# Spatially Resolved Study of Grid Effects in Field Emission Arrays Using the CMOS Electron Detector

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Field emission arrays often show non-uniform current distribution, only a few tips carry most of the current, while many others remain inactive or degrade quickly.

In our earlier work, we developed field emission arrays (FEAs) using laser-micromachining and MEMS technology. The first generation used a 4 × 4 arrangement of emitters. Based on this, we designed a larger 21 × 21 array with 441 tips (Fig. 1a). Compared with the 4 × 4 FEAs, this design showed improved overall emission and could operate at lower extraction voltages. When a grid was integrated, a higher total current was achieved, while degradation was reduced and the lifetime increased [1].

In parallel, we developed a method that uses a metal-coated CMOS image sensor (Fig. 1b) to measure the spatial distribution of emission current in real time. It does not require phosphor screens or scintillators. Using this technique on 21 × 21 arrays without a grid (Fig. 1c), we found that less than 20% of the tips carry most of the emission current, while more than 40% remain inactive or fail early. These results show that emission is strongly non-uniform in non-grid designs [2].

In this work, we will study the same 21 × 21 field emission arrays with an integrated grid, using the CMOS Electron Detector. This will allow comparison of grid and non-grid configurations under comparable conditions. We will analyze how the grid influences tip activation, their contribution to the total emission current, and the overall uniformity of the array. The goal is to understand whether the grid can reduce the dominance of a few high-emission tips and improve current sharing across all 441 emitters. A better understanding of these effects will help to optimize the design and operation of field emission arrays, reduce local degradation, and extend the lifetime of electron sources for applications such as ionization vacuum gauges and electron tube amplifiers.

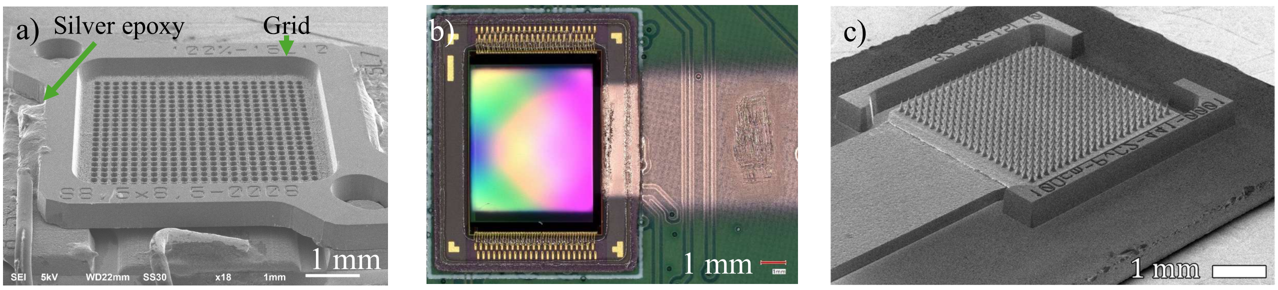


**Fig. 1:** (a) 21 × 21 field emission array with an integrated grid. (b) Metal-coated bare CMOS image sensor (IMX477). (c) 21 × 21 field emission array without a grid.

## References

[1] M. Hausladen, P. Buchner, M. Bartl, M. Bachmann, and R. Schreiner, “Integrated multichip field emission electron source fabricated by laser-micromachining and MEMS technology,” Journal of Vacuum Science & Technology B, vol. 42, no. 1, p. 012201, Jan. 2024, DOI: https://doi.org/10.1116/6.0003233

[2] Hausladen, M. et al.: Measurement of field emission array current distributions by metal-coated CMOS image sensors. Journal of Vacuum Science & Technology B, vol. 42, 2024. 062209. DOI: https://doi.org/10.1116/6.0004074