Non-contact Atomic Force Microscopy using Diamond Coated Tips

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Generally for non-contact atomic force microscopy (NC-AFM), which is one of the scanning probe microscopies, the ideal probe should be “sharp” for reducing long-range van der Waals (vdW) interaction force and “hard” to prevent the destruction of the probe even at nanometer scale due to an accidental or intentional tip-surface contact. As for the hardness, diamond is the best because it is the hardest material in the world. Nowadays, conductive diamond coated probes from Nanosensors are commercially available [1]. According to the specification of the supplier, Boron doped polycrystalline diamond covers on the tip of the cantilever. The thickness of the diamond layer is around 100nm and the microscopic tip radius is in the range of 10nm (the macroscopic tip radius is 100-200nm).

As shown in Fig.1, atomically resolved topographic images of Si(111)-(7x7) surface could be obtained after controlled soft contacts for improving the tip apex. The resonance frequency, the quality factor and the oscillation amplitude of the cantilever were 181kHz, 5500 and 25nm respectively. A sample bias of –800mV was applied to minimize the long-range-electrostatic force. Before the observation, the tip was cleaned by Ar ion sputter (Ion energy was 0.6kV) for 30min. to remove contaminations, and the experiments were carried out at 80K. Tip-surface interaction forces were calculated from the frequency shift vs. tip-surface distance curves by the inversion procedure proposed by Sader et. al. [2] Using sphere-plane model for the vdW fitting [3], a microscopic tip radius of 36nm was obtained (Fig. 2). Results on force spectroscopy and hardness comparisons between diamond coated tips and conventional Si tips will be discussed.

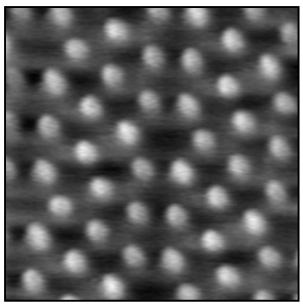

Fig. 1. Scan area : 5x5nm^2, Δf = -11.4Hz
(γ = -10.6fN$\sqrt{}$m)

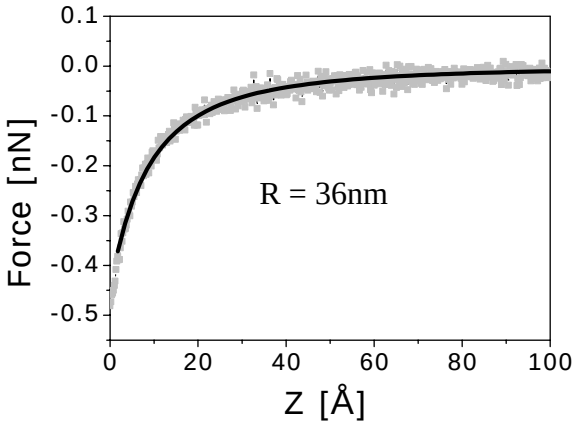

Fig. 2. vdW interaction force (gray points) and sphare-plane model fitting curve (black line)

[1] Nanosensors (www.nanosensors.com)
[2] John E. Sader and Suzanne P. Javis, App. Phys. Lett., **84** 1801 (2004)
[3] M. A. Lantz et. al., Science **291** 2580 (2001)