

Environmental Controls for Scanning Probe Microscopy with Applications in NanoScience and Nanotechnology Development

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This paper reports on some developments in SPM instrumentation with environmental controls, including high vacuum, elevated temperatures, and in-liquid operation. Images and data, including on block co-polymers, and on metallic nanoparticles made with dendrimer-chemistry nanofabrication techniques, illustrate the applications in nanoscience and technology development. Figure 1 is Atomic Force Microscope (AFM) images of poly-SBS (styrene-butadiene-styrene) in ambient environment, i.e., at laboratory room temperature and pressure. The left image is tapping mode topography (a.k.a. height), and the right image is tapping mode phase. This block co-polymer consists of a more glassy phase, and a more rubbery phase. Figure 2 is the same sample at 130 Celsius at 1×10^{-5} Torr. The tapping mode's operating amplitude setpoint was changed at about 2/3 down the scan in Figure 2, and resulted in the drastic changes in contrast, which we discuss and interpret in detail, along with other representative image pairs.

Figure 3 shows two tapping mode topography images of a highly-oriented pyrolytic graphite (HOPG) substrate, on which we spun at 2500rpm an aqueous suspension of gold nanoparticles. The nanoparticles were made from a proprietary dendrimer-chemistry-based technique. The left image was captured imaging the sample in air at laboratory room temperature. The right image is the same sample at room temperature, but at 1×10^{-5} Torr. The height (Z) scale is 3nm in both images, but it is saturated in the left image, because the material covering the HOPG is more than 20nm tall.

We use these and other examples to describe how different environmental conditions affect the way a sample surface appears to us in SPM images, and how this information can be useful when the images are properly interpreted.

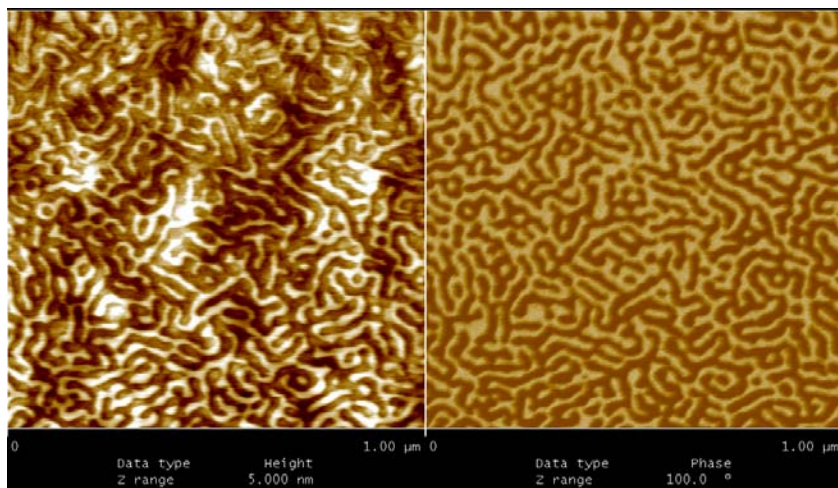


FIG. 1. Poly-SBS at room temperature and pressure. 1 μm scans. Topography (left) and phase (right).

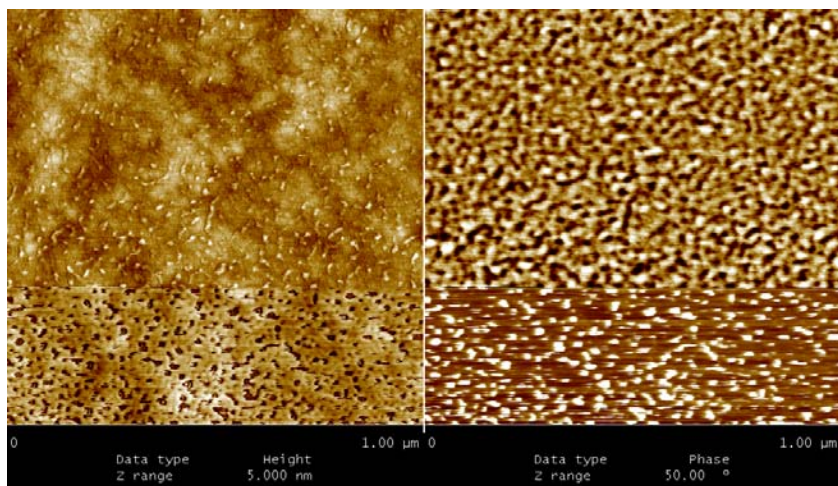


FIG. 2. Poly-SBS at 130 Celsius and high vacuum. 1 μm scans. Topography (left) and phase (right).

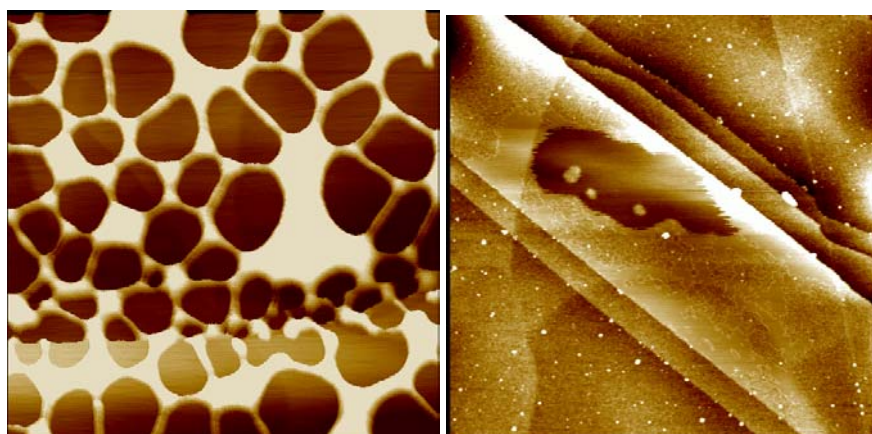


FIG. 3. Tapping mode topography (a.k.a. height) images of HOPG substrate with gold nanoparticles in aqueous suspension spun on it. At ambient pressure (left) and in high vacuum (right). 2 μm scans. Nanoparticles are visible only in high vacuum.