

MEMS Infinity – MULTIPLE USE MEMS ADAPTER TO MEASURE FIELD EMISSION IN VACUUM ENVIRONMENT

Igor Czerwiec*, Gracjan Malinowski, Michał Krysztof

*277680@student.pwr.edu.pl

Wrocław University of Science and Technology, Faculty of Electronics, Photonics and Microsystems, Department of Microsystems

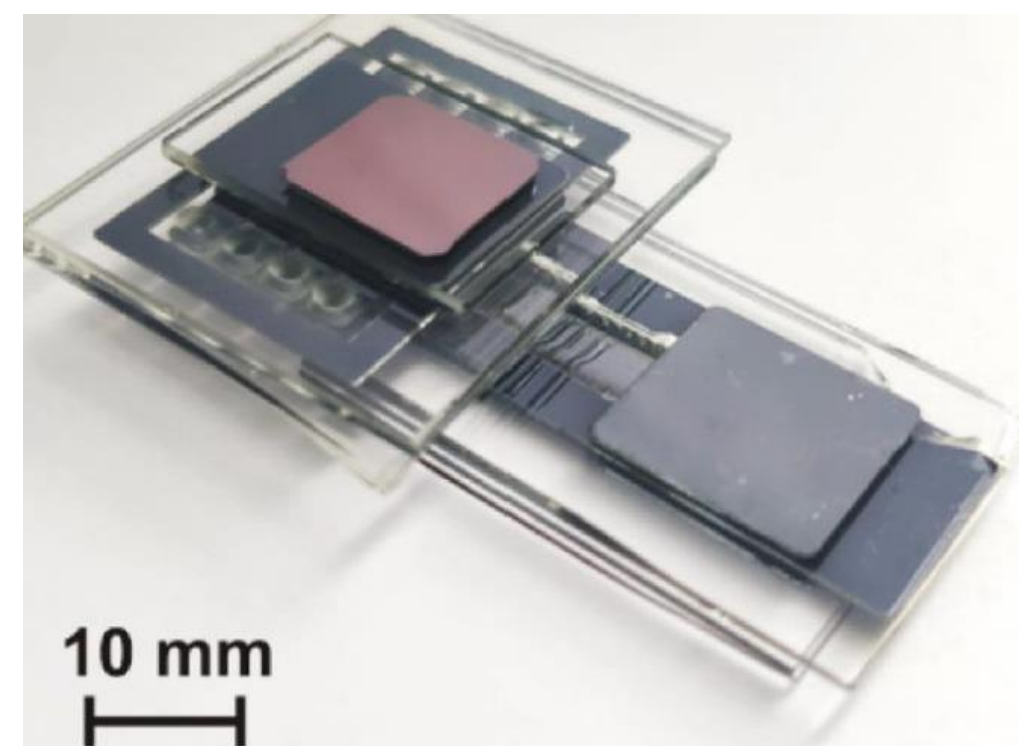
Abstract. Usually, during the development stage the MEMS electron beam systems and parts of the systems, e.g. electron emitters, are tested in vacuum chambers. However, to test the final device, all technological processes needed to be performed, including anodic bonding of the whole structure to ensure vacuum sealing of the device. This process is difficult and sometimes leakages are encountered, so the final device cannot be tested. Moreover, the anodic bonding is final, so there cannot be any changes in the structure of the device. In this work, we present our solution of a MEMS structure with a vacuum adapter and a valve that can be placed on a desk to do easier measurements and tests, e.g., field emitters in the setup of a final device. We called it MEMS Infinity because it is a compact sized portable adapter, which can be reusable, and allows carrying out tests on manufactured silicon field emitters.

Introduction

- At WUST we manufacture High Vacuum MEMS devices such as MEMS SEM or MEMS x-ray source.
- Tests of MEMS devices are usually run in vacuum chambers inside laboratory.



MEMS x-ray source [1]



MEMS SEM [2]

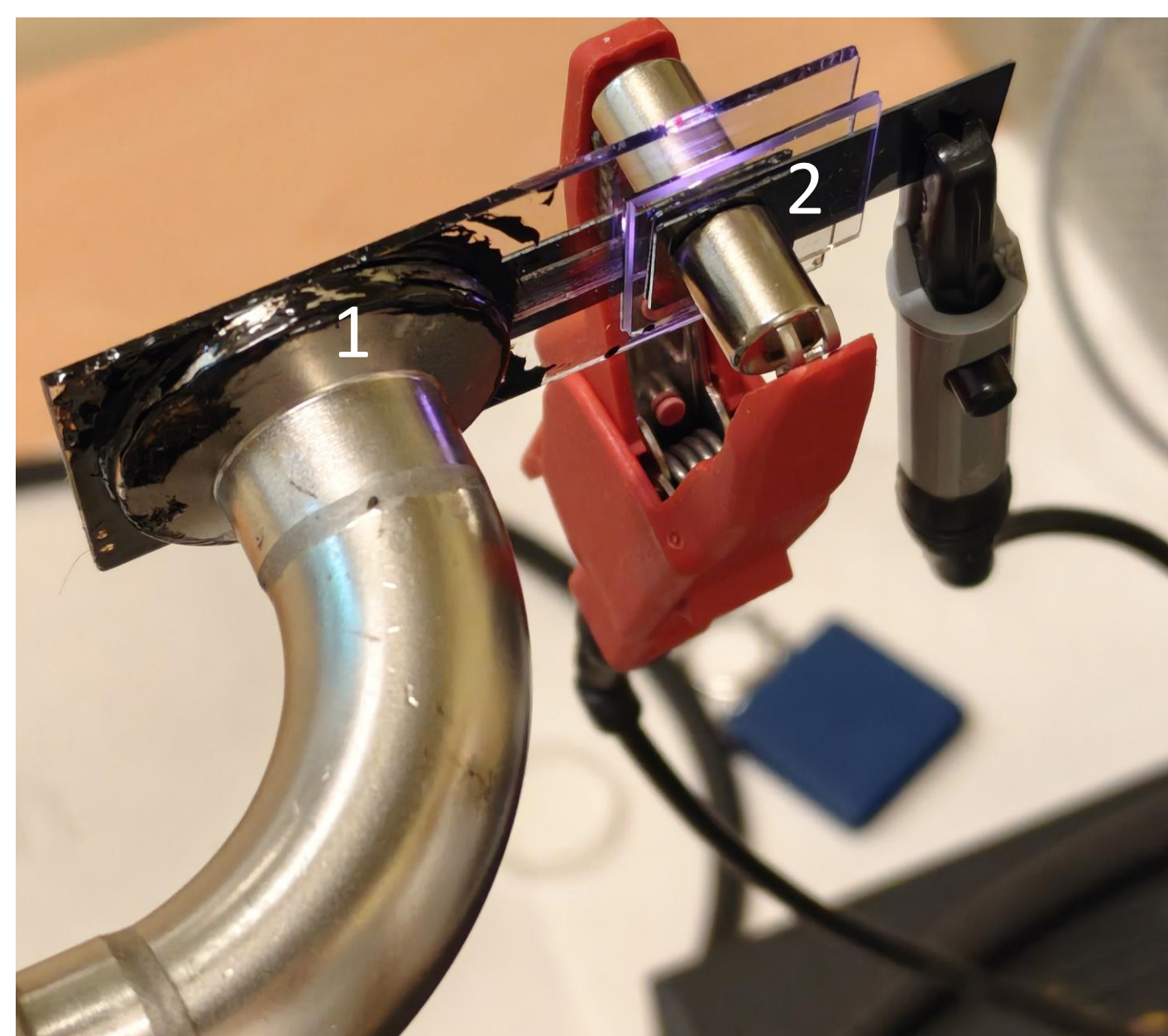
Technology

MEMS Infinity consists of 2 main parts:

- U-bend sealed with vacuum wax with glass channel.
- Micropump powered with high voltage.

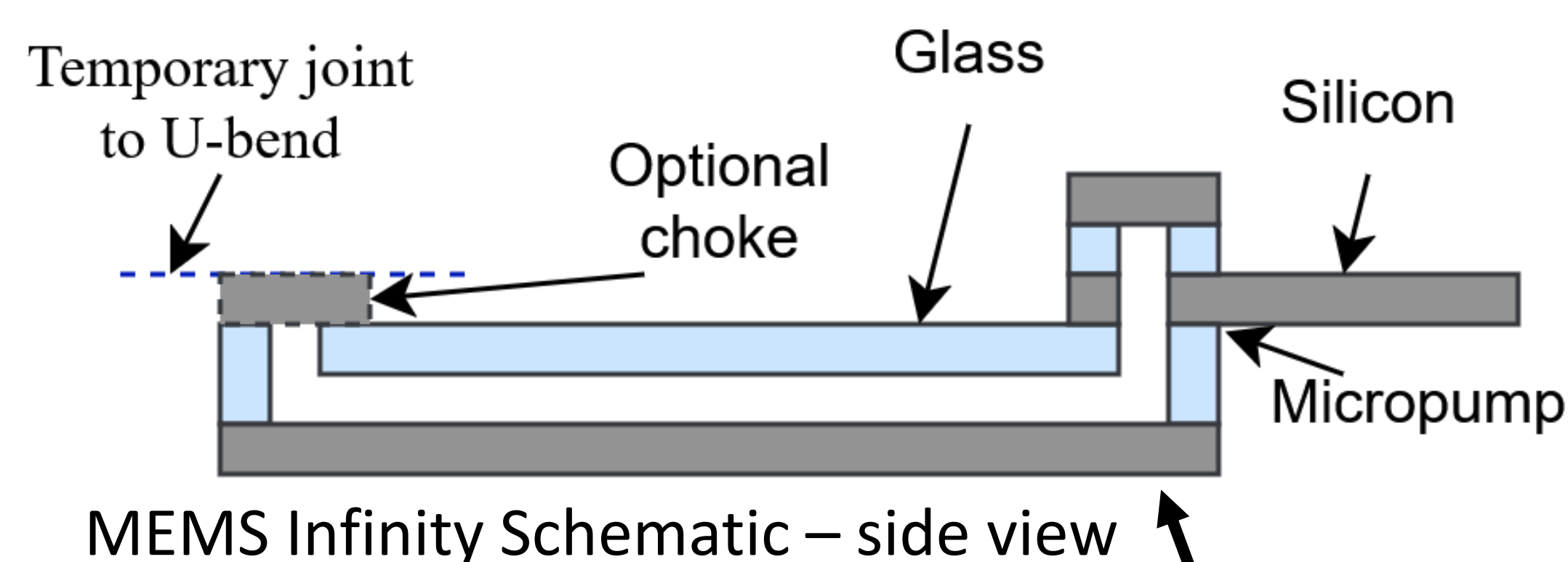
Processes used in making of MEMS Infinity:

- Wafer oxidation.
- Photolithography.
- Oxide removal in Buffered Oxide Etch.
- Wet Etching in Potassium hydroxide.
- Hydrophilization in diluted hydrogen peroxide.
- Anodic bonding.

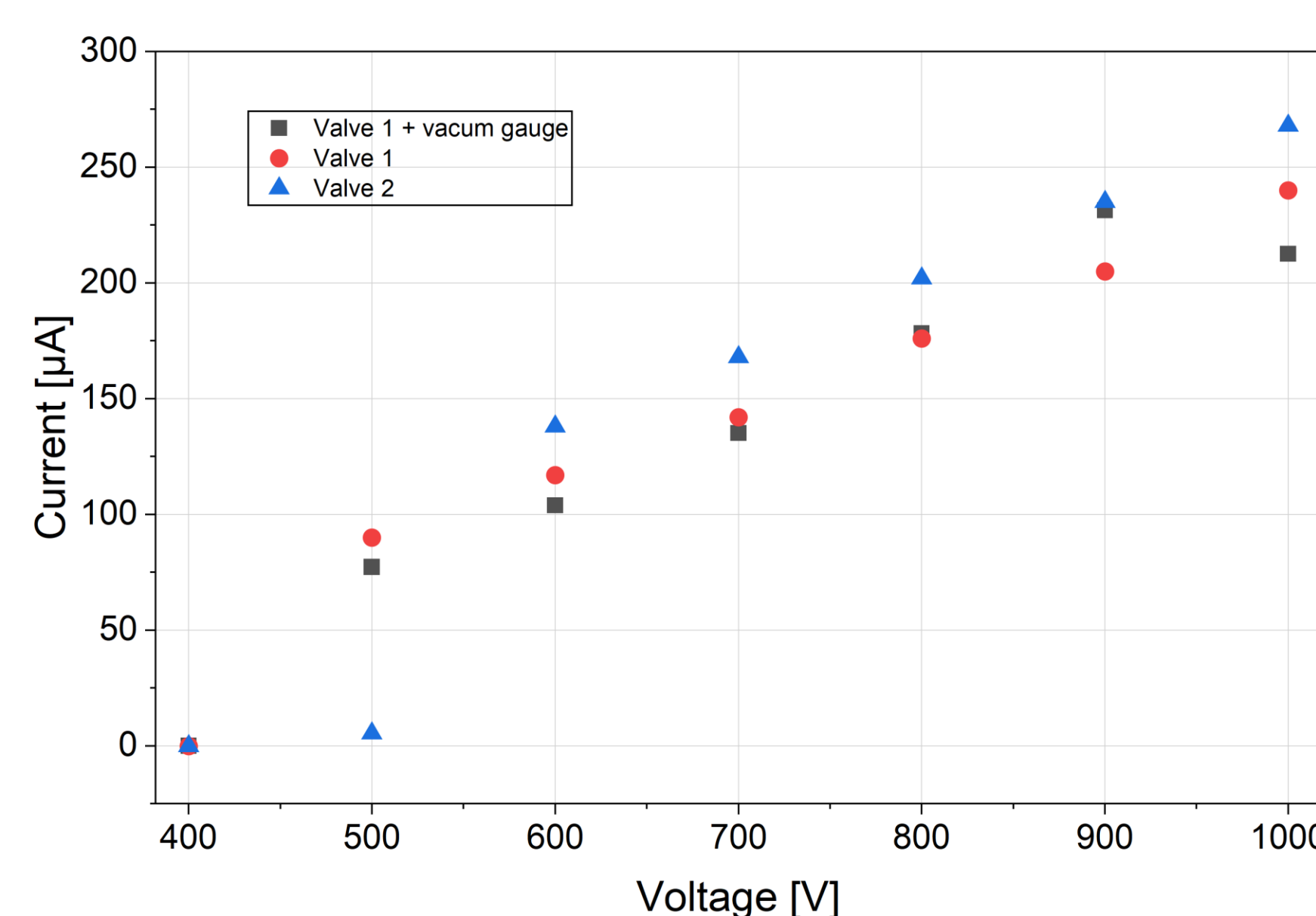


The idea behind MEMS Infinity

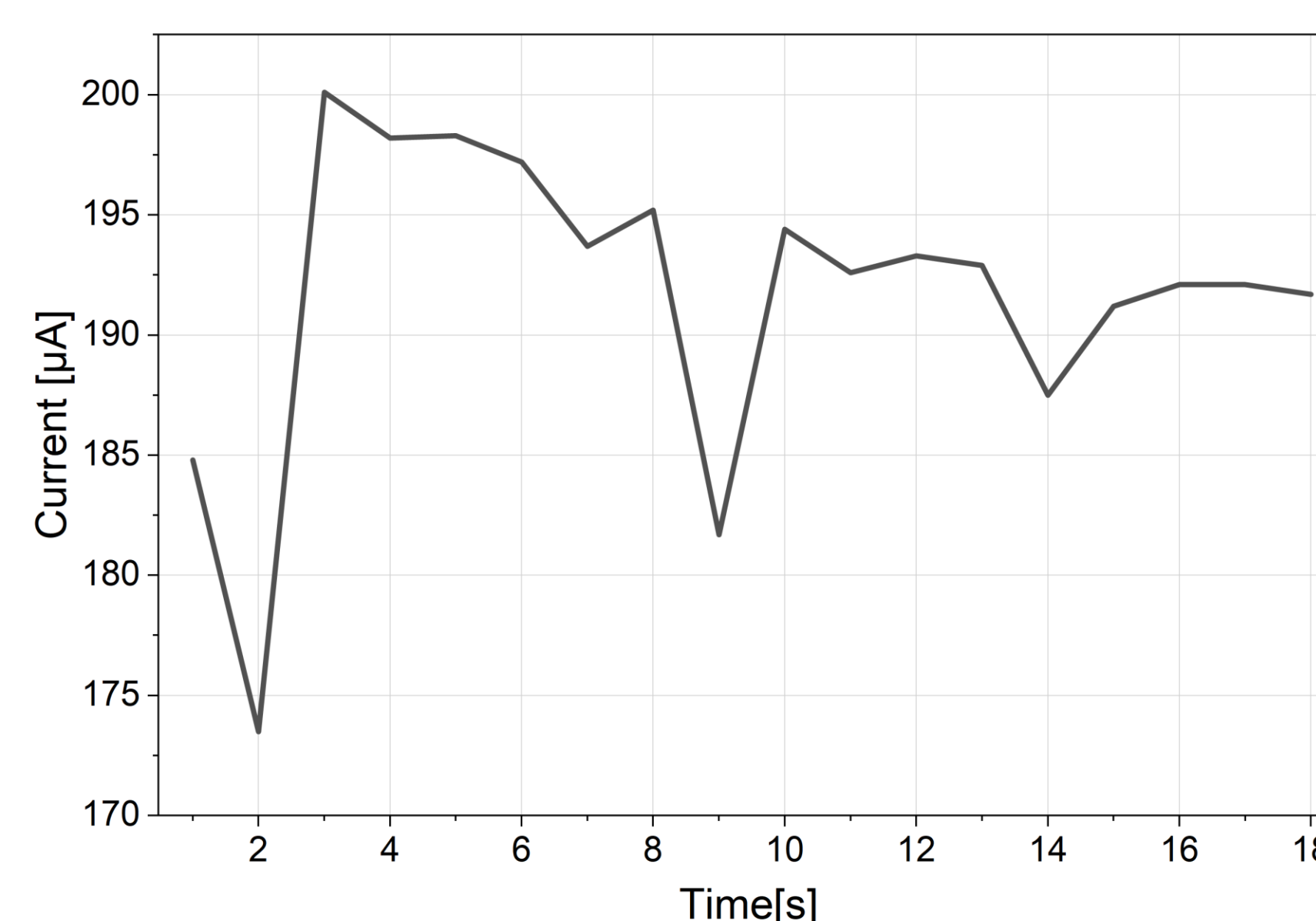
- Difficulty of conducting measurements with high vacuum MEMS devices.
- The concept of MEMS Infinity – Bring measurements outside of vacuum chamber onto your desk.
- No large vacuum chambers, easy access, ability to do measurements and demonstrations on the go.



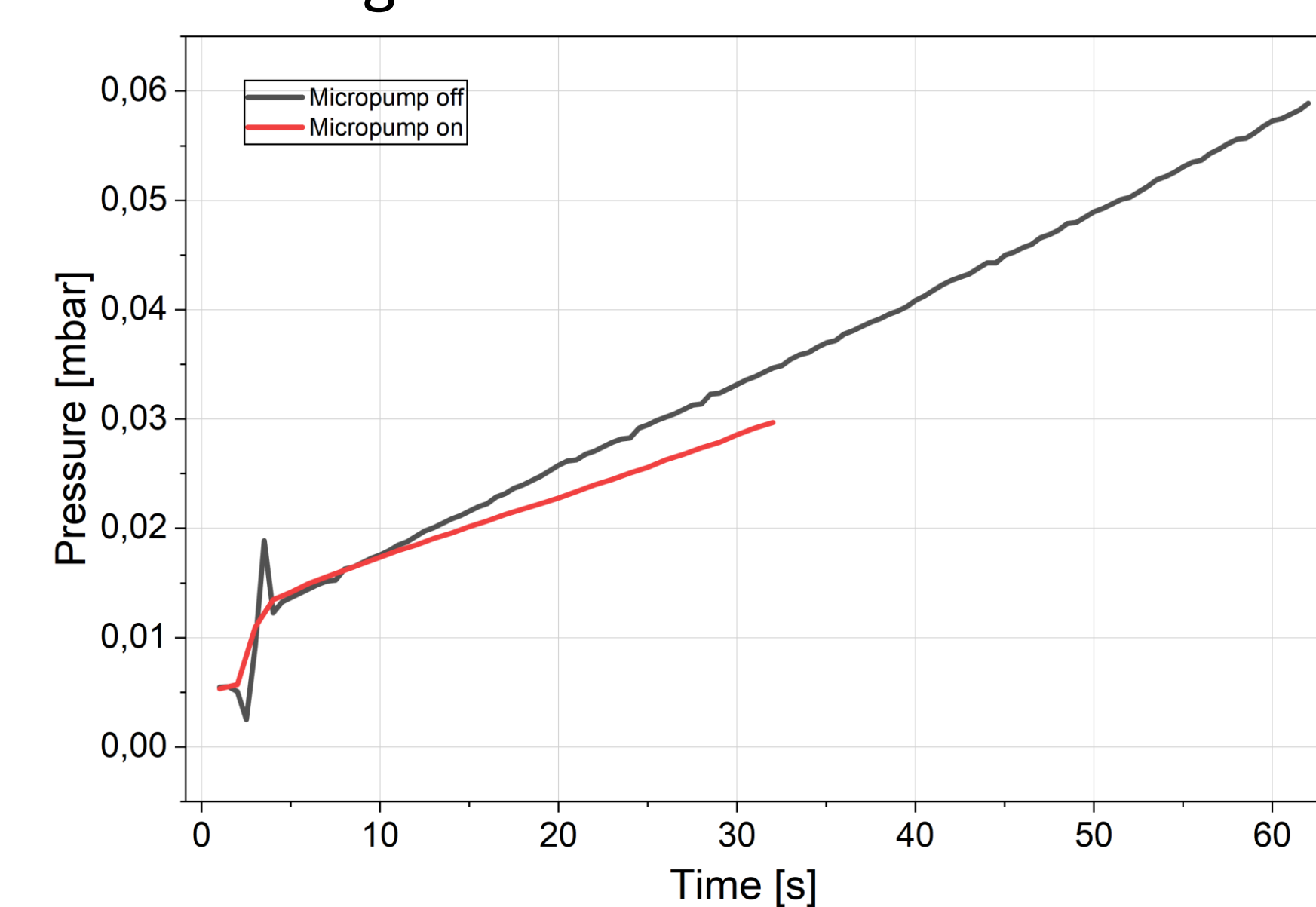
Test of micropump with different volumes of chambers



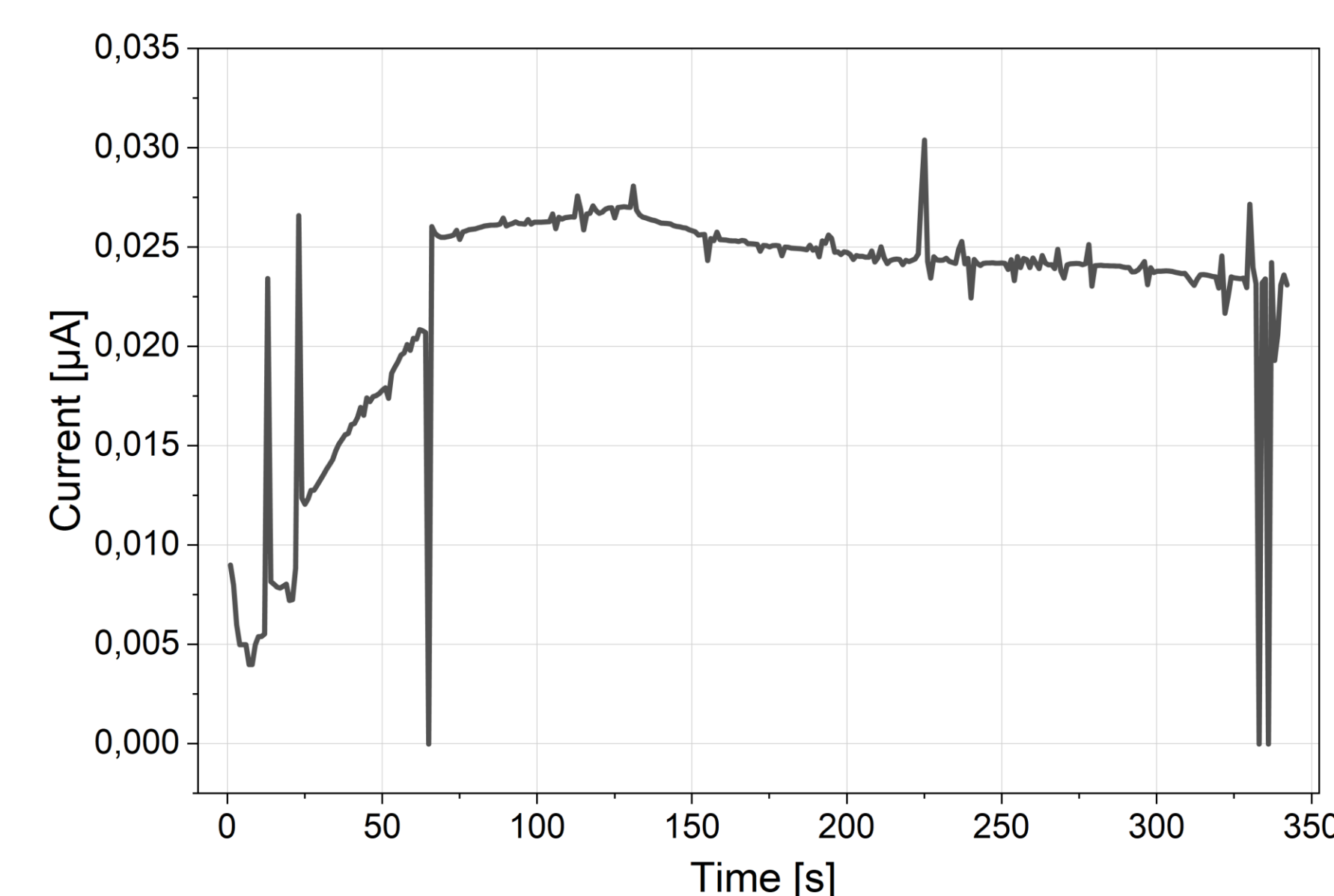
Micropump current through time before closing the valve



Outgassing of MEMS Infinity through time

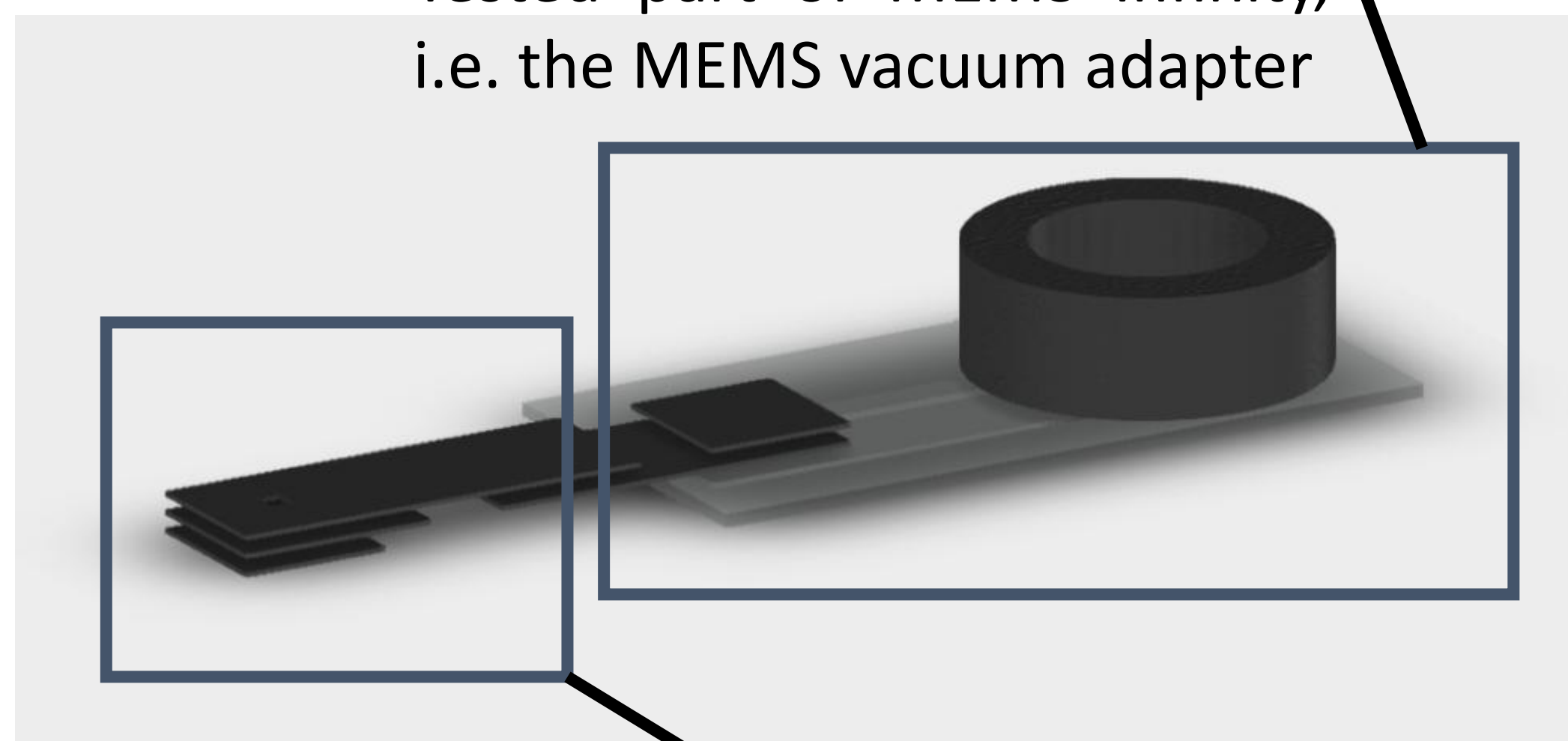


Micropump current through time after closing the valve



MEMS Infinity drawing

Tested part of MEMS Infinity, i.e. the MEMS vacuum adapter



Additional MEMS structure of tested device, i.e. emitter with extraction electrode and anode

Bibliography

- [1] M. Krysztof, P. Urbański, T. Grzebyk, M. Hausladen and R. Schreiner, "MEMS X-Ray Source: Electron Emitter Development," 2022 21st International Conference on Micro and Nanotechnology for Power Generation and Energy Conversion Applications (PowerMEMS), Salt Lake City, UT, USA, 2022, pp. 248-251, doi: 10.1109/PowerMEMS56853.2022.10007563.
- [2] M. Biały, T. Grzebyk, M. Krysztof, A. Górecka-Drzazga, Signal detection and imaging methods for MEMS electron microscope, Ultramicroscopy, Volume 244, 2023, 113653, <https://doi.org/10.1016/j.ultramic.2022.113653>.

Summary

MEMS Infinity project proved that concept of having MEMS device tested on your desk is possible due to leak proofness and viable to pursue. However, one micropump without any choke like a silicon membrane with microchannel is not sufficient to pump out remaining gasses that emerge after initial vacuum was created with a rotary vacuum pump, unlike second MEMS structure with a choke which yielded great results, micropump was able to create vacuum, which is showed in current dropping from hundreds of μA to dozens of nA. In the future we hope to test field emission using MEMS infinity.