MEASUREMENT OF THE CURRENT DISTRIBUTION OF A FIELD EMISSION CATHODE ARRAY USING A CMOS CAMERA AND COMPARISON WITH THE ACTUAL DIRECTLY MEASURED CURRENT VALUES.

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ABSTRACT

We used a copper coated Raspberry Pi HQ-Camera to determine the field emission (FE) currents from a FE-cathode with 4 individually addressable single emitters [1] (Fig. 1a). An optical image is generated by measuring the Bremsstrahlung signals of the decelerated electrons at the surface of the sensor [2]. From the images, we determine a normalized factorial share map and multiply the separate share factors with the electrically measured total current of the entire cathode. As a result, individual optically mapped (OMap) tip currents are obtained which are compared with their electrical counterparts. These are measured by a multi-channel current control circuit which is able to regulate an adjustable set current. Simultaneously, the circuit measures the values of the FE current as well as the internally used drop voltage of the regulation MOSFET. However, during the measurements we observed unstable emission behaviour and locally damaged areas at the emitter locations on the surface of an uncoated image sensor (Fig. 1b). Since the micro lenses on the surface of the sensor consist of non-conductive carbon-compounds, each emitter charges and heats a small, localized area which is dependent on the emitted power ($P = U \cdot I$). As the material is non-conductive, various local floating potentials occur on the sensor surface, weakening the effective extraction voltages of the FE tips time dependent. This most likely applies also for surrounding emitters, especially when in close distance. Therefore, we coated an image sensor with a 150 nm layer of copper to avoid local surface charges and surface damages (Fig. 1c). This improves and stabilizes the accuracy of the measurement method. More details about the technique and its accuracy will be presented at the workshop.

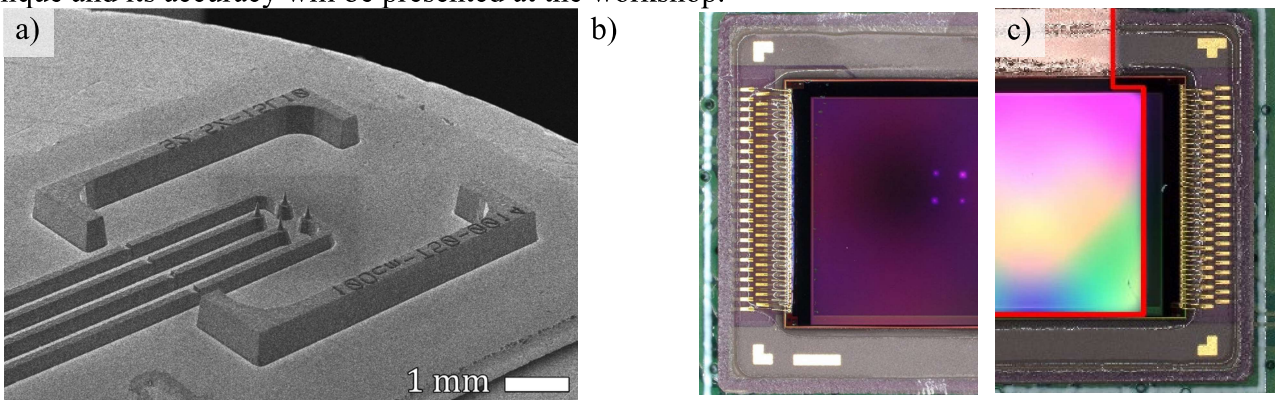

Fig. 1: a) SEM image of the field emission cathode with 4 individually controllable single tips in a 2x2 arrangement. b) Microscope image of a bit more than the left half of the uncoated image sensor with local differently damaged microlens areas. c) Microscope image of a bit more of the right half of a copper coated image sensor. The red line indicates the border of the copper layer.

References

[1] R. Lawrowski, M. Hausladen, P. Buchner, und R. Schreiner, „Silicon Field Emission Electron Source With Individually Controllable Single Emitters“, IEEE Trans. Electron Devices, Bd. 68, Nr. 8, S. 4116–4122, Aug. 2021, doi: 10.1109/TED.2021.3093374.

[2] A. Schels u. a., „In-situ quantitative field emission imaging using a low-cost CMOS imaging sensor“, Journal of Vacuum Science & Technology B, Bd. 40, Nr. 1, S. 014202, Jan. 2022, doi: 10.1116/6.0001551.