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Resolution Investigation of Potentiometric-Scanning Ion Conductance Microscopy

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Scanning ion conductance microscopy (SICM) is a scanned probe technique that utilizes a pipette with a nanoscale opening as the probe. The traditional instrument set-up features two electrodes and an ion current feedback system. The position of the electrode is precisely controlled above the substrate surface by monitoring ion current changes as the pipette is close to the surface. SICM is a non-contact technique capable of topographic and ion current image generation. We have developed a new version of SICM, potentiometric-scanning ion conductance microscopy (P-SICM), which utilizes a double barrel pipette and five electrodes to produce topographic, ion current and potentiometric images. While SICM resolution has been studied, P-SICM resolution has not yet been characterized.

Resolution in SICM is dependent upon tip geometry and pipette-sample distance. The standard vertical and lateral resolutions are ~10 nm and ~50 nm, respectively [1]. Through finite element simulation, the smallest distance between two particles at which an individual particle can be observed was defined as three times the inner radius of the pipette [2]. No studies have been conducted to determine the resolution limits of P-SICM. However, potential measurements have been shown to be extremely sensitive in comparison to normal SICM measurements.

For resolution characterization, features were milled onto 200 nm thick silicon nitride membranes with a focused ion beam (FIB) and imaged with P-SICM. Two types of features were milled. Intersecting lines of 10^o, 20^o, 30^o, and 40^o were milled onto a membrane. The fidelity of potential measurements for the small angles of these features was examined. Closely spaced pores were also milled onto silicon nitride membranes. As before, the fidelity of these features was examined.

To image the milled features, P-SICM was utilized. A milled silicon nitride membrane was mounted in a conductivity cell and a transmembrane potential was applied. The top chamber of the cell contained a Ag/AgCl reference electrode and Pt counter electrode, while the bottom chamber of the cell contained a Ag/AgCl reference electrode. The double barrel pipette probe contained two electrodes, one in each barrel. One barrel served as the pipette electrode, which controlled pipette position and ion current measurements. The other barrel served as the potential electrode responsible for potential measurements and conductance quantification.

Conclusions we wish to gain from these studies are the determination of resolution limits of P-SICM.

References:

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