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ToF-SIMS Investigations of Tip-Surface Chemical Interactions in Atomic Force Microscopy on a Combined AFM/ToF-SIMS Platform

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Atomic force microscopy (AFM) has become one of the premier tools of nanoscale surface characterization over the last 20 years. The technique is used in a variety of industries to understand topological and functional (electrical, mechanical, magnetic) properties of the material surfaces, but has the disadvantage of being chemically insensitive [1, 2]. However, this problem can be solved by combination of AFM with one of mass spectrometric techniques. Here, we utilized combined Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) with AFM to understand chemical effects in the AFM tip-surface junction during contact mode scanning. Electrochemical processes are important in materials, for instance it can significantly affect spontaneous polarization behavior in ferroelectrics [3] and the combined ToF-SIMS/AFM system can provide insight to such phenomena. Previous studies using this system have shown that SPM tip-induced polarization switching in ferroelectrics can cause changes in surface and bulk chemistry [4].

To understand the chemical effects of AFM on samples, systematic changes in tip parameters (contact force, scanning velocity, applied electrical bias) were employed while scanning in contact AFM mode $PbZr_{0.2}Ti_{0.8}O_3$ (PZT) and $SrTiO_3$ (STO) films. The samples were cleaned in-situ using an oxygen ion sputtering gun to eliminate adsorption surface layer influences. After scanning, local changes of surface chemistry were inspected using ToF-SIMS.

ToF-SIMS investigation of the surface revealed no changes in the underlying sample chemistry. Multivariate analysis of data show layers of Si deposition in scanned region, which is confirmed using a high spectral resolution ToF-SIMS imaging (Fig. 1). Tip parameters were varied while scanning 10 µm squares and show that scanning speed is the primary parameter controlling Si deposition (Fig. 2), which shows chemical interaction at the tip-surface junction drives this phenomenon.

This study shows first time observations of chemical effects that occur at the tip-surface junction using a combined AFM/ToF-SIMS system [5].

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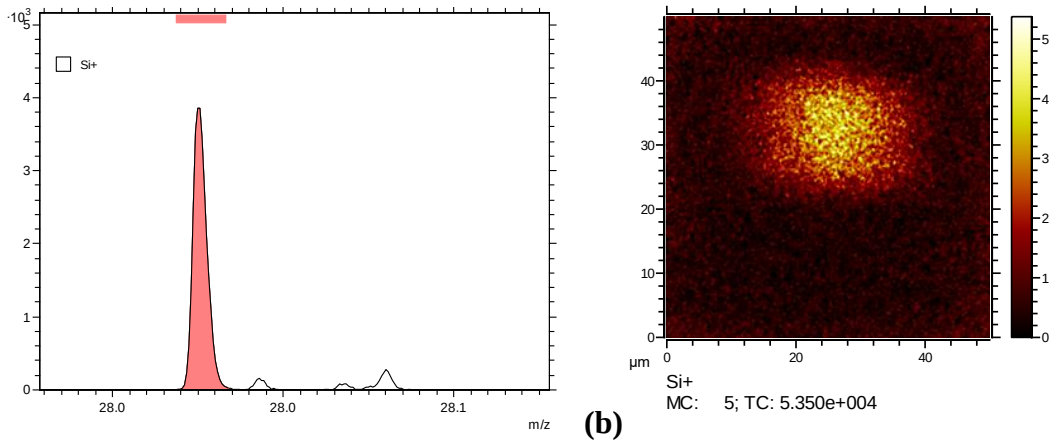
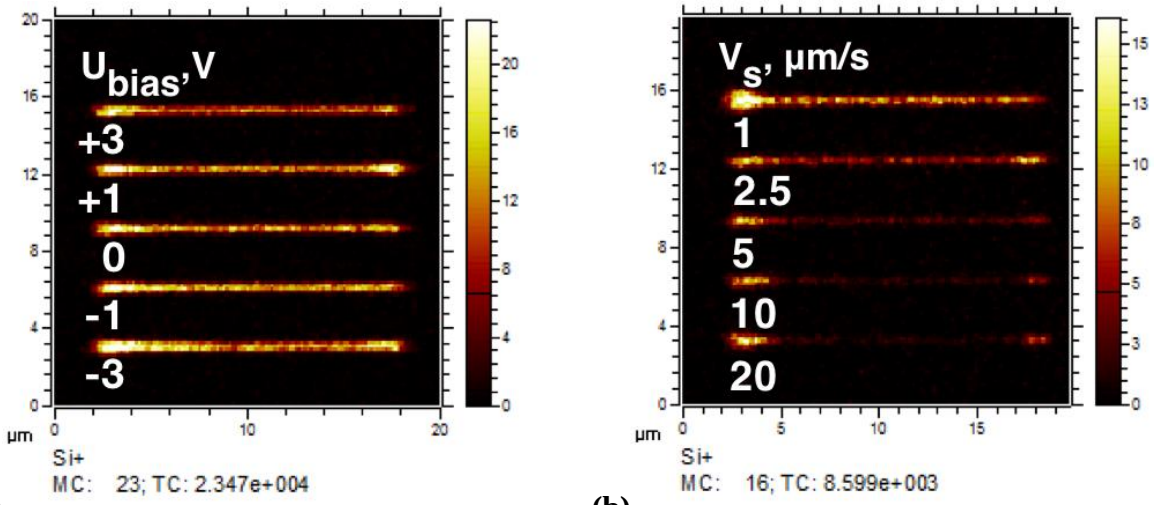


(a) **(b)**

Figure 1. (a) High resolution mass spectra showing Si peak (left) and (b) map of Si^+ spatial distribution inside 10 µm scanned region.



(a) **(b)**

Figure 2. Line scans on PZT film surface varying tip bias (a) and scanning speed (b).

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