Simple Finite Element Model of the Topografiner

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Abstract

In our recent experiments we are revisiting the topografiner technology for the imaging of surface topography with a resolution of a few nanometers. In these new technique called Near-Field Emission Scanning Electron Microscopy (NFESEM), low-energy electrons are emitted from a polycrystalline tungsten tip via electric-field assisted tunneling. In order to characterize and improve the capabilities of our microscopes, in particular the vertical and lateral resolutions, we simulate the tunnel junction consisting of a metallic tip placed at distance d from a planar electrode and consider current versus voltage (I-V) and voltage versus distance (V-d) measurements. The experimental and numerical results give us evidence for a scaling hypothesis: all I-V curves are found to collapse when the distance d is rescaled, suggesting that the current I=I(V,d) is a generalized homogenous function of one single variable, that means I=I_s(Vd^(-L)), where L is some characteristic exponent and I_s(x) the scaling function. In this paper we want in particular to discuss the use of two different parametric sweeps inside COMSOL Multiphysics® software. First, we consider the calculus of the field emission current using a Fowler-Nordheim equation and our new proposed expression based on the scaling hypothesis (Figures 1 and 2) [1]. Second, we use several geometrical parameters in the junction model to analyze the trajectories of the electrons, looking for an estimation of the microscope resolution (Figure 3).

Reference

[1] Scaling theory of electric-field-assisted tunnelling Proc. R. Soc. A July 8, 2014 470 2167 20140014; doi:10.1098/rspa.2014.0014 1471-2946.

Figures used in the abstract

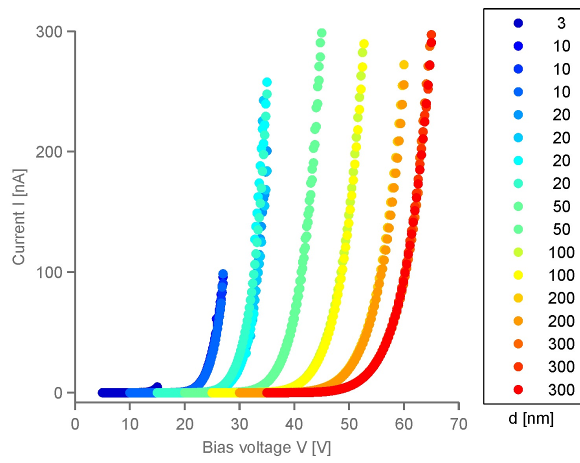

Figure 1: I-V experimental curves.

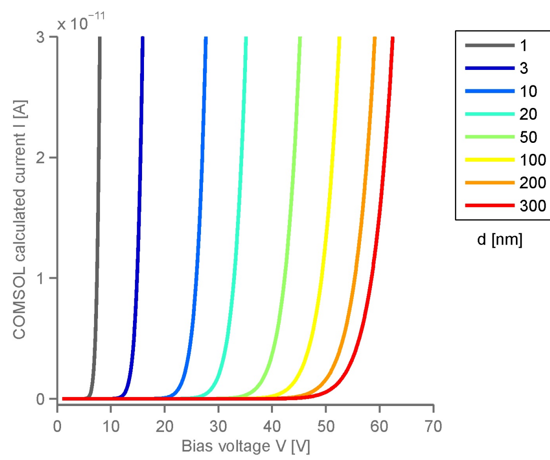

Figure 2: COMSOL calculated I-V curves.

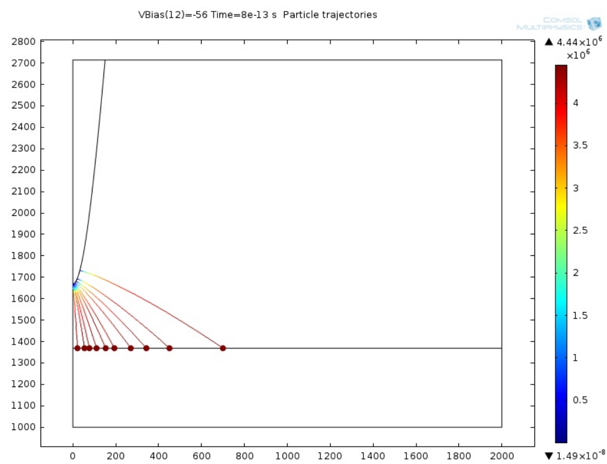

Figure 3: Simulated electron trajectories between tip und sample.