Primary Topic: Technologies and Production Processes in Vacuum Electronics Presentation: Oral
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EMISSION PROPERTIES OF SILICON NANOWIRE FIELD EMITTERS

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The fabrication process and performance of silicon nanowire field emitters on pillars are described in [1]. In order to investigate effects of geometrical parameters, e. g. distance between extraction grid and emitters, in detail, simulations using the finite element method were performed.
A simplified 2-dimensional geometry was used for the simulation of the silicon nanowire structure. It comprises of two emitter tips with a height of 50 µm and a tip radius of 0.1 µm. These are arranged at a distance of 5 µm. The basic grid was modeled with a thickness of 50 µm, 30 µm openings with an opening angle of 5° and a grid spacing of 50 µm. The distance between the anode and the topside of the extraction grid was fixed at 500 µm. The emitter voltage was set to -300 V, the grid voltage to 0 V and the anode voltage to 500 V. With this model setup, a time resolved simulation of the trajectories of the emitted electrons was carried out for various emitter tip to grid distances in the range of -30 µm (tips protruding into grid) to +50 µm (gap between tips and grid). The result for the emitter tip to grid distance of 0 µm is shown in figure 1, with the grey lines being the trajectories of the emitted electrons. The electric field is indicated by the background color scheme. For reasons of clarity, only a limited number of electron trajectories is shown in the snapshot. A part of the electrons collides with the grid, resulting in a reduced electron transmission. Simulations with various tip to grid distances yield the shown relations regarding the electron transmission and the electric field at the emitter tips (Fig. 2). The maximum electric field was simulated for an emitter tip to grid distance of +10 µm. The electron transmission rises with the emitter tip protrusion into the grid openings.
In addition to the emitter tip to grid distance at perfect alignment, we also studied the influence of grid geometry and misalignment on electron transmission, the achievable electric field and more. Using the results of the simulations, we were able to optimize the emission performance of the silicon nanowire field emitters on pillars. The improved geometry will be presented at the workshop.

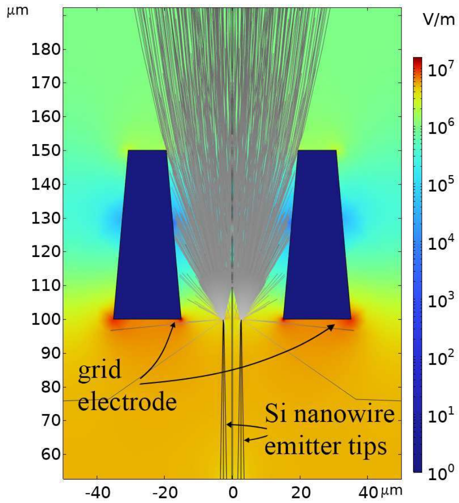

Fig. 1. 2D-Simulation of a silicon nanowire field emission pillar with electron trajectories indicated with grey lines and electric field indicated with a color scheme.

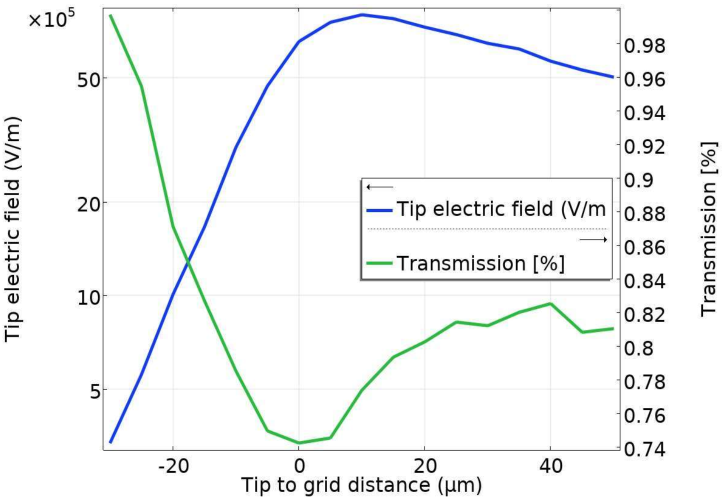

Fig. 2. Electric field at the emitter tips (blue) and electron transmission (green) by varying emitter tip to grid distances in the range of -30 µm to 50 µm.

References
[1] BUCHNER, P.; HAUSLADEN, M.; BARTL, M.; BACHMANN M.; SCHREINER, R. High current field emission from Si nanowires on pillar structures. *J. Vac. Sci. Technol. B,* 2024; 42 (2): 022208.