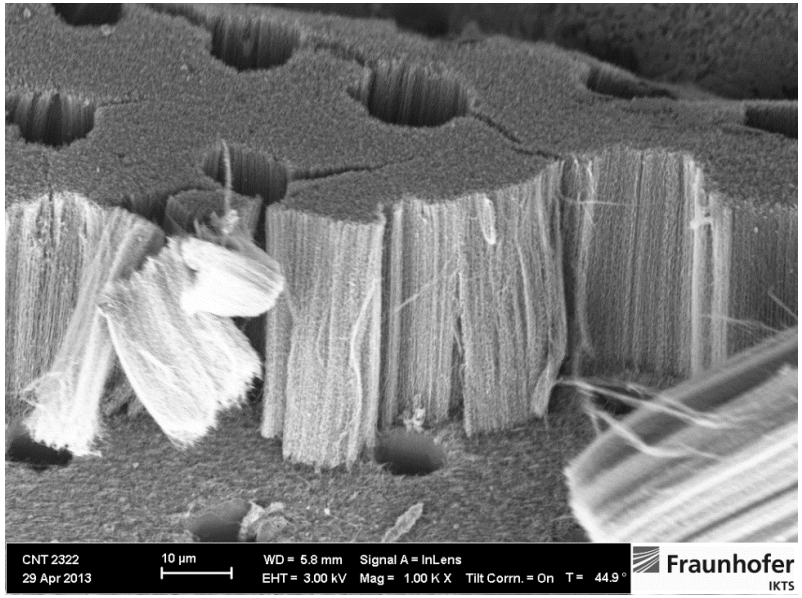
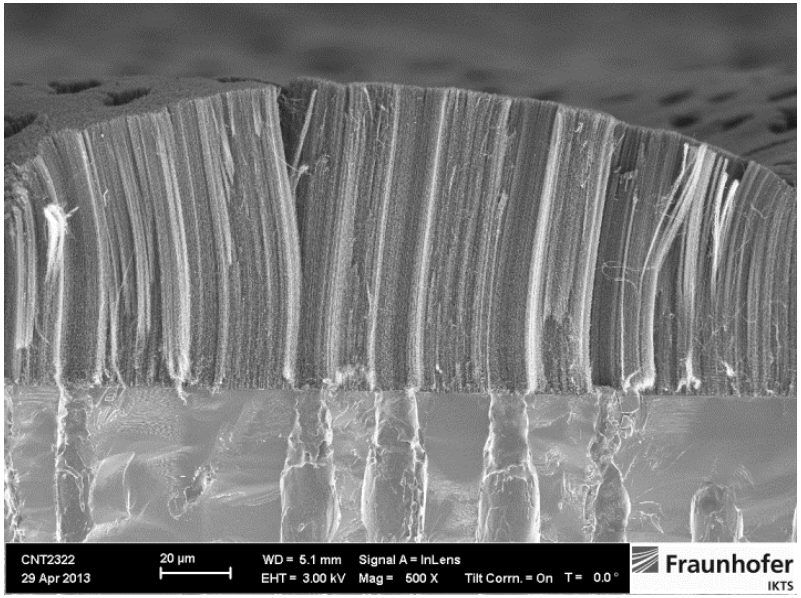
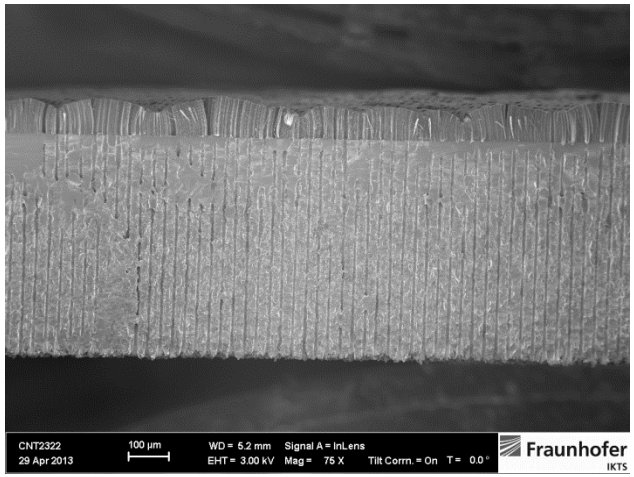
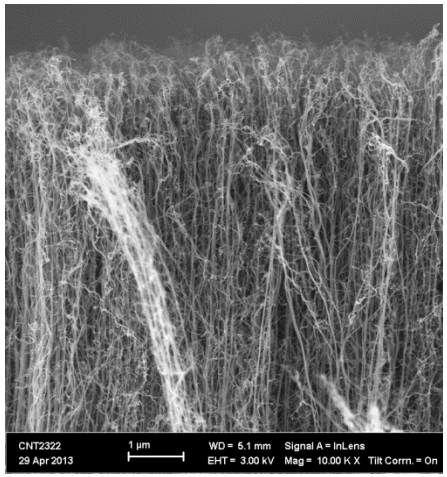
CNT Array



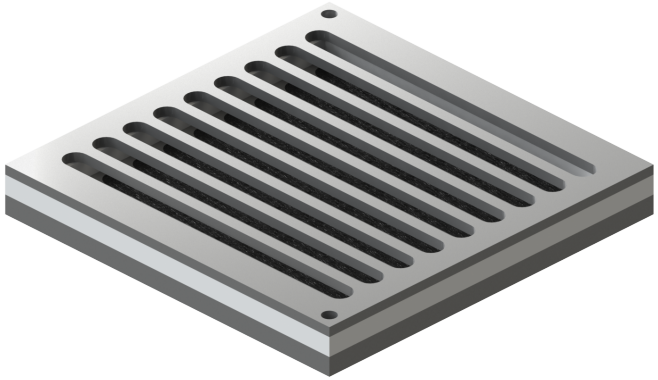


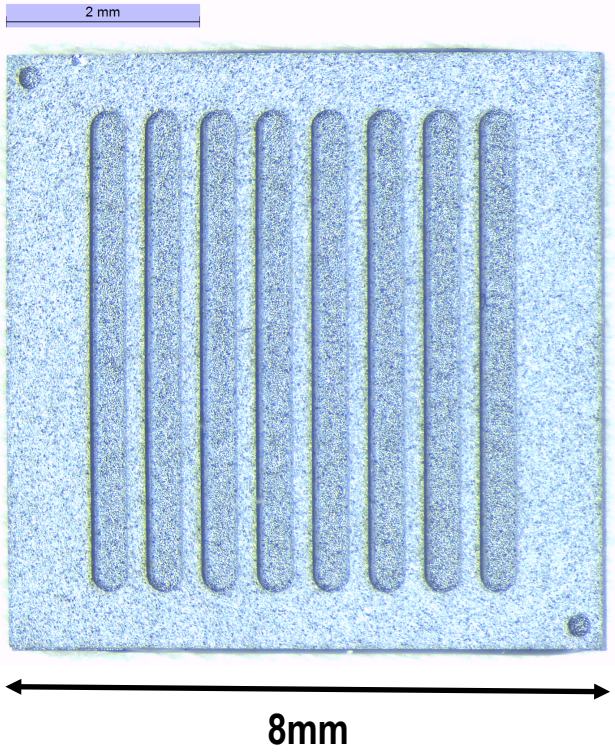


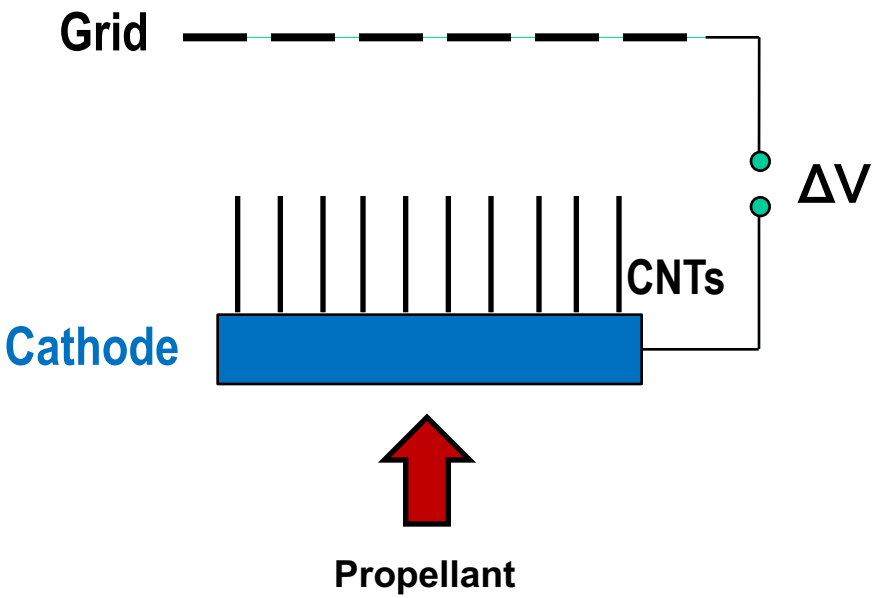


- Vertically alligned
- High density
- „Waves“ on top surface

Scalable Chip-Design

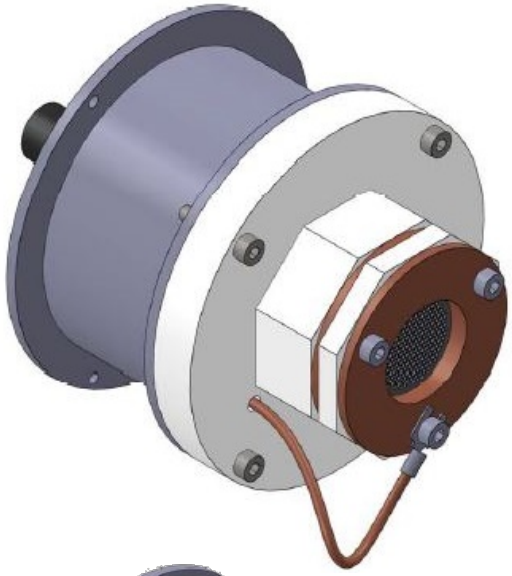


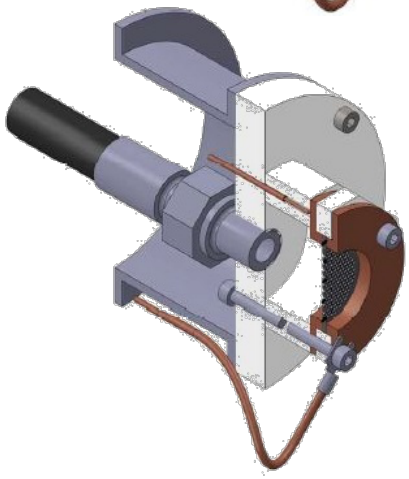


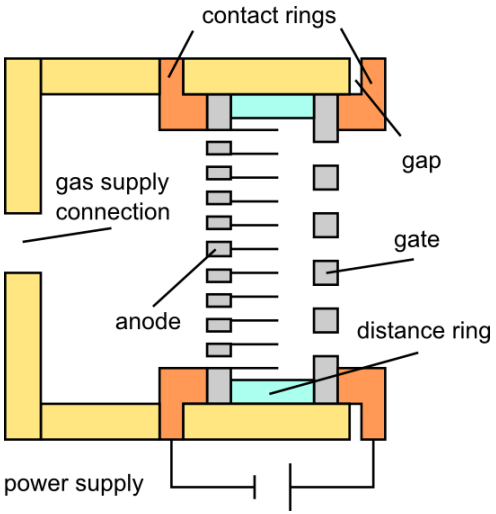


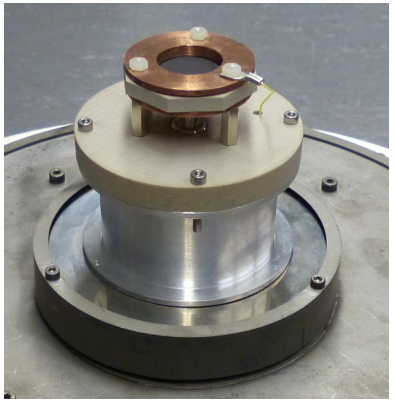
- Works with any kind of propellant – also nitrogen
- Is it's own neutralizer
- Required only a few hundred Volts

Module Design









- Modular design
- Gas supply with needle valve and pressure regulator
- Vacuum chamber with 10^{-6} mbar

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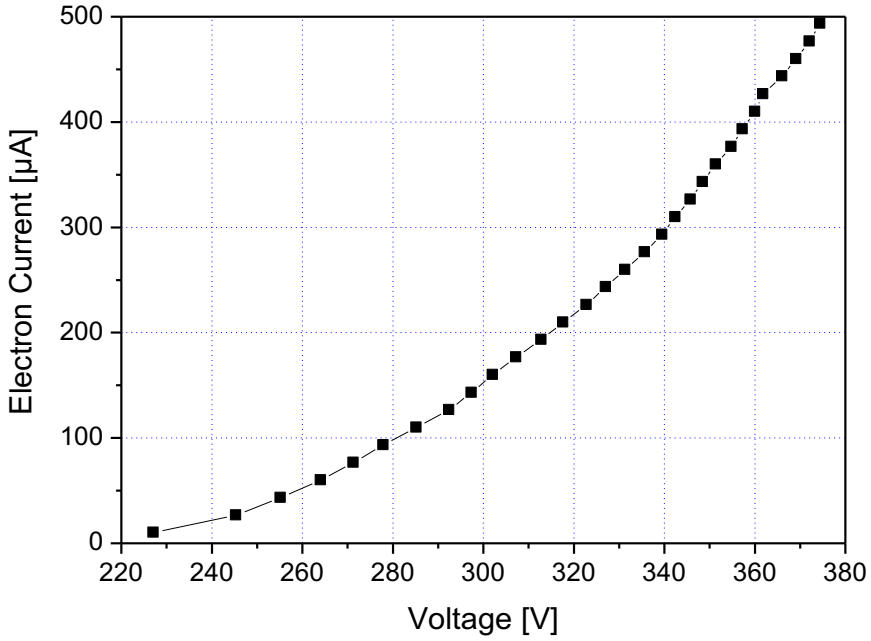
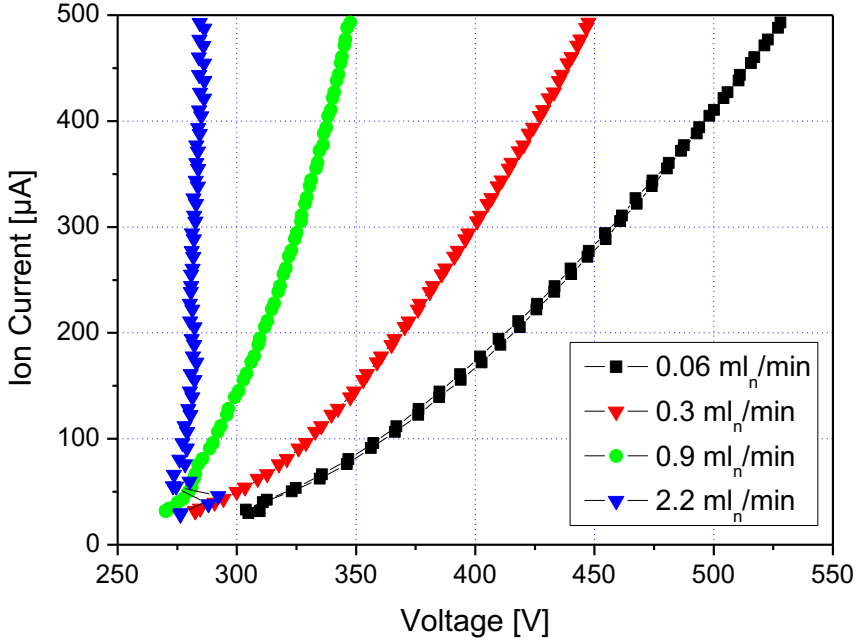
Thruster Performance with Argon

Electron Emission



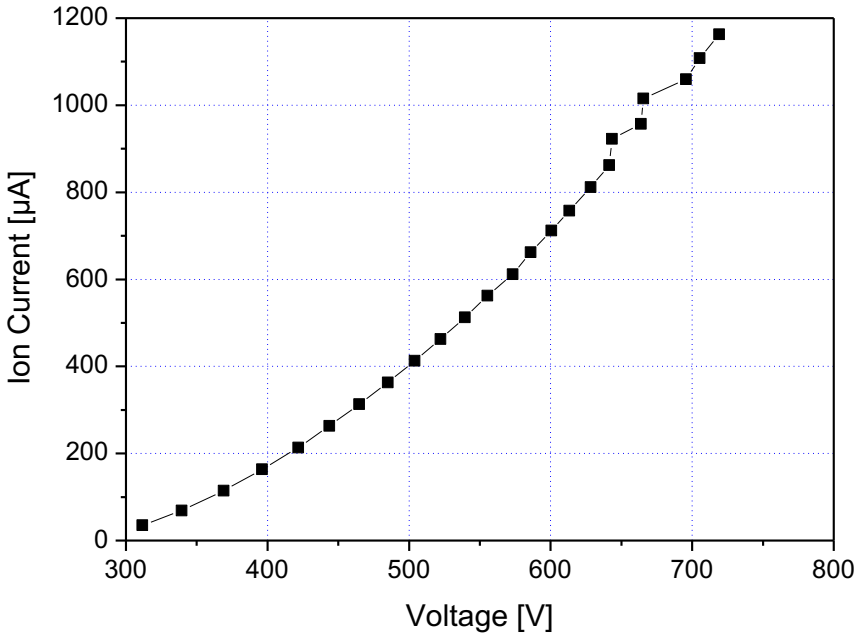
Ion Emission



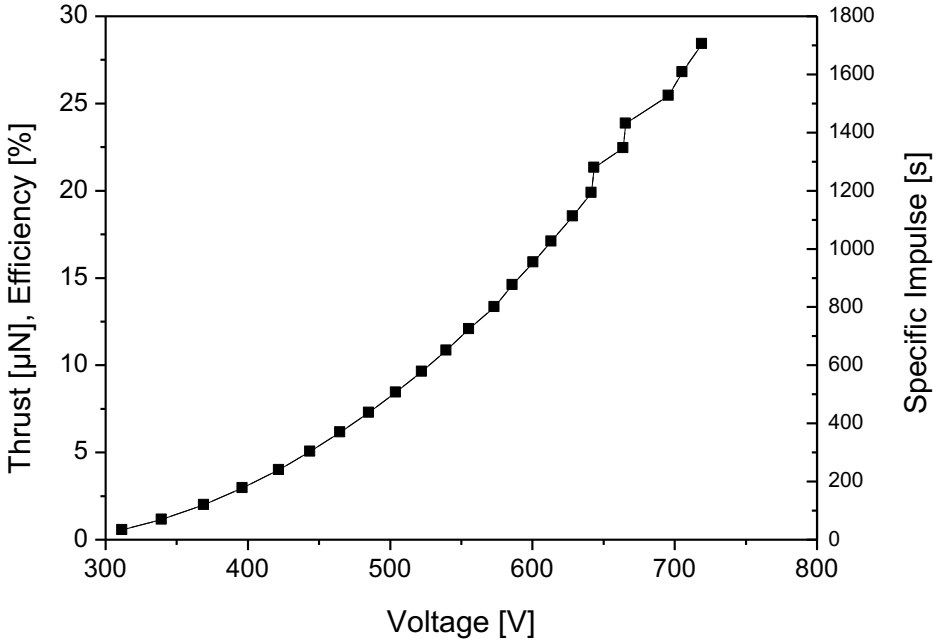
- Currents up to 1 mA possible
- Voltages < 1 kV for first trials (reduce risks of microdischarges)
- True bipolar capability demonstrated !

Thruster Performance with Argon

Maximum Current



Thruster Performance



Argon – Chip with 20 mm Diameter:

Thrust: 30 µN, I_{sp}=1700 s, η=30% at 740 V

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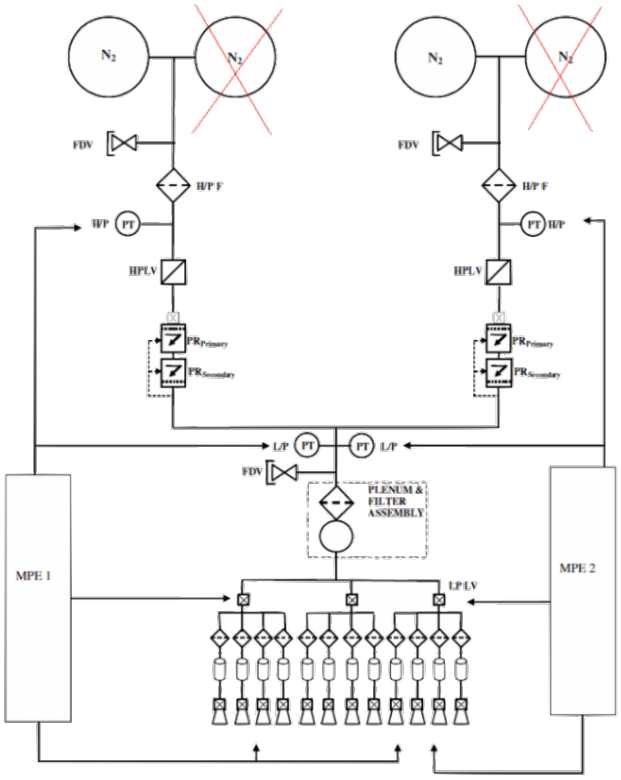
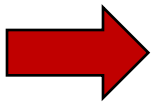
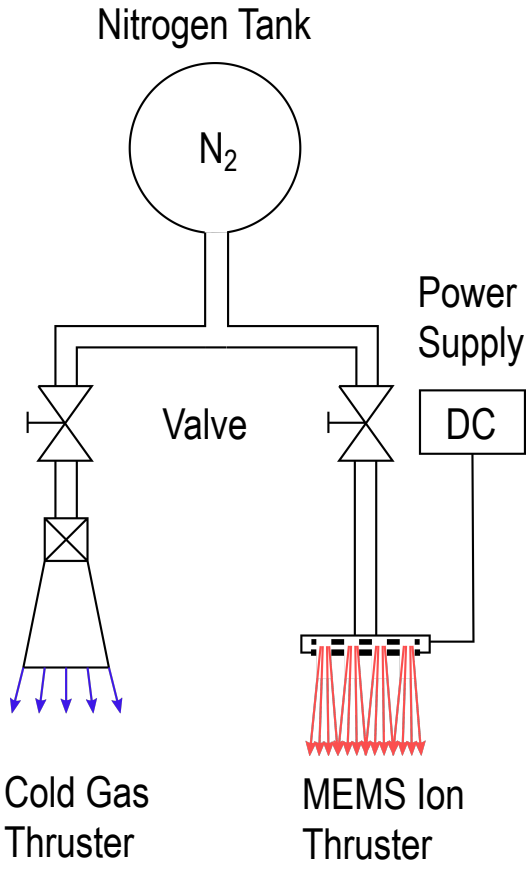
Integration of MEMS Ion Thruster with Minimum Risk

Source: Caltech







- Keep Gold Gas System
- Switch with valve to Micro Ion Thruster - Switch back in case of problems, etc.
- Nitrogen I_{sp} with 500 V is 2150 s $\Rightarrow$ Increase Propellant Lifetime by Factor 48 !
- No separate neutralizer, no magnetic field, etc. – only one DC power supply!

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Integration of MEMS Ion Thruster with Minimum Risk

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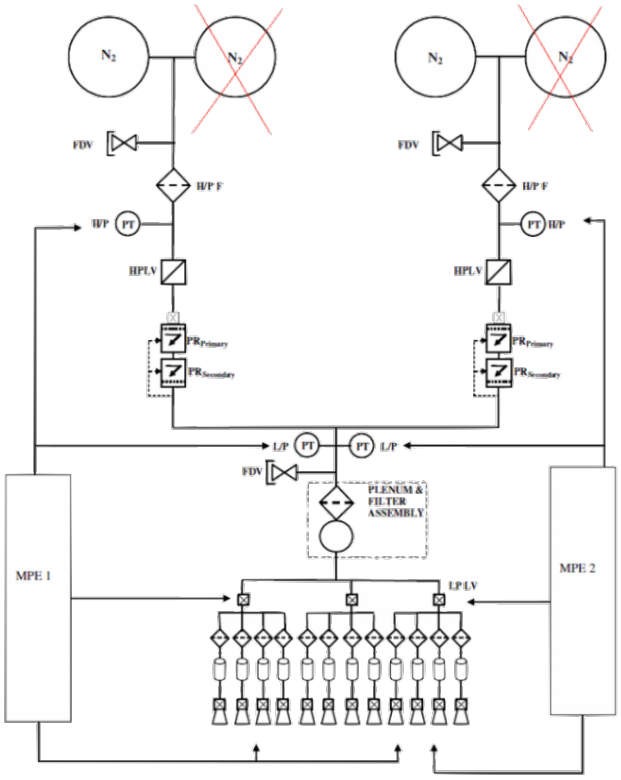

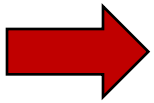

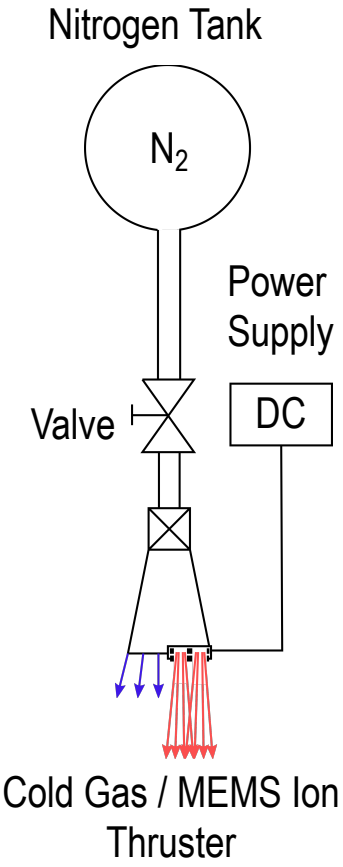

- Integration into Gold Gas System
- No Voltage – Cold Gas, With Voltage – Ion Thruster
- Keep low Thrust Noise (FEEP like), Improve Maximum Thrust Capability


Dresden, Skyline
Thank you very much for your attention!