A milli-Newton-level two-stage μCAT-MPD thruster

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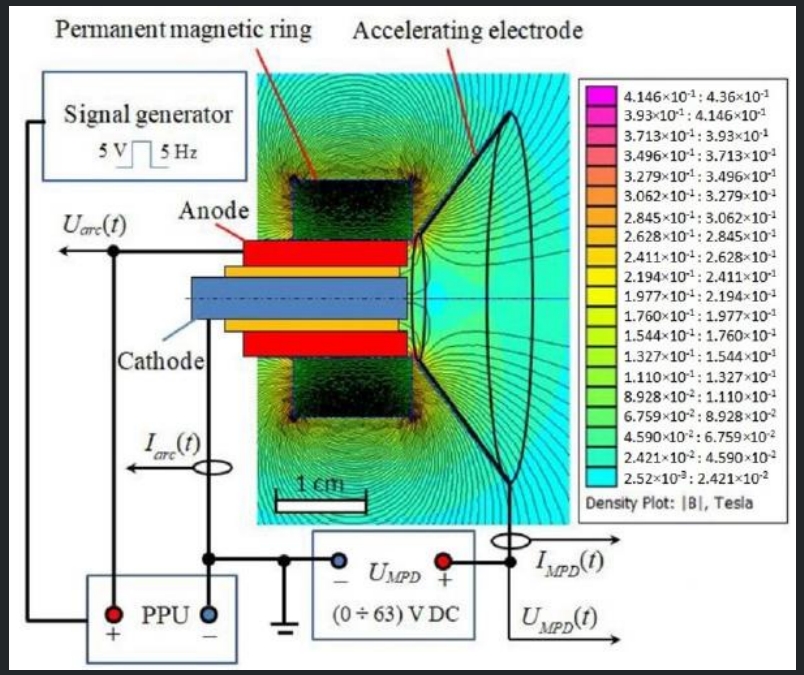
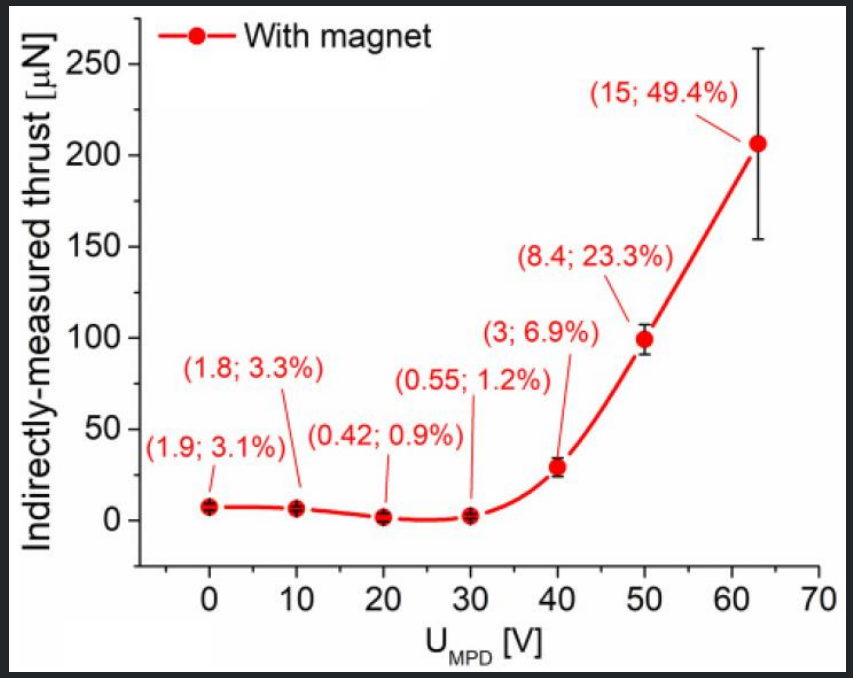
Motivation of the research

- *Previously, by adding a second MPD stage to a single μCAT, we achieved high thrust (~210 μN) together with high TPR (~18 μN/W) and efficiency (up to 50 %)*.*





➢ *The question is: can we reach much higher thrust values (up to milli-Newton range), and what will be the thruster performance in this range?*

*D.B. Zolotukhin et al, *Physical Review E* (2020) Vol. 102(2), p. 021203

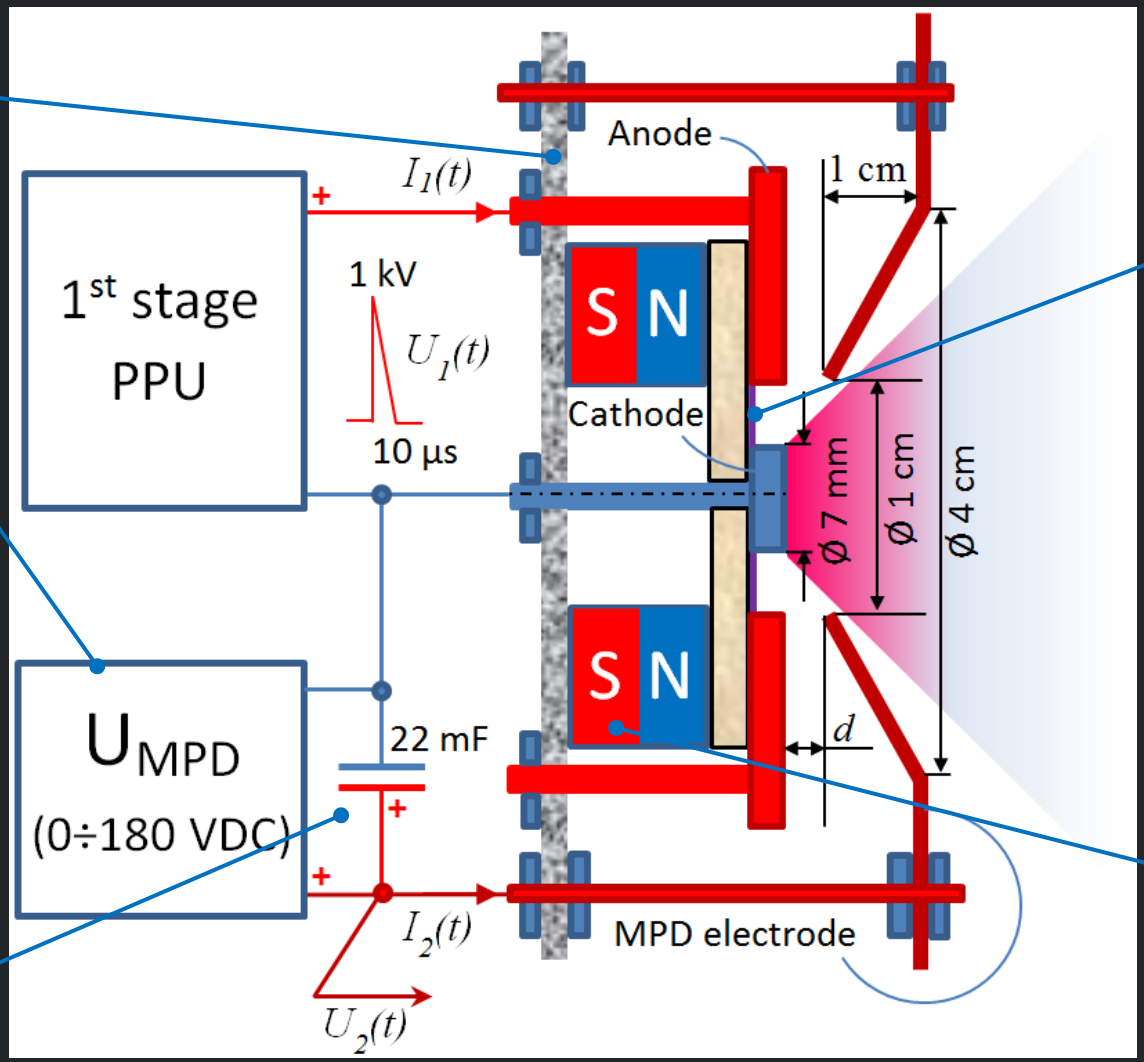
A milli-Newton-level thruster configuration

- *To answer this question, we designed a new, more powerful version of the thruster, with the following features:*

Light-weight planar construction: can be placed on thrust stand arm

Second-stage voltage U_{MPD} is lifted up to 180 V to supply high power

Huge capacitor in second-stage circuit ensures the stable voltage level during high-current discharge in the 2nd stage



Lifetime improvement:
*Planar electrodes are always pressed => constant electrical contact

*Ceramic washer is coated by multi-layer thermo-barrier (B-Cu) thin film. The film protects ceramic from thermal cracking.

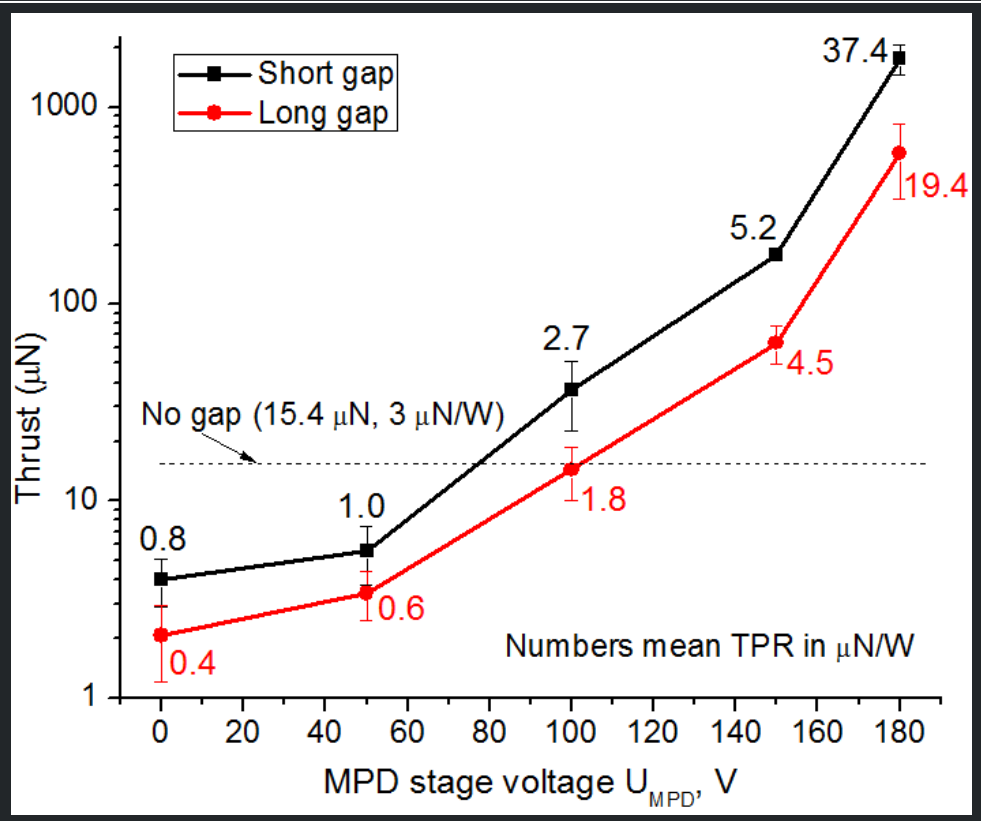
* Anode-Cathode gap is optimized for the high power

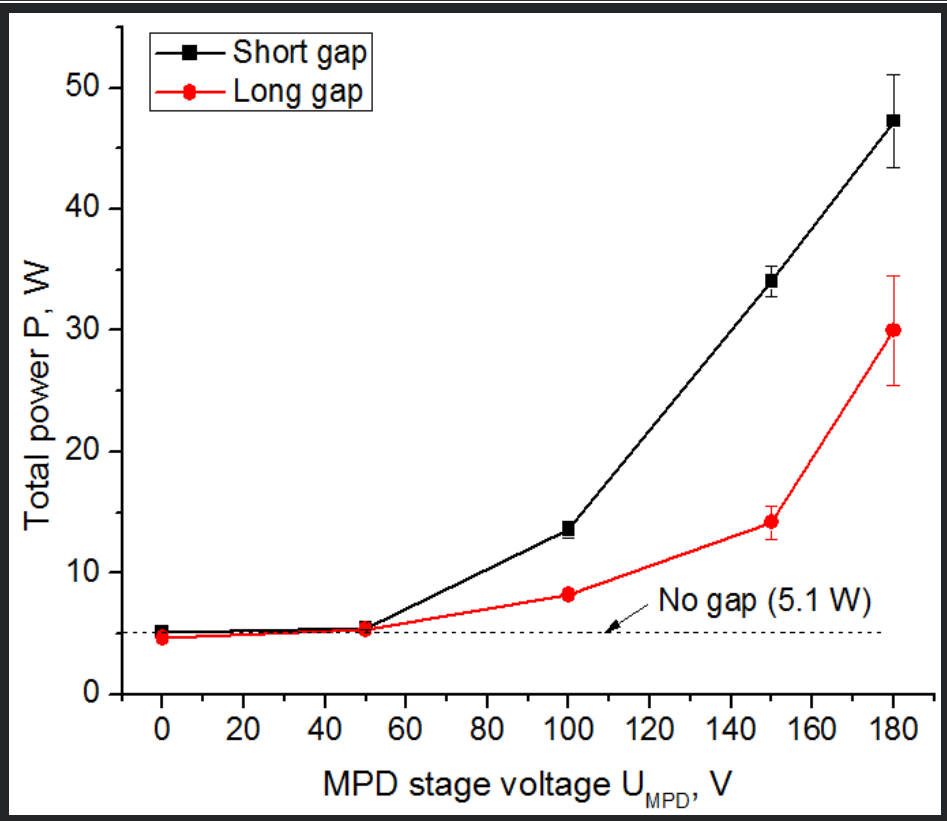
Magnet overheating is minimized by:

*placing the magnet behind the thermally-insulating ceramic washer, screening the magnet from the heating by the discharge.

*No touching of magnet with current-conducting electrodes

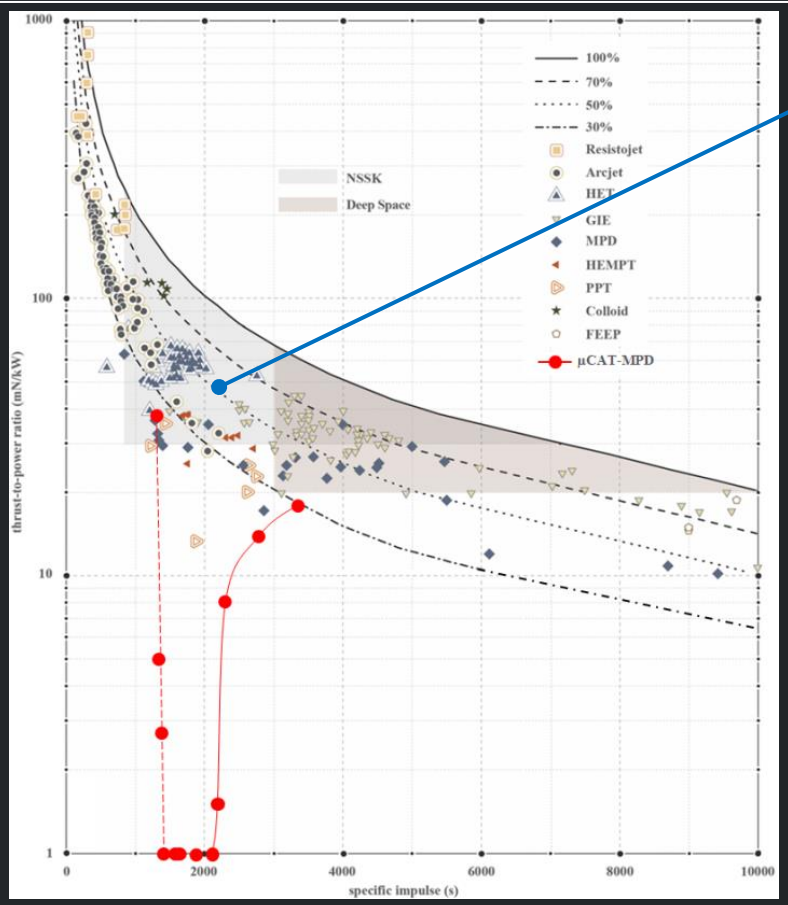
Results: thrust, TPR and power versus second-stage voltage



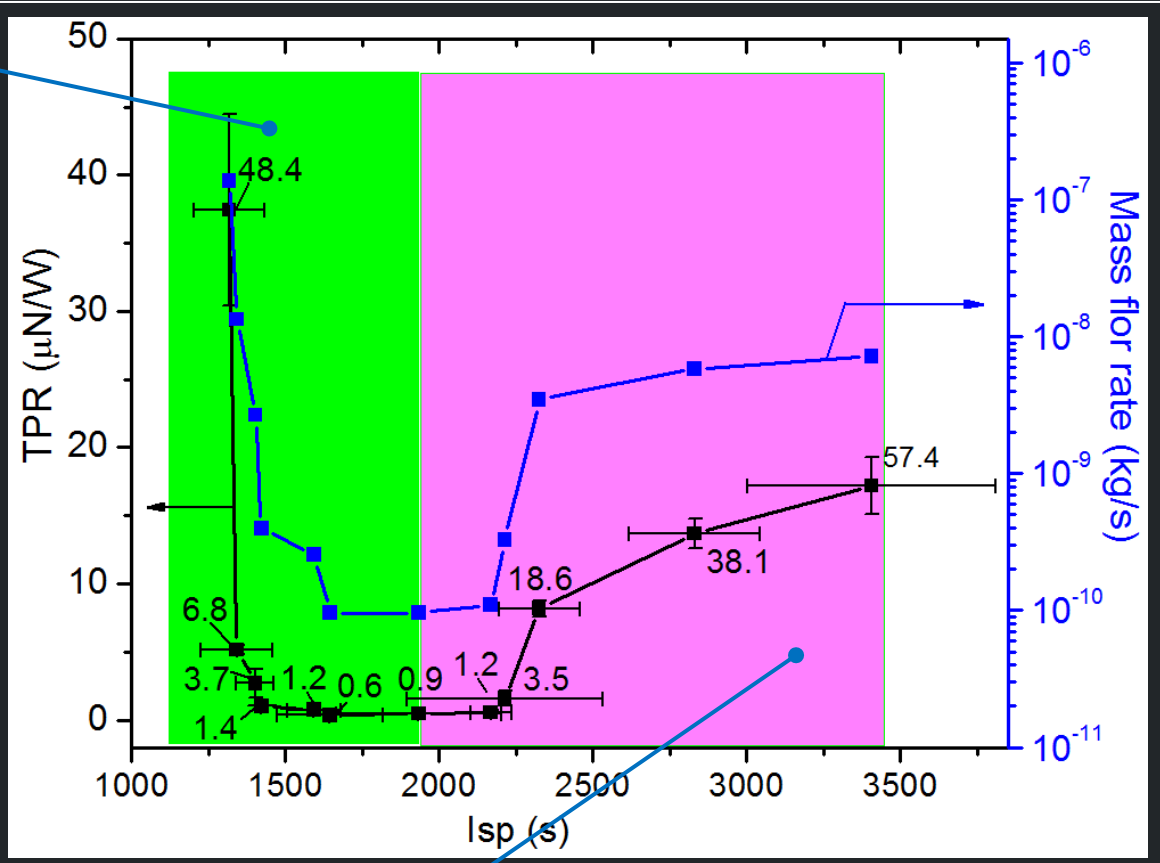


- New thruster is able to generate thrust of milli-Newton level (1.7 mN) with higher TPR (37.4 μN/W) and efficiency of 48.4 %.
- Optimal gap between 1st and 2nd stages exists: higher gaps results in decrease of thrust, TPR and efficiency level, no gap deteriorates thruster performance without any ability to control it.
- Total power dissipating in both stages remains below 50 W which means moderate requirements for cooling and electric power-supplying systems

Results: two modalities in 'TPR versus I_{sp}' trends



'Traditional': falling "TPR vs. Isp" trend



'Unusual' trend: TPR grows with Isp

*K. Holste et al, *RSI* (2020) 91, p. 061101

- For μCAT-MPD thruster, two modalities (falling and growing) of 'TPR vs. I_{sp}' trend is possible.
- High thrust values are achieved thanks to high mass flow rate, but not due to very high ion velocities.

Concluding remarks

- A newly-designed configuration of μCAT-MPD thruster achieved superior combination of performance parameters: thrust (up to 1.7 mN), together with TPR (up to 37 μN/W) and efficiency (up to 57 %) at moderate power (below than 50 W).

- Advantages of the vacuum arc physics (almost 100% degree of ionization in vacuum arc plasmas, almost infinite emission of charged particles from cathodic spot), speaks for even higher possible values of performance parameters that may be achieved with the future progress of μCAT technology

Acknowledgments

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