Contribution ID: **13** Type: **Oral**

Silicon Field Emitter fabrication by TMAH Etching of convex/concave corners

Thursday, 11 March 2021 14:30 (30 minutes)

Recently a novel fabrication method of silicon field emission arrays (FEAs) was introduced by Edler et al. [1], [2]. By combining wafer saw dicing with anisotropic wet chemical etching a versatile, inexpensive and easy reproducible manufacturing process is being presented. In accordance to literature the formation of the tips is explained by the differing etching rates of silicon crystal facets in tetramethylammonium hydroxide (TMAH) solutions and the etching behavior of TMAH towards convex and concave corners [3], [4]. It is shown that the density and size of the tips within the 4x4 mm2 arrays can be defined by adjusting the diameters of the square based silicon pillars structured by the dicing saw. Electrical I-E measurements at 10-5 mbar and emission currents up to 10 µA show reproducible characteristics of n- and p-doped FEAs fabri-cated with the same dicing parameters. The onset fields of the investigated n-type FEAs start at a few V/µm. Due to the fabrication process a higher tip density leads to a smaller height to radius ratio and variation of the individual tips. Despite the thereby expected decline in field enhancement emission currents of 10 µA are initially reached below 10 V/µm for FEAs with high tip densities. Constant current measurements of different FEAs at 10 µA and 10-5 mbar also suggest a connection between the tip quantity and the degradation over time, which is measured by the shift of the field necessary to obtain the regulated current. Lower degradation rates are measured for higher tip quantities as well as for p-doped FEAs compared to n-doped. Furthermore, it was found that the degradation is partly reversible for n-doped FEAs by heated opera-tion at 200 ℃, whereas the p-doped emitters degraded further through heated emis-sion.
In order to investigate the influence of the aspect ratio an additional process step is being introduced. It is shown that the emission properties of the FEAs can be altered by structuring pillars of different heights underneath the etched tips. Finally, a method to further increase the tip density is being presented. By replacing the pillar structu-ration before etching with a lithography step followed by a dry etching Bosch process the tip densities can be increased beyond the capabilities of the dicing saw.

References

[1] S. Edler et al., "Silicon field emitters fabricated by dicing-saw and wet-chemical-etching,"J. Vac. Sci. Technol. B, vol. 39, no. 1, p. 013205, Jan. 2021, doi: 10.1116/6.0000466.
[2] S. Edler et al., "Silicon Field Emitters fabricated by Dicing-Saw and TMAH-Etch,"in 2020 33rd International Vacuum Nanoelectronics Conference (IVNC), Jul. 2020, pp. 1–2, doi: 10.1109/IVNC49440.2020.9203262.
[3] P. Pal and K. Sato, "A comprehensive review on convex and concave corners in silicon bulk micromachining based on anisotropic wet chemical etching,"Micro Nano Syst. Lett., vol. 3, no. 1, 2015, doi: 10.1186/s40486-015-0012-4.
[4] K. Tokoro, D. Uchikawa, M. Shikida, and K. Sato, "Anisotropic etching properties of silicon in KOH and TMAH solutions,"Proc. Int. Symp. Micromechatronics Hum. Sci., no. May, pp. 65–70, 1998, doi: 10.1109/MHS.1998.745752.

Primary authors: Mr SCHELS, Andreas (Institute of Physics, Faculty of Electrical Engineering and Information Technology, Universität der Bundeswehr München); Mr EDLER, Simon (Institute of Physics, Faculty of Electrical Engineering and Information Technology, Universität der Bundeswehr München)

Co-authors: Dr BACHMANN, Michael (Ketek GmbH); Dr BIBA, Josef (Institute of Physics, Faculty of Electrical Engineering and Information Technology, Universität der Bundeswehr München); Prof. HANSCH, Walter

(Institute of Physics, Faculty of Electrical Engineering and Information Technology, Universität der Bundeswehr München); DÜSBERG, Felix (Ketek GmbH); Mr LANGER, Christoph (Ketek GmbH); Mr MEYER, Manuel (Ketek GmbH); Mrs EDER, Magdalena (Ketek GmbH); HERDL, Florian (Ketek); Mr DUDECK, Markus (Ketek GmbH); Mr GEESMANN, Henning (Ketek GmbH); Dr PAHLKE, Andreas (Ketek GmbH)

Presenter: Mr SCHELS, Andreas (Institute of Physics, Faculty of Electrical Engineering and Information Technology, Universität der Bundeswehr München)

Session Classification: Field emission