

ELECTRON BEAM FOCUSING USING AN OCTUPOLE

Damian Opiela, Janusz Rozum, Michał Krysztof

Wroclaw University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wroclaw

E-mail of corresponding author: 275611@student.pwr.edu.pl

ABSTRACT

Achieving precise electron beam focusing is still a major challenge in MEMS-based electron microscopes [1]. These devices usually rely on Einzel lenses, which can introduce strong distortions and aberrations [2] and are very sensitive to voltage changes, lowering image quality. To improve this, the developed design uses an octupole as a focusing element: by adjusting the voltages on its eight electrodes, it can recreate the field of an Einzel lens while also allowing real-time correction of the beam. While traditional MEMS electron columns rely on high-risk, multi-step anodic bonding [3] that prevents component replacement, the implemented modular architecture restricts bonding to the component level. While this ensures a vacuum-tight seal, the process is permanent and risky, a single error during any of the numerous bonding stages can destroy the entire column, with no possibility of repairing or replacing individual components. This work presents a new approach of integrating MEMS electron columns by replacing the monolithic bonded architecture with a modular system. A key point of this design is the strategic use of anodic bonding: it is not entirely eliminated, but its role is shifted from system-level assembly to component-level fabrication. Specifically, anodic bonding remains essential for creating the octupole element. To function correctly, the octupole's silicon electrodes must be permanently joined to a glass insulator to maintain their precise radial positions and electrical isolation. However, once this "silicon-on-glass" component is finished, no further bonding is required to build the rest of the microscope. This modular approach replaces permanent bonding with a high-precision DLP 3D-printed housing and custom PCB interface, enabling precise axial alignment of MEMS components and the easy replacement of individual layers during prototyping. Design improves flexibility for research in high vacuum environments, discussed further in a separate abstract on this conference. Replacing the standard Einzel lens with an octupole can also improve performance. By adjusting voltages on its eight electrodes, the octupole can act as a focusing element, beam deflector, and shape corrector. This makes beam scanning possible, which is needed for Scanning Electron Microscopy (SEM). In this study, the focusing ability of the octupole is compared with a traditional Einzel lens. Beam spot quality is measured using a CMOS camera detector [4], enabling detailed image analysis and evaluation of focusing performance. By comparing the results 'before' (standard Einzel mode) and 'after' (octupole-based focusing), this research aims to determine the superior method for beam manipulation, providing a quantitative basis for the transition toward multifunctional MEMS electron optics.

References

- [1] M. Krysztof, et al. Przegląd Elektrotechniczny, vol. 90 (2014) pp. 116-119.
- [2] E. Steinwand, et al., Ultramicroscopy, vol. 110 (2010) pp. 1148-1153.
- [3] M. Białas, et al., Ultramicroscopy, vol. 244 (2023) pp. 1-8
- [4] M. Hausladen, et al., Sensors, vol. 25 (2025) pp. 7-17

P: Poster