Poster

EFFECT OF TIP SHAPE ON ELECTROSTATIC FORCE MICROSCOPY

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Electrostatic Force Microscopy (EFM) is a probe microscopy technique derived from Scanning Force Microscopy (SFM). Like in SFM, a tip senses proximity interactions forces of a sample surface. In EFM, the forces are of electrostatic nature and typically generated by an applied electric field. It has been extensively used to study liquid and solid surfaces, as well as polarization of small atomic chains [1].
It has been established [2] that the size and shape of the tip are relevant parameters in the electrostatic field and consequently, in the EFM interactions. In the same reference, the authors explain the problems with finite-element and similar numerical calculations –due mostly to the dissimilar spatial extend of the micrometer cantilever-tip system, and the nanometer tip-sample system.
To contribute to overcome the above described scale problem, we present here a semi-analytical algorithm to calculate EFM forces of realistically shapes tips (figure 1).

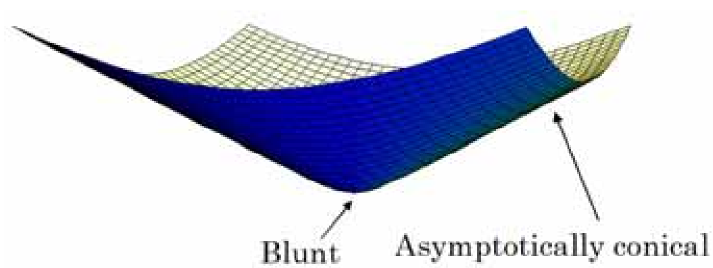

Figure 1. A real tip looks like a cone at large scales, but like a sphere at small scales.

The model consists of two main ingredients figure 2). First, the shape of the tip is considered to be a blunt-terminated cone. That is, at its apex the tip has a radius of curvature Ro. Far from the apex, the tip becomes asymptotically a circular cross section cone. The parameter Ro is allowed to vary to obtain tips ranging from very blunt to very sharp. Second, The surface of the tip is considered as a collection of charged rings. Each of these charged rings generate an electric field which in turn can be computed with the fast algorithm developed previously [3].

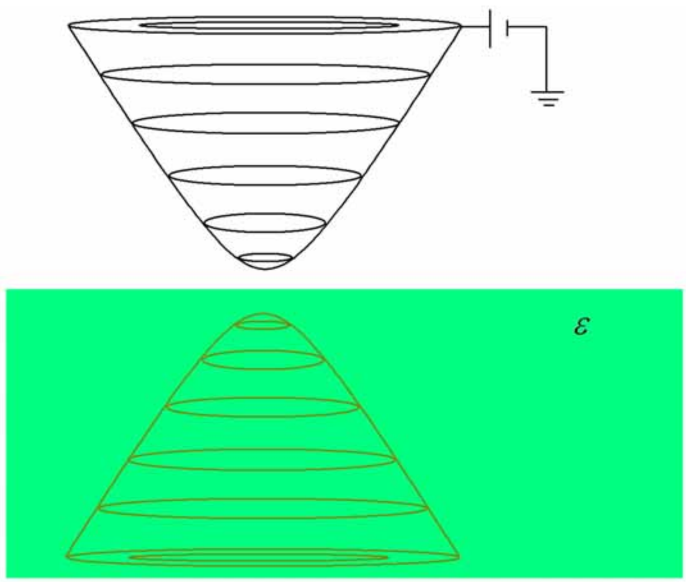

Figure 2. Schematic diagram of the tip made up of charged rings. In the presence of a dielectric material, an image set of charged rings is considered.

When the tip is close to a dielectric material, the whole electric field is the sum of those produced by the real rings and those produced by the image charge rings.
Thus posed, the problem becomes a linear inversion for the unknown charges on the rings. They are found by imposing the equipotential condition on the surface of the tip.
We emphasize that all this program is doable for real dimension tips due to the use of analytically simple expressions for the electric fields produced by rings of charges as demonstrated in reference [3].

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[1] P Girard , "Electrostatic force microscopy: principles and some applications to semiconductors", Nanotechnology **12** (2001) 485-490
[2] GM Sacha, E Sahagún, JJ Sáenz, A method for calculating capacitances and electrostatic forces in atomic force microscopy", J Appl Phys **101** (2007) 024310
[3] FR Zypman, "Off-axis electric field of a ring of charge", Am J Phys **74** (2006) 295