INDIVIDUALLY ADDRESSABLE SILICON FIELD EMISSION CATHODES FABRICATED BY LASER MICROMACHINING

Robert Ławrowski*, Matthias Hausladen und Rupert Schreiner
Faculty of General Sciences and Microsystems Technology,
OTH Regensburg, D-93053 Regensburg, Germany
*E-Mail: robert.lawrowski@oth-regensburg.de

ABSTRACT

Recent investigations on a silicon field emission electron source fabricated by laser micromachining, containing sixteen emitters, show a great integral performance [1]. This approach was modified and leads to the realization of an individually addressable 2x2 field emission electron source. A regulation circuit with a proportional-integral controller and voltage power amplifier [1] or a metal oxide semiconductor field effect transistor and operational amplifier [2] leads to a variation of the emitted field emission current of about 0.1‰. A modified version of the circuits was developed to allow the individually regulation of these emitters.

First, a silicon substrate was anodically bonded onto a borofloat substrate. The cathode with the segmented emitters was fabricated by laser ablation. For this purpose, the laser beam was deflected in parallel lines across the substrate. The lines were interrupted in certain areas. Due to the beam waist, less silicon was ablated in these areas and a conical structure was formed. The arrangement was rotated by 90° and repeated, until the target emitter height was reached (Fig. 1a). Afterwards, the separation of the input leads to the emitters were realized by the laser. Due to the local heat treatment, the silicon surface was oxidized. The oxide was removed wet chemically with HF and a wet chemical etching with TMAH led to the final emitters (Fig. 1b).. The grid itself was fabricated in a similar way. In order to thin the grid, a groove was created by laser ablation (Fig. 1c). Afterwards the rectangular holes were realized with the laser. The formed oxide was removed by a wet chemical etching with HF and a smoothing with a silicon polish etch ($HF:HNO_3:CH_3COOH$) was performed (Fig. 1d). Finally, the assembling of the electron source was possible with the cathode (Fig. 1e) and anode (Fig. 1f).

Afterwards, integral field emission current measurement without the regulation circuit were performed (Fig 2). A more detailed description of the fabrication process and characterization (field emission behaviour, current stability and electron transmission) will be presented on the conference.

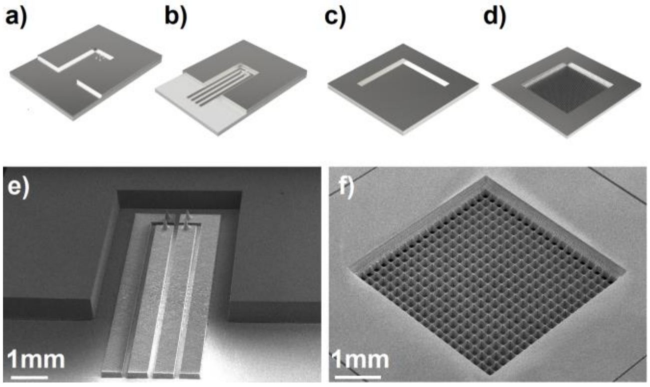

Figure 1. Illustration of the fabrication process of the cathode (a-b) and the anode (c-d). SEM images (tilted view) of the final cathode (e) and the anode (f).

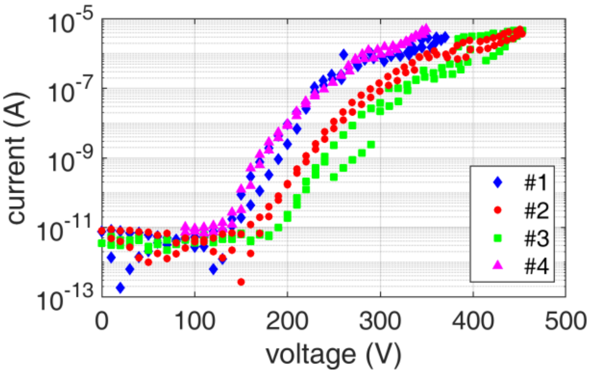

Figure 2. Integral I-V measurements without regulation of each individual emitter in semi-logarithmic chart.

References

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[2] C. Prommesberger *et al.*, “Regulation of the Transmitted Electron Flux in a Field-Emission Electron Source Demonstrated on Si Nanowhisker Cathodes,” *IEEE Trans. Electron Devices*, vol. PP, no. 99, pp. 1–6, 2017, doi: 10.1109/TED.2017.2763239.