PROGRESS REPORT FOR AINGRA07173

PROJECT TITLE
Ion selective atomic force microscopy: a powerful new imaging technique for materials science

INVESTIGATOR(S)
Chief Investigator: Professor Roland De Marco
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Other Investigators: Prof. Erno Pretsch, ETH Zürich
Prof. Eric Bakker, Purdue University
Students: Mr. Adam Martin, Honours Student, Department of Applied Chemistry, Curtin University of Technology
ANSTO Investigators: Dr. Kathryn Prince

SCIENTIFIC OBJECTIVES
The overarching aim of this project is to develop an innovative approach for chemically modified atomic force microscopy (AFM) using tips comprising miniaturized ion-selective sensor nanoparticles. These ion-selective sensor modified AFM tips or nanosensors will permit atomic resolution force imaging of unique molecular structures, and the Project Team will employ these AFM tips in the imaging of ion efflux events in model or ion channel mimetic systems, as well as real ion channels in living cells.

In this project, we have characterized silver sulfide nanoparticles that were synthesized in a spinning disc reactor using secondary ion mass spectrometry, and the project has specifically targeted a determination of whether the particles had the required stoichiometry (i.e., Ag₂S), or a non-stoichiometric composition ascribable to the presence of occluded salts and/or partially oxidized particles.

PROGRESS REPORT and RESEARCH OUTCOMES
In this project, we spin coated the nanoparticles of silver sulfide onto a mica substrate from an aqueous suspension of nanoparticles to produce an even distribution of nanoparticles on the substrate. Since the mica substrate is electrically insulating, the samples were coated with 20 nm of gold using the sputter coater at ANSTO. This strategy was insufficient to combat the charging of the samples, so the Project Team also employed the SIMS instrument’s electron flood gun to yield reliable depth profiles on 500 μm² square areas of the specimens. This strategy was successful, as evidenced by a depth profile of one of the specimens (see Figure 1 including mica and silver sulfide elemental profiles, and Figure 2 only showing the silver, sulfur, gold and cesium ion profiles). It is evident that, as the silver sulfide particles are sputtered away, there are peaks in the silver and sulfur ion counts at around 75 to 120 seconds, and a diminution in the gold counts after approximately 120 seconds. We integrated the intensities under the silver and sulfur ion curves, determined the ratios of silver-to-sulfur ion intensities, and compared these ratios with the one obtained on a standard sample of silver sulfide prepared using a conventional precipitation technique.

On each specimen, SIMS analyses were conducted in duplicate, and fourteen samples corresponding to different nanoparticle sizes obtained by controlling the experimental conditions in the spinning disc reactor were examined. The SIMS analyses confirmed that the nanoparticles had bulk compositions commensurate with those of silver sulfide, as evidenced by silver-to-sulfur intensity ratios of 1.9 ± 0.6 for the 28 assays on the bulk nanoparticles and a corresponding silver-to-sulfur intensity ratio of 1.7 ± 0.5 on the standard silver sulfide material.

Most significantly, these silver sulfide nanoparticles have been used successfully in ion-selective atomic force microscopy, and two papers are pending publication.

DATA

Date electronic copy received at AINSE: 22 September 2008
Figure 1: A SIMS depth on a mica specimen spin coated with an aqueous suspension of silver sulfide nanoparticles, noting that all ion profiles (i.e., mica, silver sulfide and gold) are presented.

Figure 2: A SIMS depth on a mica specimen spin coated with an aqueous suspension of silver sulfide nanoparticles (same sample as the one presented in Figure 1), noting that only the relevant ion profiles (i.e., silver, sulfide, gold and primary cesium beam) have been presented.

Signature of Investigator preparing the report for
After signing this report please fax this page with your signature for our files

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PUBLICATIONS / REPORTS arising as a result of your work.

No publications have appeared yet, although we are presently drafting two papers for inclusion in a high profile surface science journal such as Langmuir.

PhD STUDENTS

Not applicable; this was an Honours student project (and funded accordingly by AINSE) that was conducted by Mr Adam Martin.