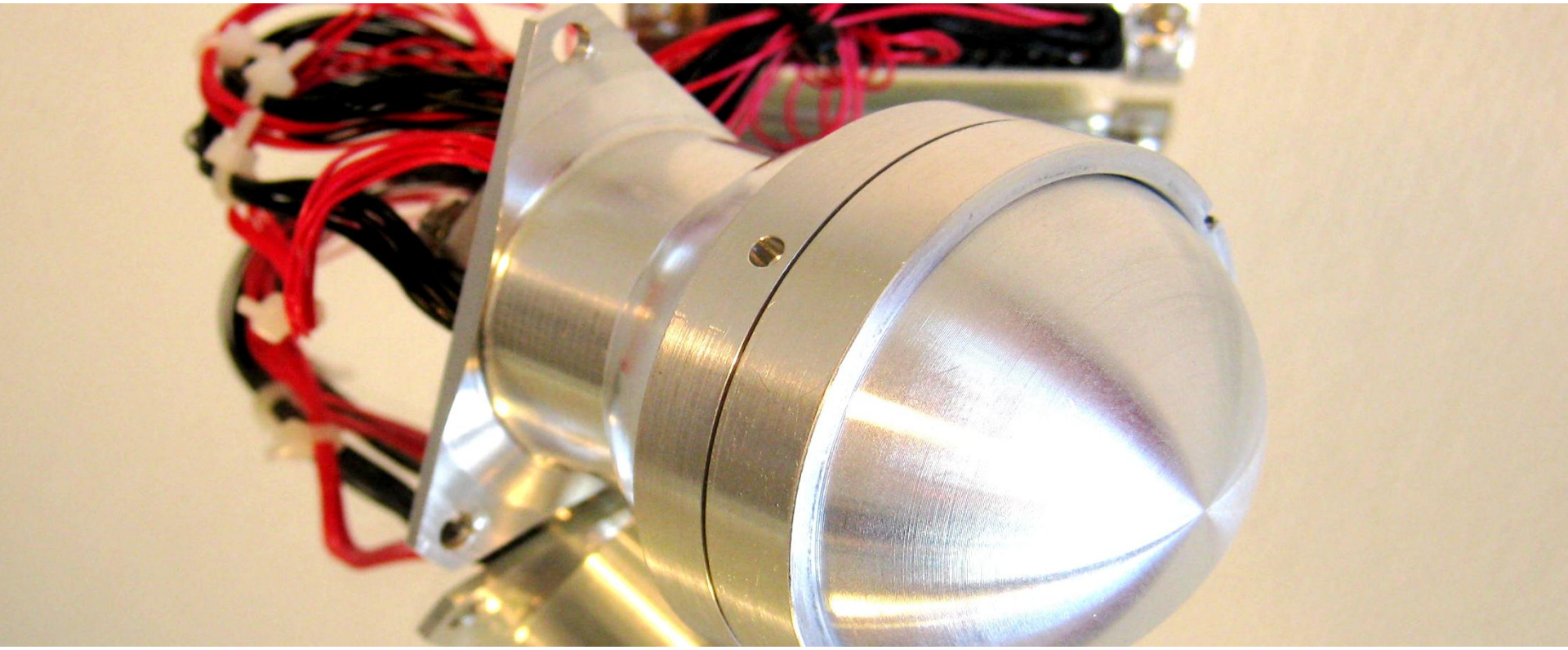
MEMS Micropropulsion Components for Small Spacecraft



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Sweden

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Summarizing Countdown

10

swedish MEMS & space engineers

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innovations

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components to build a propulsion system

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years of preparatory research at ÅSTC, Uppsala University

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silicon wafers to manufacture some thrusters

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years of hard work

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4

thousand clean-room hours

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3

M€

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satellites

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launch ticket

…and ZERO you are in space with a micropropulsion system!

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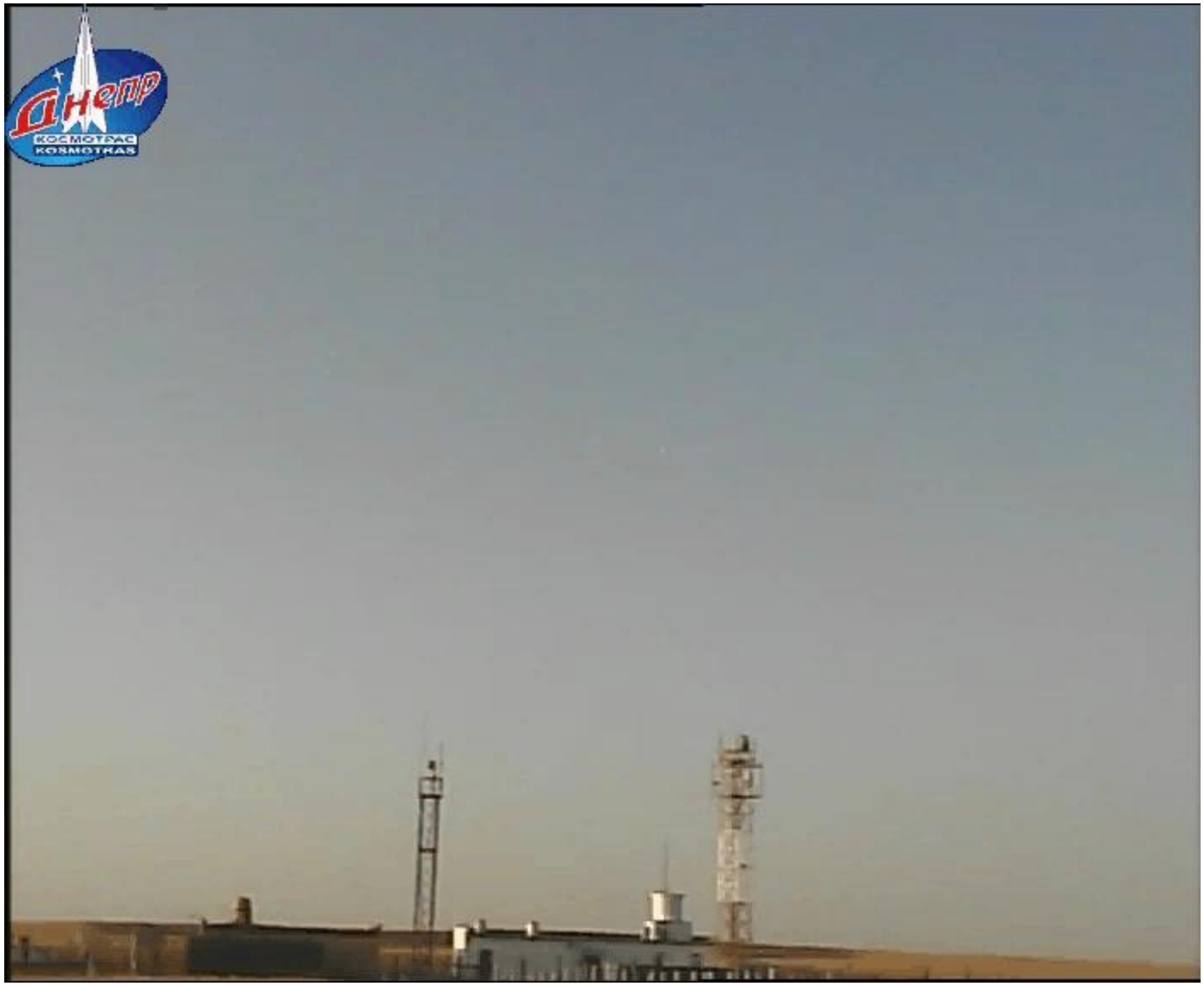


Movie: Prisma on Dnepr launcher

…and that was the last time we ever saw our MEMS thrusters… ☺

Thank you for your attention!

Any questions?

MEMS-based Cold Gas Micropropulsion System

- From proposal to launch in 5 years

2005 2006 2007 2008 2009 2010

NanoSpace starts operation

phase B contract

First test of MEMS thruster

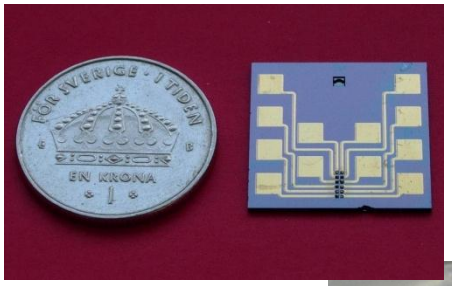
1st complete thruster module

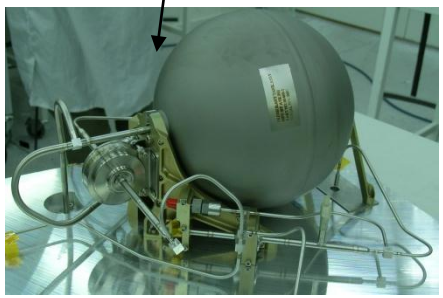
1 st delivery of flight H/W

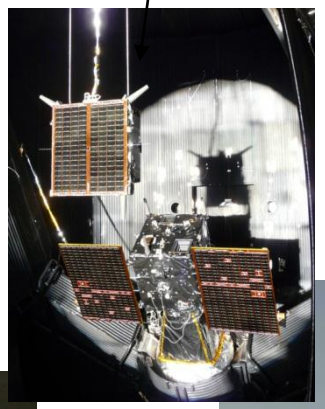
Final delivery to Prisma

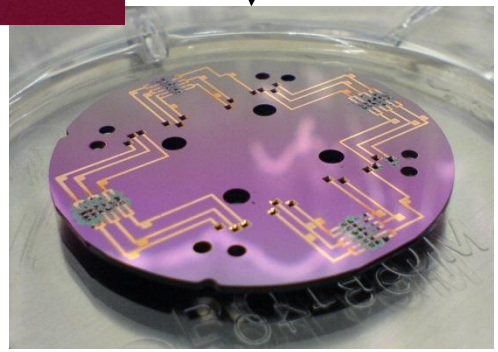
End-to-end testing on S/C

Launch!









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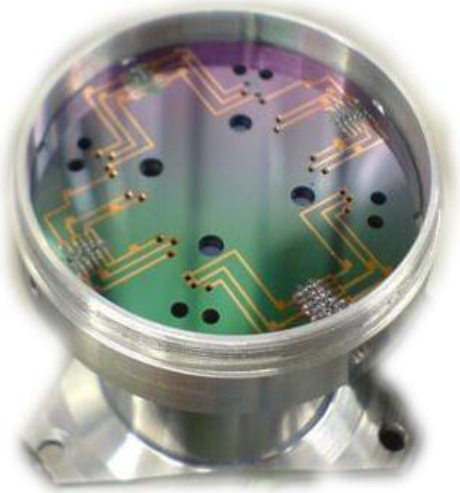
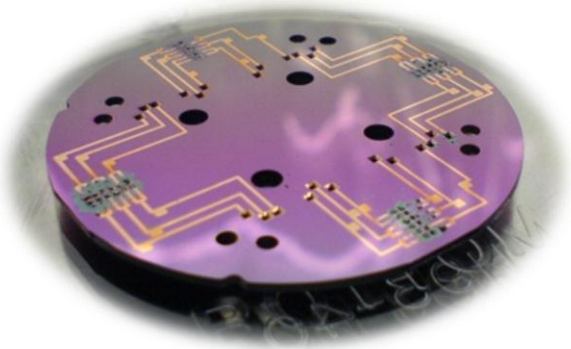
Thruster Pod Assembly – Plenty of MEMS inside

∅= 44 mm (1.73”)
Four thrusters per pod
10 µN – 1 mN
Mass: 115 g





Six-wafer-stack MEMS Thruster Chip

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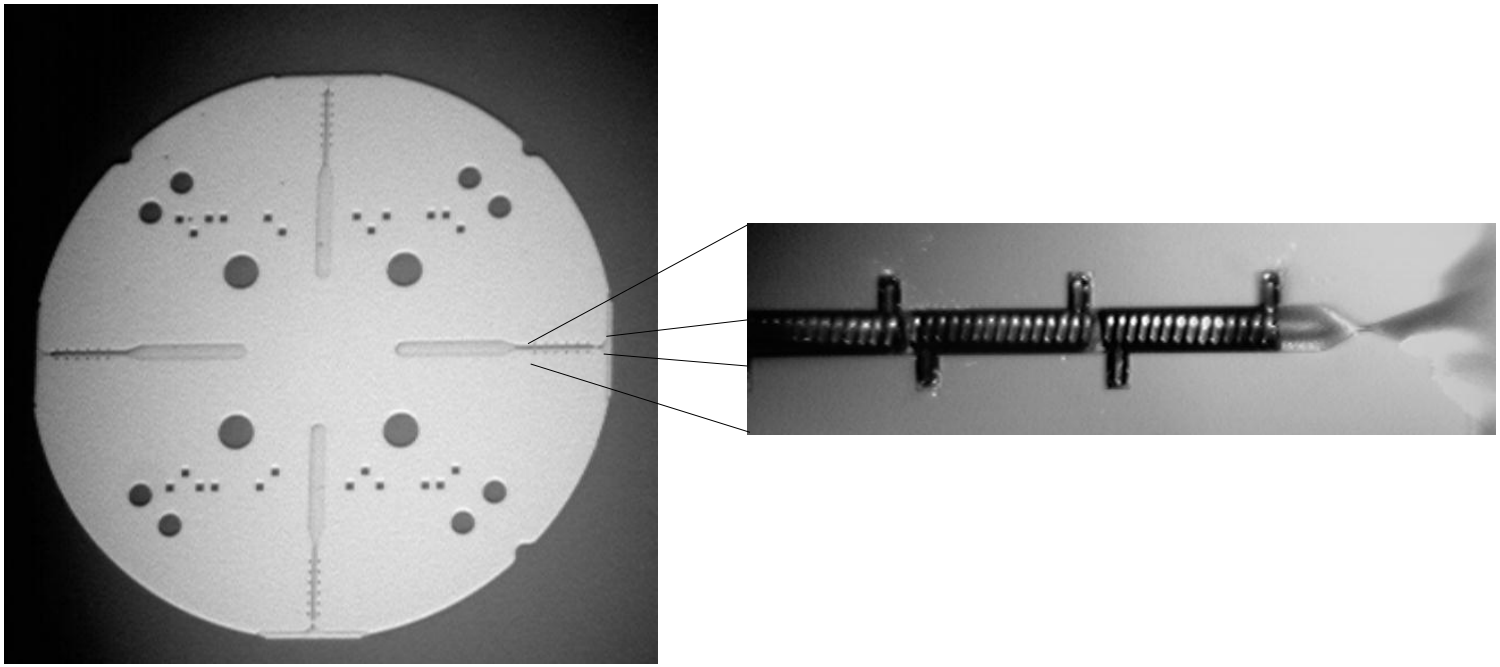
MEMS Thruster Chip - Nozzle package



Nozzles, gas inlets, electrical and fluidic vias, stagnation chambers with internal gas heaters

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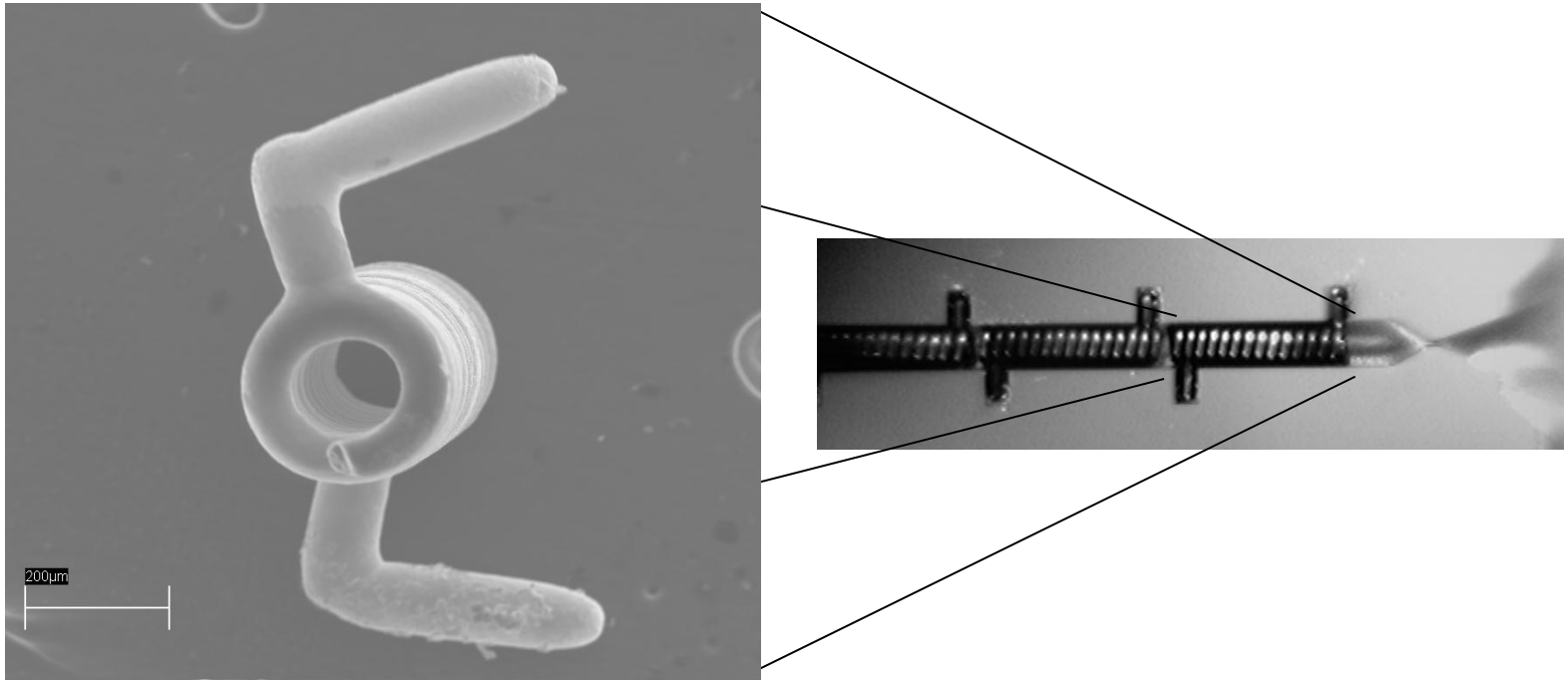
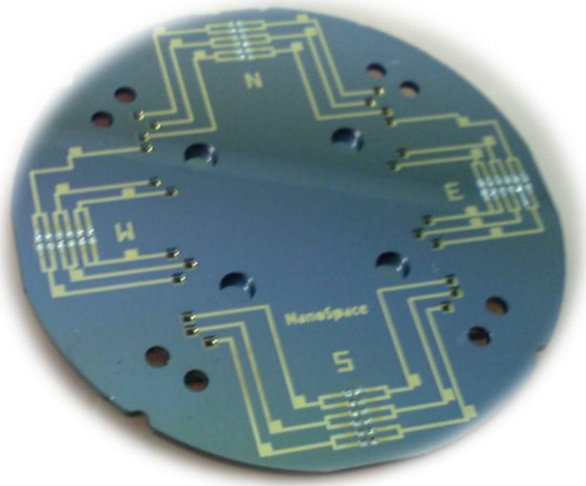
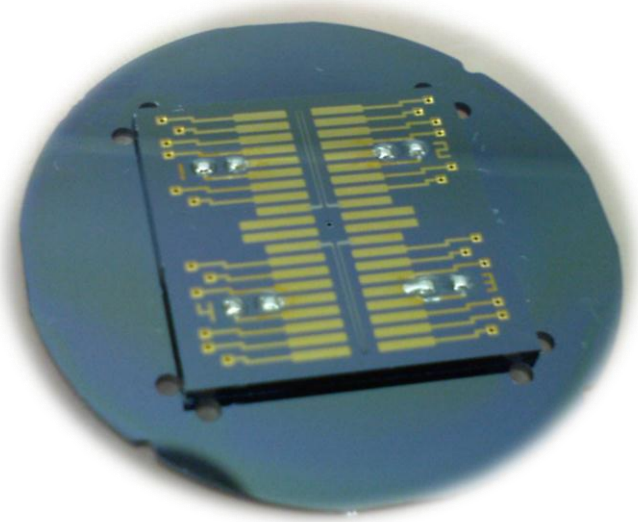
MEMS Thruster Chip - Nozzle package

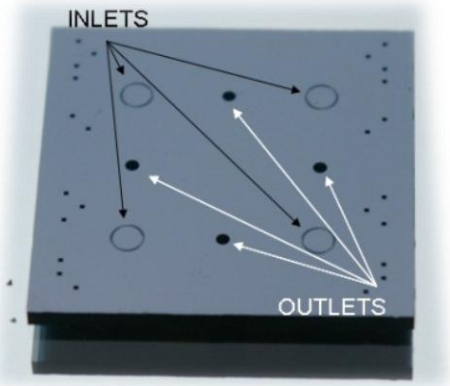


Nozzles, gas inlets, electrical and fluidic vias, stagnation chambers and internal gas heaters

MEMS Thruster Chip – Valve package







- 4 valves/chip
- 2-way, normally-closed
- 0 – 2 mg/s GN2
- MEOP 6 bar (87 psi)
- 22x22 mm (0.9”)
- 1.2 mm thick

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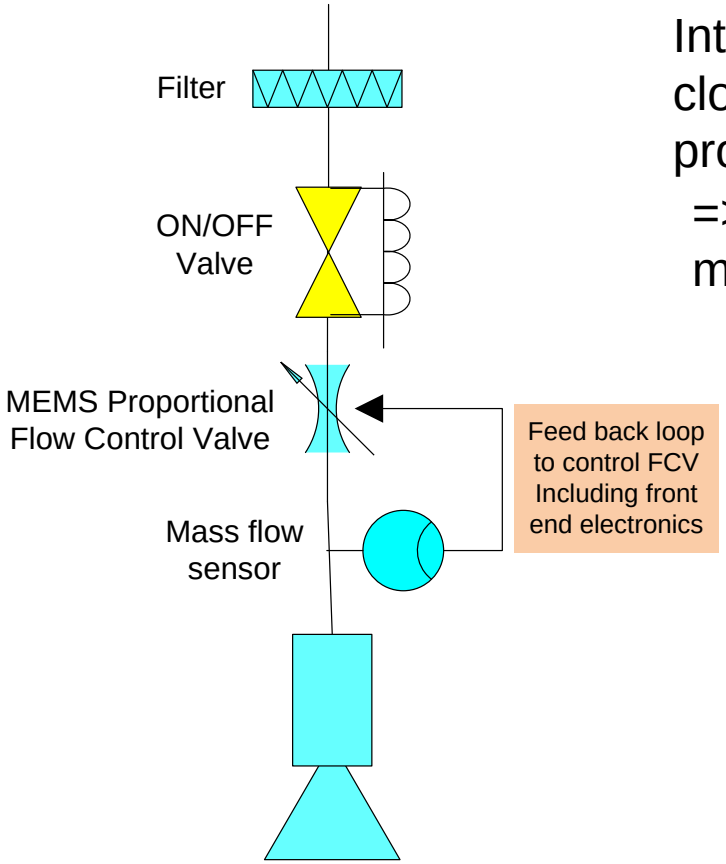
Next generation – Closed-Loop Thrust Control



Integrated mass flow sensor provides closed loop control signal to the proportional flow control valve

=> Unique performance, enabling new mission scenarios

Key component:

Integrated MEMS flow control valve and mass flow sensor

Figure: Schematic view of a complete closed loop control thruster. ON/OFF valve in conventional technology, the rest in MEMS.

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Key capabilities – Like any other

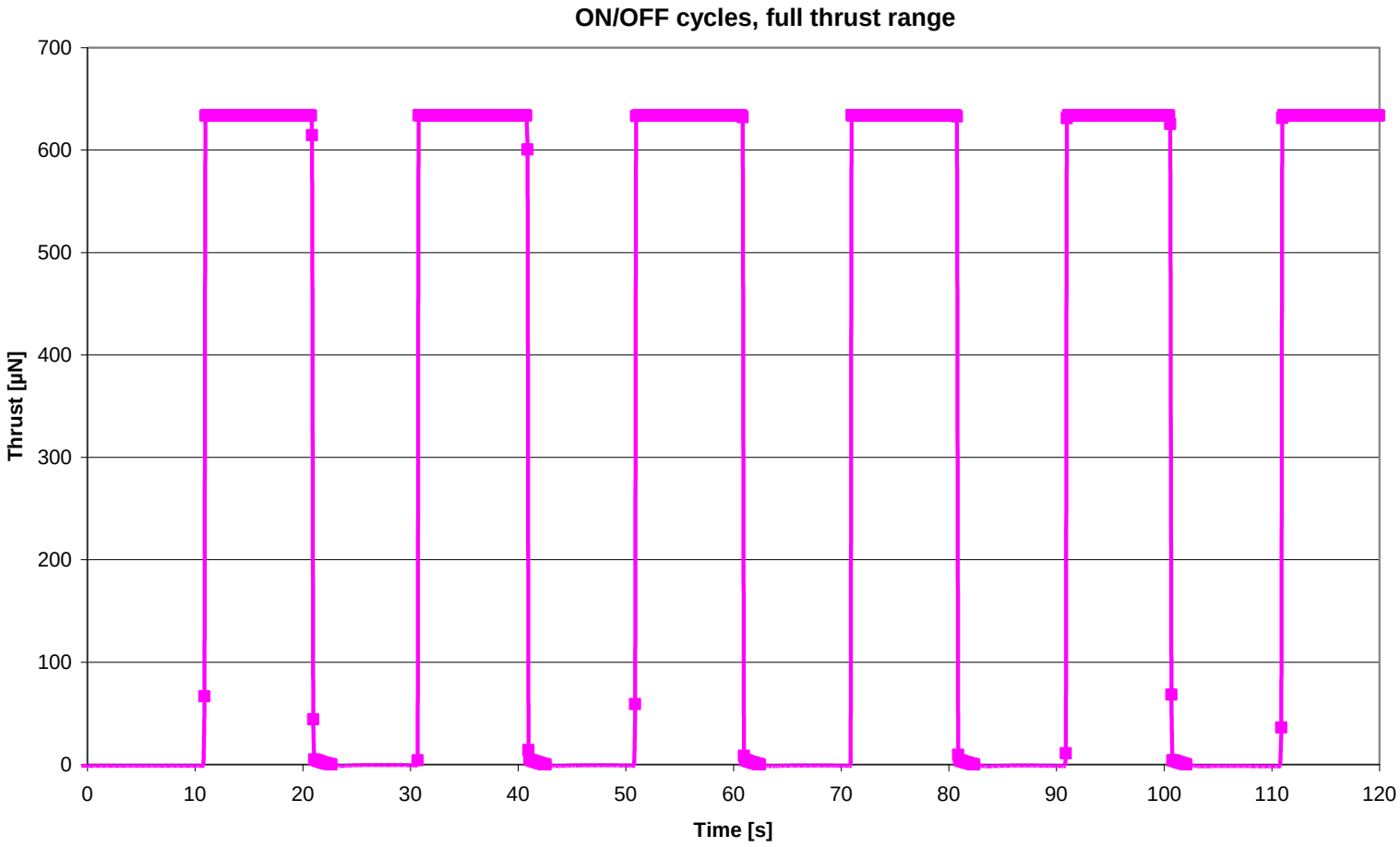

Figure: Test result of MEMS thruster operating in ON/OFF mode (open loop, using solenoid valve only) to show thrust range.
Full thrust can be set in the range **50 micro-Newton** to **5 milli-Newton**

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Key capabilities – Unlike any other

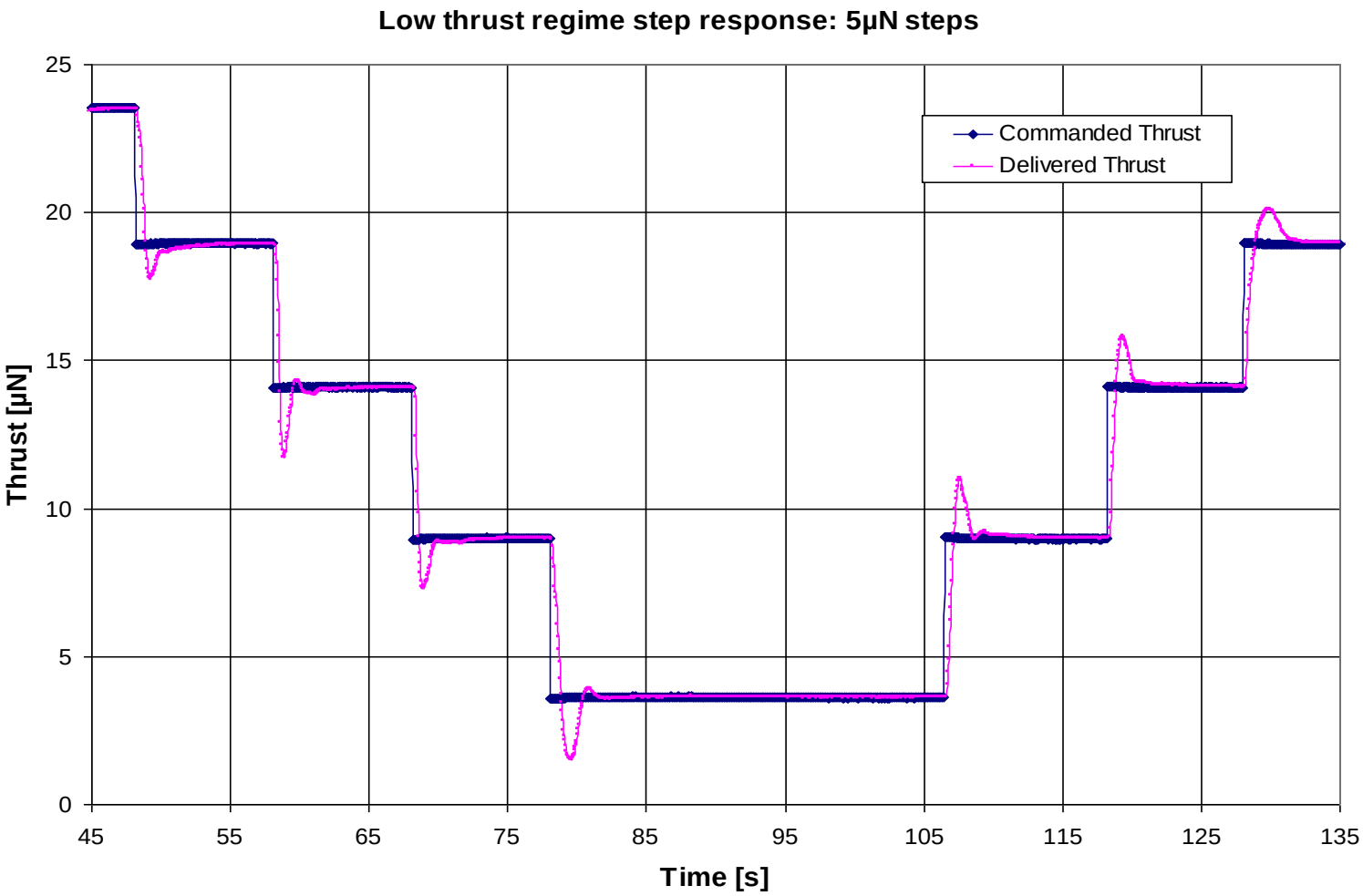

Figure: Test result of a MEMS valve operating in closed loop control mode showing the the thrust response to commanded steps of 5 μN.

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Unique performance

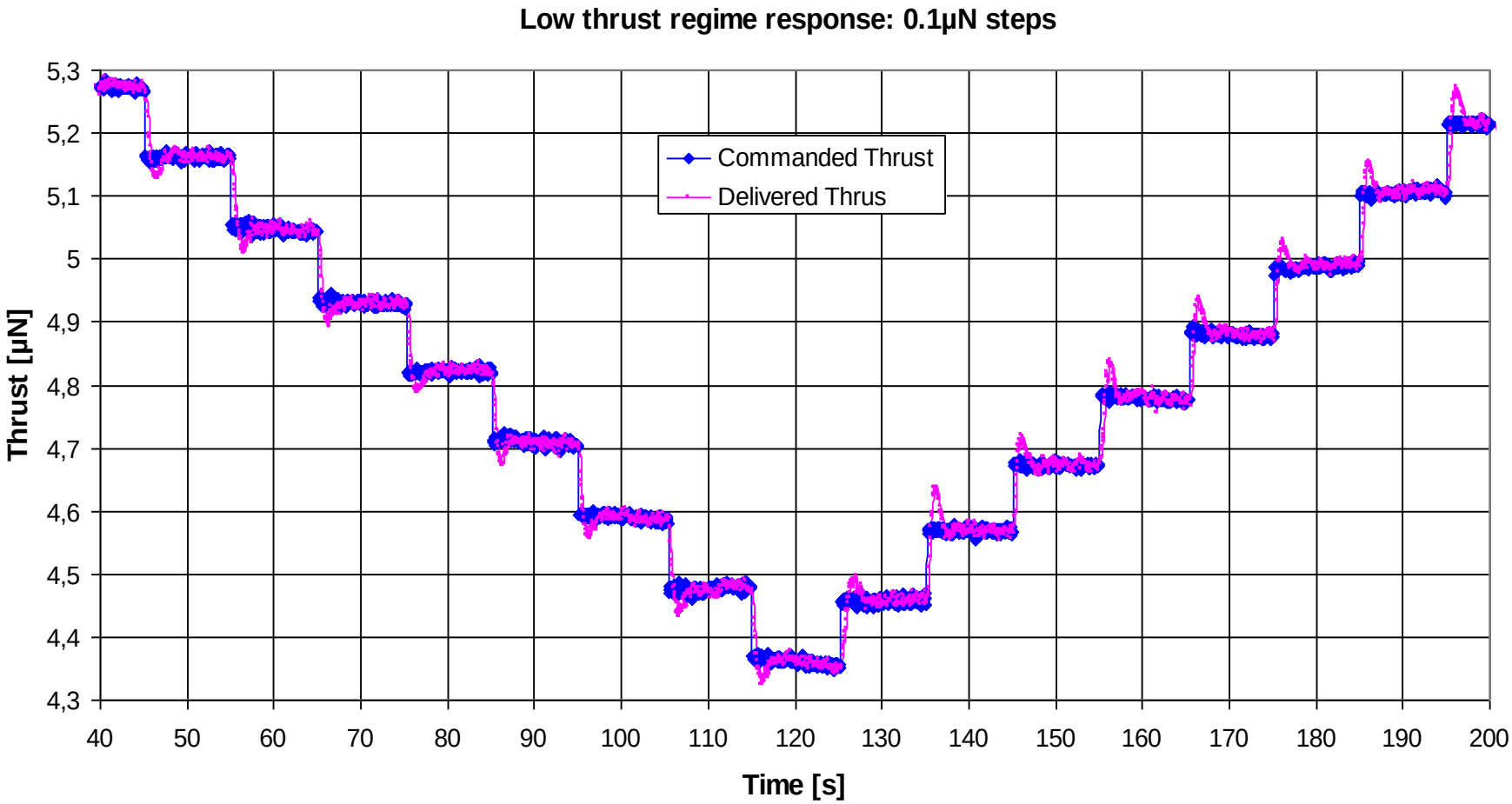

Figure: Test result of a MEMS valve operating in closed loop control mode responding to the commanded steps of 0,1 µN.

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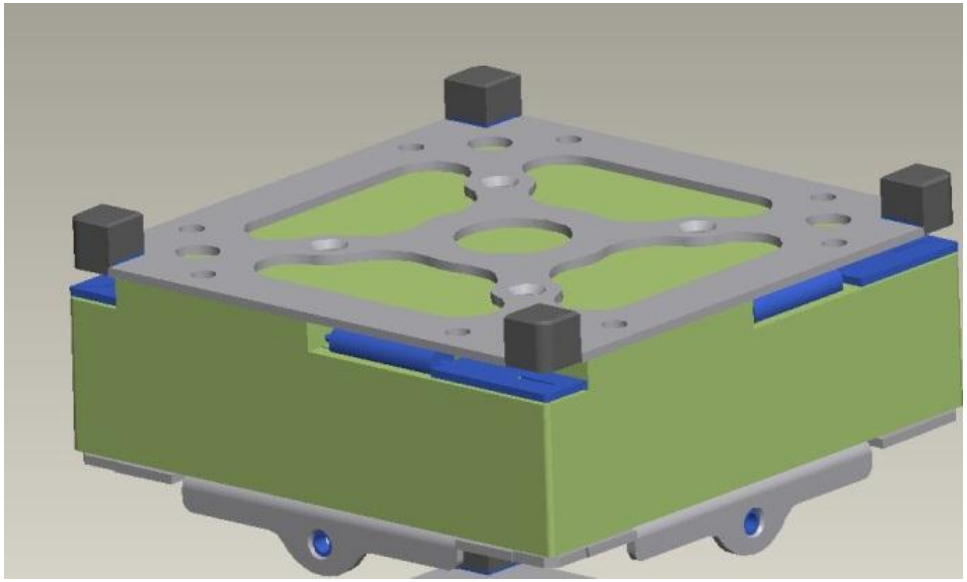
Low Flow Control Module - Mini-Ion engines

Precise control of Xenon flow rate in the range 5 – 50 µg/s (one µN-RIT)

Specification	
Operating media	Xenon
Flow Range	5-50 µg/s
Flow rate resolution	± 0.5 µg/s
Mass	65 g
Power	<1 W
Dimensions	Module: ∅=43 mm Chip: 8x20 mm

MEMS-based Propulsion Module - CubeSat



Requirement	
Thruster config.	4 thrusters
Mass	Dry mass: 130 g Propellant: 70 g
Total Impulse	40 Ns
Propellant	Liq. Buthane
Dimensions	10x10x3 cm

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Concluding Remarks

- We have a number of novel MEMS components
- We want them to be used in space applications
- We realize system aspects, such as integration and interface issues, are crucial
- We need to hear your opinion.
  Please, let us know what you want!

Please, come and visit part of NanoSpace MEMS team at the SSC booth no 47

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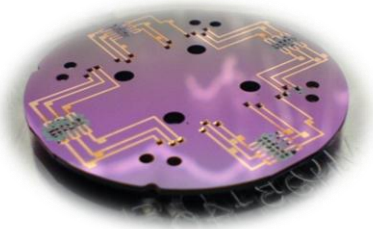
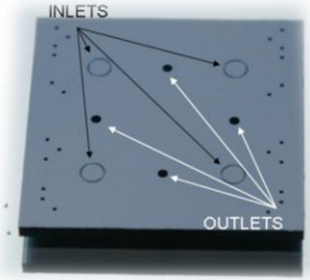
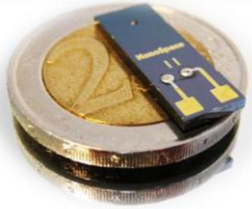
MEMS Micropropulsion Components for Small Spacecraft

Thrusters



Flow Control Valves





Filters

MEMS Isolation Valve

Pressure Relief Valve

Pressure Sensors

Presens A/S
Norway

SSC NANOSPACE