“One nanometer radius of curvature metallic probes created by field-directed sputter sharpening”

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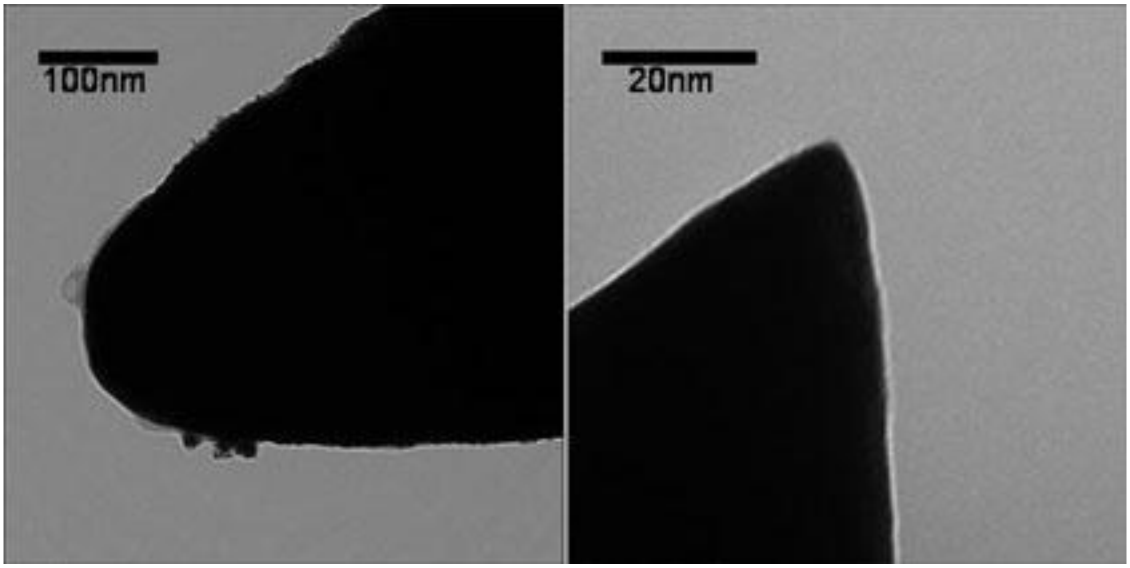
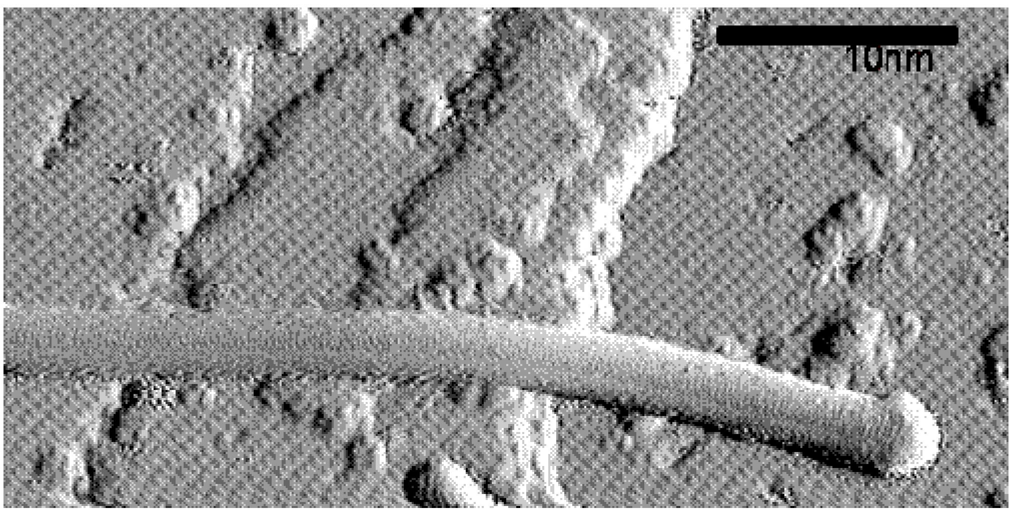
Ultra-sharp metallic probes are desirable for applications including scanned probe microscopy, field emitter displays, and electron microscopy. A novel technique of field-directed sputter sharpening (FDSS) has been developed for the reproducible sharpening of metallic probes to nanometer or sub-nanometer radii of curvature. In FDSS a metallic probe of nominal sub-micron sharpness is placed in an axial ion beam that is directed toward the probe apex. The key aspect of this technique is the application of a voltage to the probe which establishes an electric field that deflects the incoming ions. For normal probe geometry the apex will have the smallest radius of curvature, and thus the highest electric field strength. Consequently, ions are preferentially deflected around the apex, which then sputters at a lower rate than the remainder of the probe. This sharpens the probe which further enhances the apex electric field and preferential sputtering, leading to a self-limiting probe shape with a nanometer-scale apex radius of curvature.

Within Sigmund’s theory of sputtering [1] it is well understood that a probe tip apex can be reproducibly sharpened to about a 5 nm radius of curvature by exposure to a beam of directional, energetic ions incident along the longitudinal axis of the probe [2]. Simulation and experiments demonstrate improved probe apices under FDSS. Radii of curvature of 1.5 nm or less are reliably produced by this technique and sub-nanometer apices have been achieved. Nanometer-scale sharpening has been demonstrated for polycrystalline tungsten, iridium and platinum-iridium alloys. It is expected that similar results should be achievable for any conductive probe.

Transmission electron microscopy (figure 1) and ultrahigh vacuum scanning tunneling microscopy (figure 2) have been used to characterize FDSS probes.

[1] P. Sigmund, J. Mat. Sci., 8, 1545 (1973)
[2] J.A. Kubby and B.M. Siegel, J. Vac. Sci. Technol. B, 4, 120 (1986)


100nm
20nm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