AN OVERVIEW OF THE DEVELOPMENT OF SILICON NANOWIRE ELEKTRON SOURCES

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ABSTRACT

This contribution presents recent progress in the development of field-emission-based electron sources. Key requirements for such sources include high emission currents at low extraction voltages, a compact and monolithic design, long-term operational stability, and high electron transmission through the extraction electrode in order to utilize the emitted electrons as efficiently as possible. To meet these requirements, the cathodes were first optimized with respect to material selection and emitter geometry. This optimization led to the development of silicon nanowire-on-microtube cathodes (Fig. 1, left), combining an adapted emitter geometry to minimize mutual field shielding with the use of low-doped silicon. The increased resistance of the material limits the current of dominant emitters, thereby promoting a more homogeneous emission distribution. At the same time, it suppresses thermal runaway of individual emitters, preventing their destruction and substantially increasing the achievable current density [1]. Based on these cathodes, two types of electron sources were developed for different application requirements. First, electron sources with a glass insulation spacer and an aligned silicon extraction grid were fabricated (Fig. 1, center) [1]. These devices exhibit very good long-term stability and high robustness against electrical discharges between the cathode and the extraction grid. Second, electron sources with an integrated metal extraction gate were realized using benzocyclobutene as the insulating material (Fig. 1, right) [2]. These sources can be fabricated at wafer level and provide a promising platform for the direct integration of additional electrodes at the emitter level, for example for incorporating electron lenses directly into the cathode architecture.

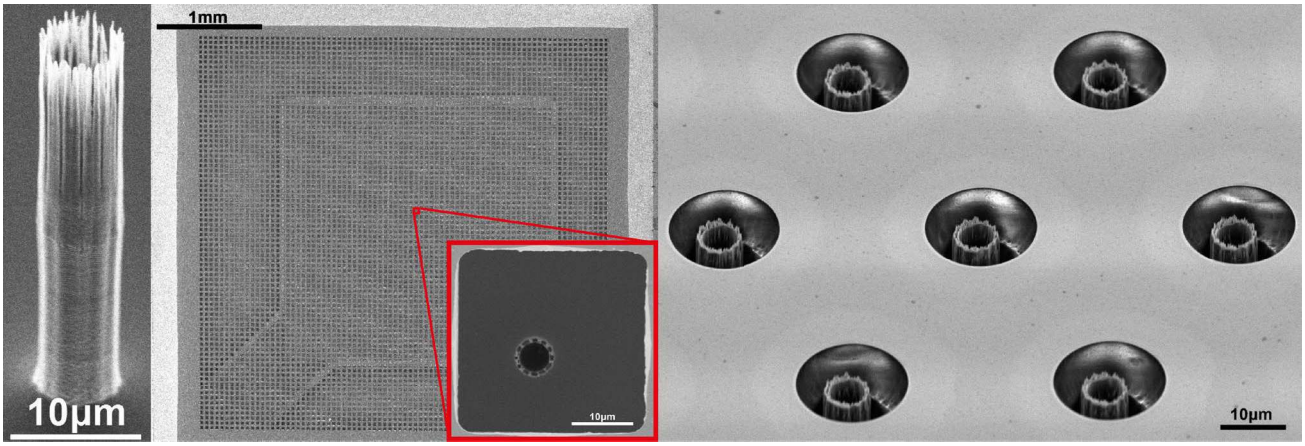

Fig. 1. Left: Single Microtube with Si-Nanowires. **Middle:** Microtube array with glass insulation path and aligned extraction grid. The insert depicts a detail top-down view of a single microtube centered in its grid opening. **Right:** Section of an electron source with integrated extraction gate using benzocyclobutene as an insulator.

References

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[2] P. Buchner, et. Al., IEEE 37th International Vacuum Nanoelectronics Conference (IVNC), (2024).