

# Modular 3D-Printed MEMS Platform for a Field Emission Scanning Electron Microscope

Janusz Rozum\*, Damian Opiela, Michał Krysztof

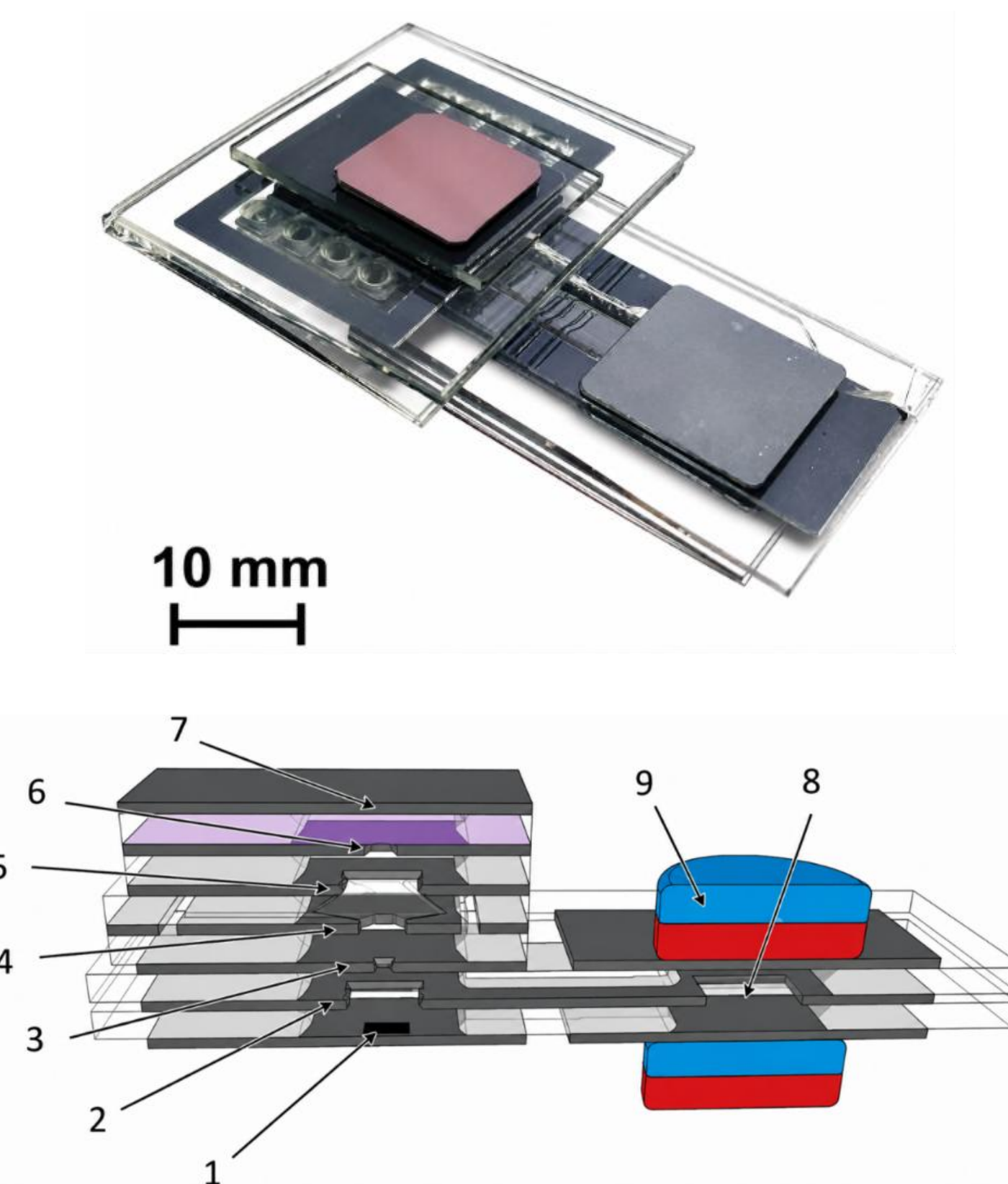
\*278017@student.pwr.edu.pl

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

A modular 3D-printed vacuum platform is proposed for testing MEMS electron-optical components. The architecture enables precise alignment and exchange of field emitters, electrodes, and octupole systems, providing a flexible approach for the development of miniaturized electron devices. Its reconfigurable design enables rapid prototyping and iterative optimization prior to final device integration. A dedicated PCB connection board supports quick and reliable connection from power supplies to silicon electrodes.

## Introduction

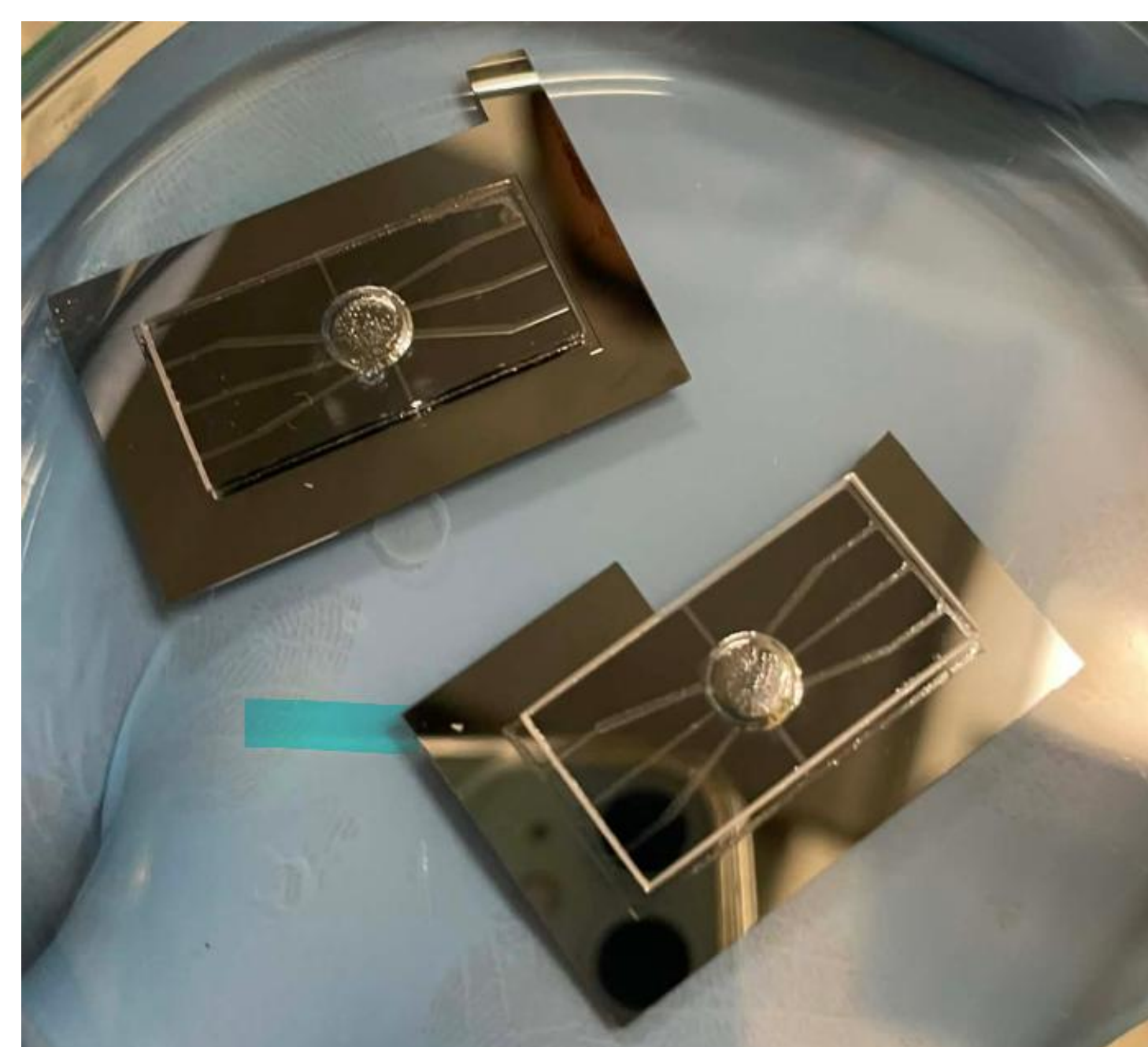
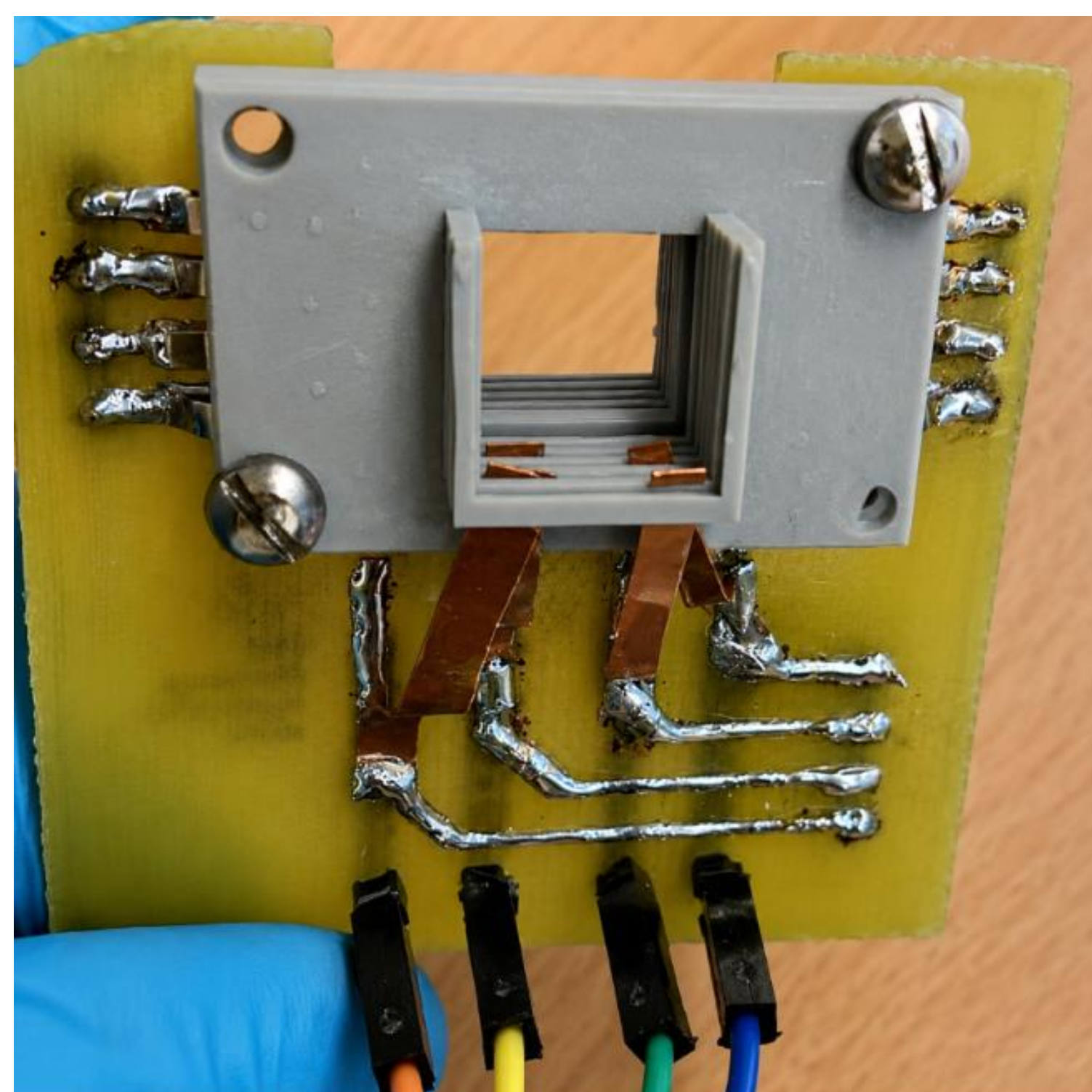
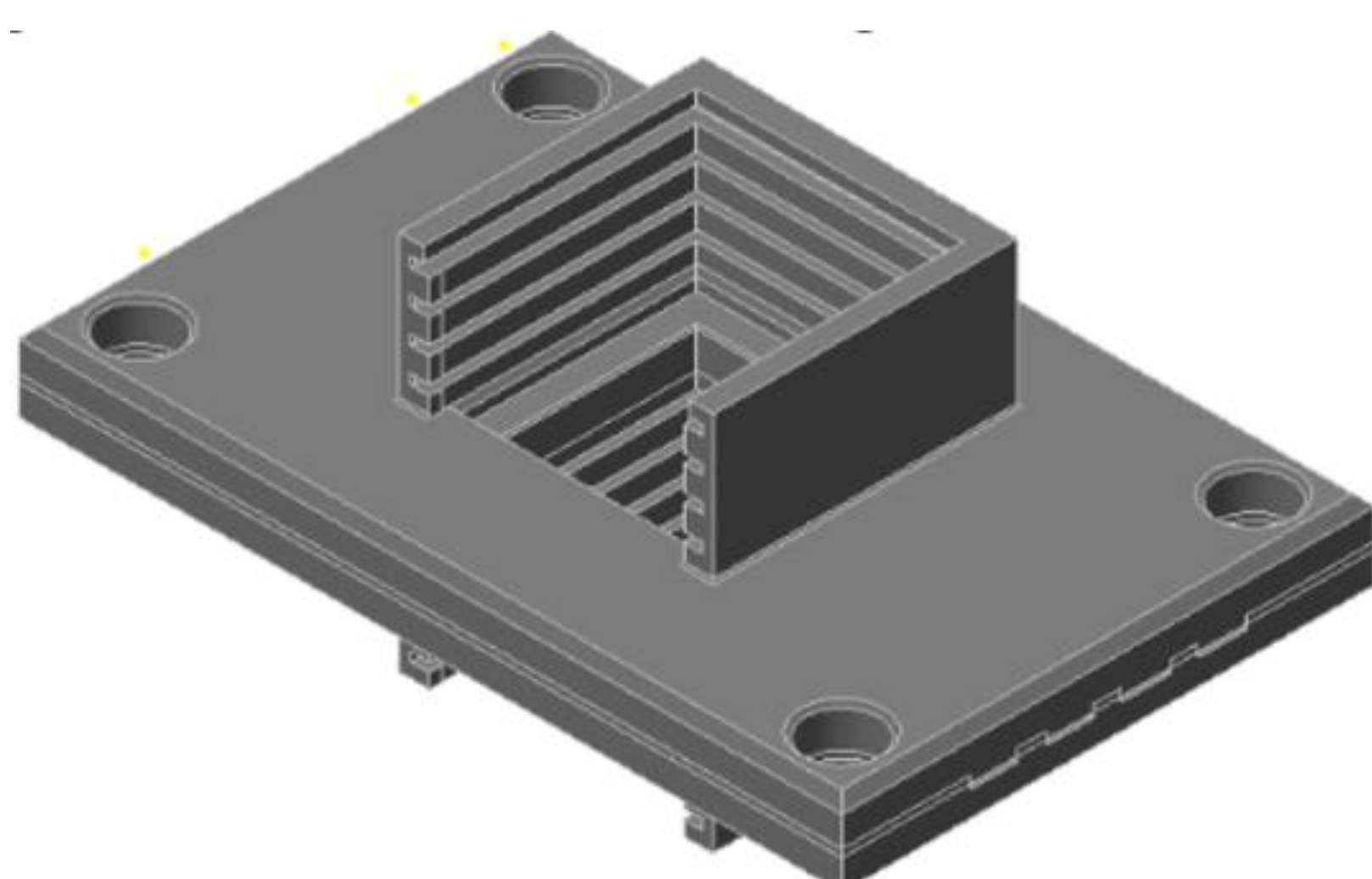
The development of MEMS scanning electron microscopes [1] is challenging by the complexity of the electron-optical system, the need for multiple electrical interconnections, and the limitations of irreversible anodic bonding [2]. This work presents a modular platform that enables reliable electrical interconnections and iterative testing before final bonding, thereby reducing fabrication risk, improving design flexibility, and facilitating efficient system development.



## Device fabrication

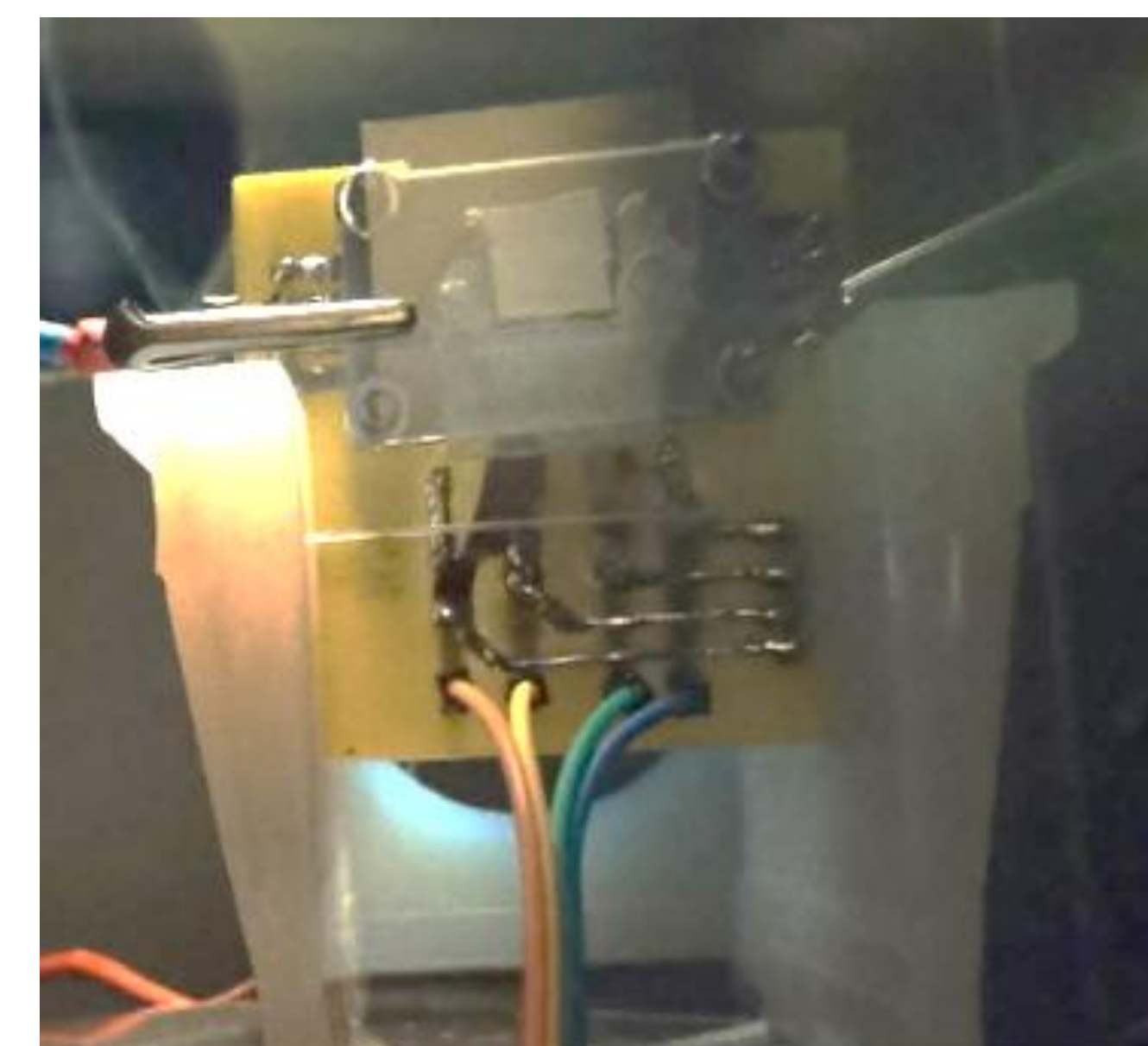
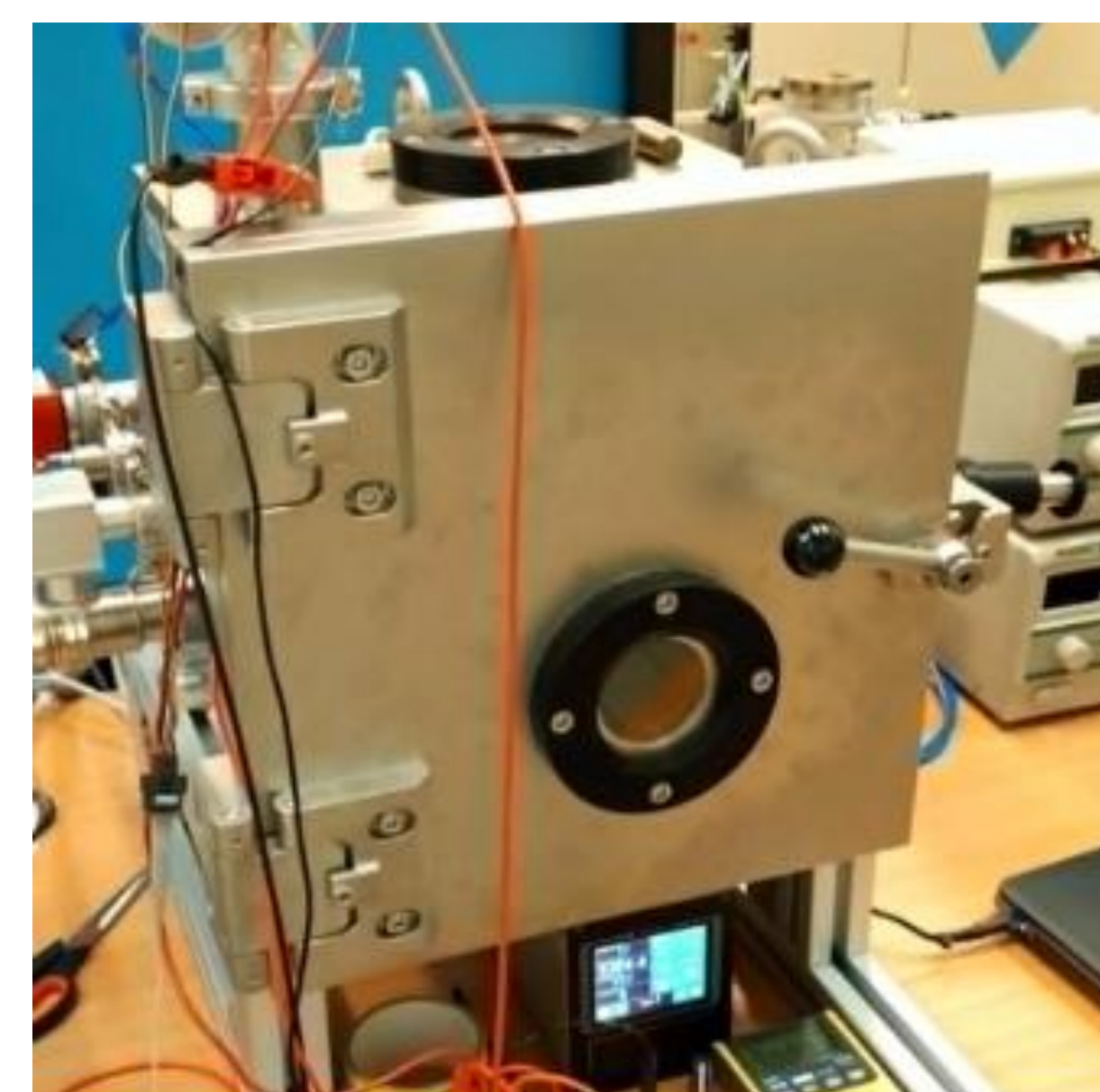
A compact positioning platform was designed and fabricated for precise integration and alignment of silicon MEMS components forming a scanning electron microscope column. The structure provides mechanical support for the devices and incorporates a precision positioning mechanism enabling accurate placement of individual silicon elements within the electron-optical system.

The prototype was manufactured using 3D printing and assembled with dedicated electrical interfaces. A key engineering challenge was the implementation of up to 16 independent electrical interconnections required for the electrostatic lens system. The developed architecture enables reliable electrode addressing and provides a flexible platform for integration, testing, and optimization of MEMS-based electron-optical components. The proposed approach reduces limitations associated with permanent bonding processes and facilitates iterative development of complex MEMS scanning electron microscope architectures.

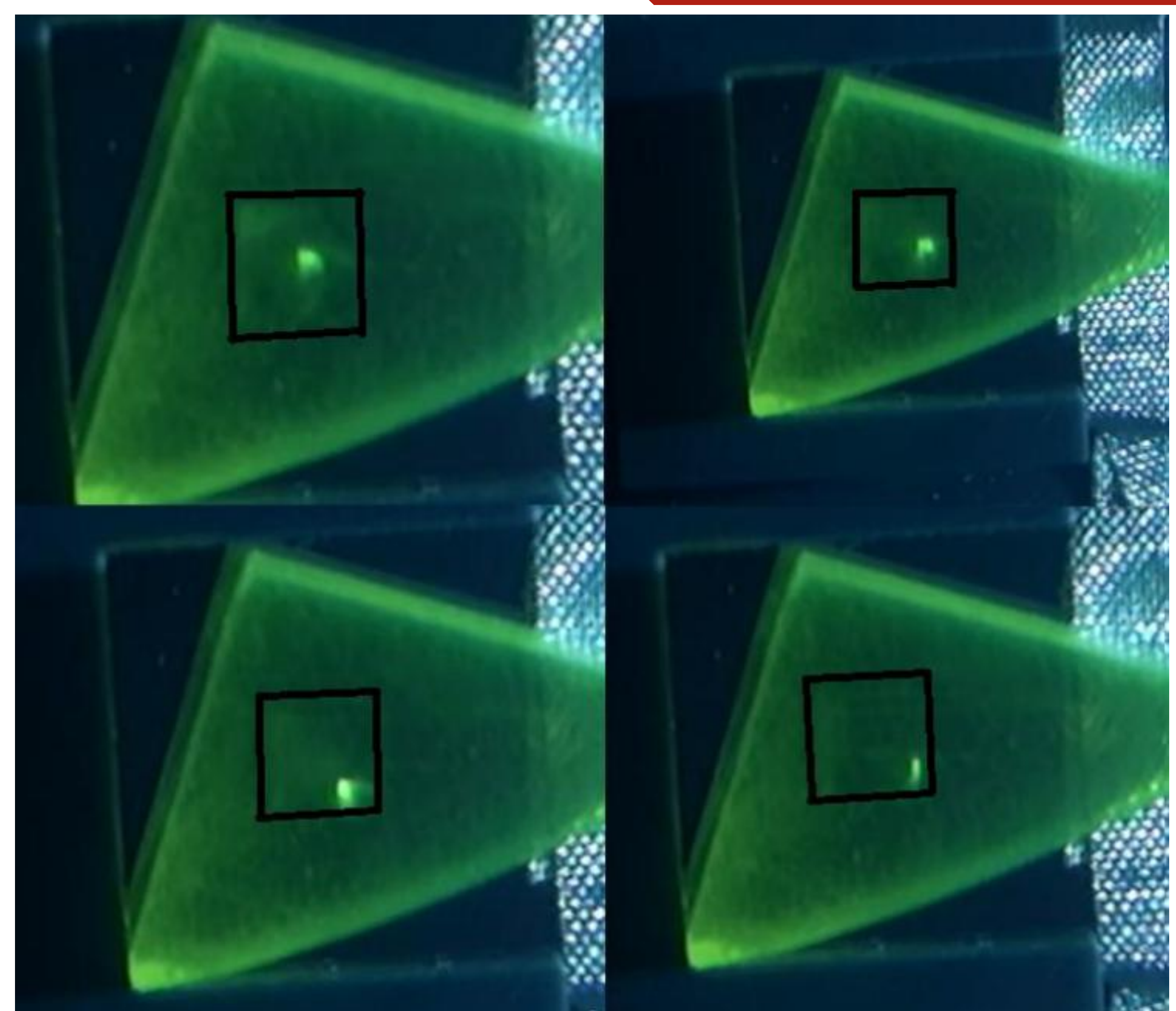


## Measurement system overview

Testing of the final structure with basic setup of MEMS SEM was done in a high-vacuum environment ( $3 \times 10^{-5}$  mbar) inside an external high vacuum chamber.



## Experimental results



Experimental demonstration of electron beam scanning using the octupole deflector [3]. The black square indicates the anode aperture, while the beam position changes in response to the applied deflection voltages, confirming proper operation of the scanning system and the whole developed device.

- [1] M. Białas, T. Grzebyk, M. Krysztof, A. Gorecka-Drzazga, Signal detection and imaging methods for MEMS electron microscope, *Ultramicroscopy*, 244 (2023) 113653.
- [2] J. Dziuban, Bonding in Microsystem Technology, Advanced Microelectronics series, Springer 2006, The Netherlands.
- [3] G. Kowal, (2024). *Integracja elementów miniaturowego mikroskopu elektronowego MEMS za pomocą obudowy wykonanej w technologii druku 3D* (Praca inżynierska). Politechnika Wrocławska.

## Summary

A dedicated 3D-printed structure provides accurate alignment of silicon MEMS components and electrodes, enabling testing of electron-optical elements such as octupole scanning systems and electron lenses. This solution supports the development of MEMS-based electron microscopes and electron beam systems by allowing precise component positioning and evaluation. Its modular design enables rapid assembly, straightforward modifications, and iterative optimization of the electron-optical systems. However, the integration of substrates into the final device is still under investigation.