2Q06 EPRI Project Report

“Consultant to EPRI Project Management on the Fabrication of New Superconducting Materials”

EPRI Contract Agreement No. EP-P18263/C9013
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2Q06 Summary

- The object of this project is to explore meta-stable cubic copper oxide as a possible new high temperature superconductor.
- Previous results have shown it is possible to grow at least 5-6 atomic cells of cubic CuO on strontium titanate and magnesium oxide. These films, although quite thin, nonetheless would be capable of exhibiting bulk transport and magnetic properties.
- Efforts this quarter focused on the use of strontium ruthenate as a suitable electrical contact to cubic CuO to enable device configurations to probe for superconductivity.

Activities & Results

I. Experimental

II. Theory & Modeling

III. Plans for “Device” Fabrication and Measurements

I. Experimental

- As reported earlier, we have successfully deposited 6-7 atomic layers of cubic CuO (c-CuO) on MgO and $SrTiO_3$ (strontium titanate, or STO). We believe these films are sufficiently thick that we can begin to examine potential for bulk magnetic and transport properties.
- We have thus shifted our emphasis to fabricating “device-like” structures for their experimental determination.
- For these studies, we need to form conducting contacts to these very thin layers of c-CuO. $SrRuO_3$ (strontium ruthenate, SRO) is isomorphic to STO, conducting and also ferromagnetic.
- However, the surface of SRO, unlike that of STO, is SrO terminated, and not TiO, which c-CuO favors for epi-growth. Thus we have tried various etching procedures, to expose the TiO layer of SRO.
- The Atomic Force Microscope (AFM) images (next two slides) show that attempts to effect this by etching with HF (hydrofluoric acid) were largely unsuccessful.

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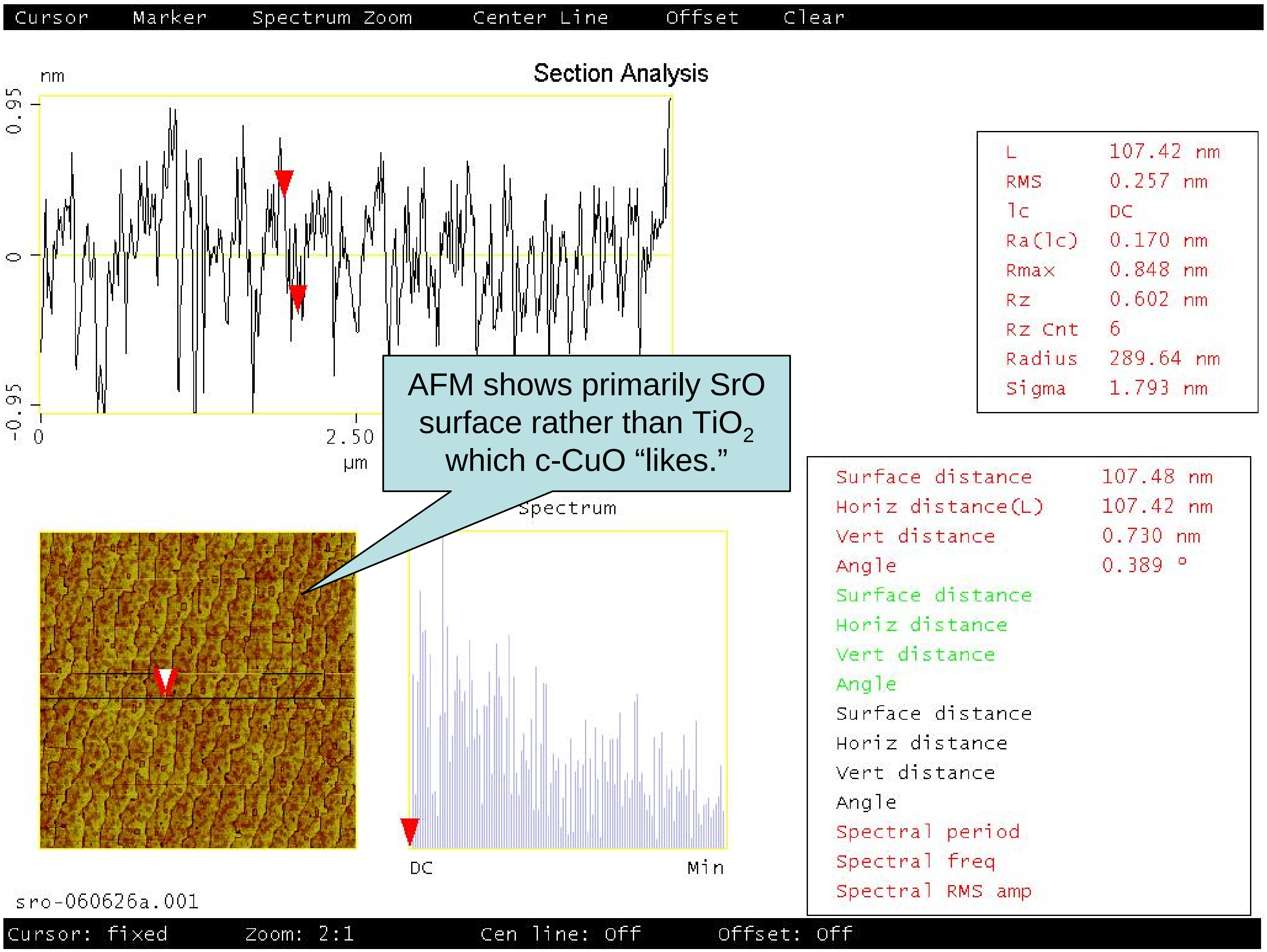
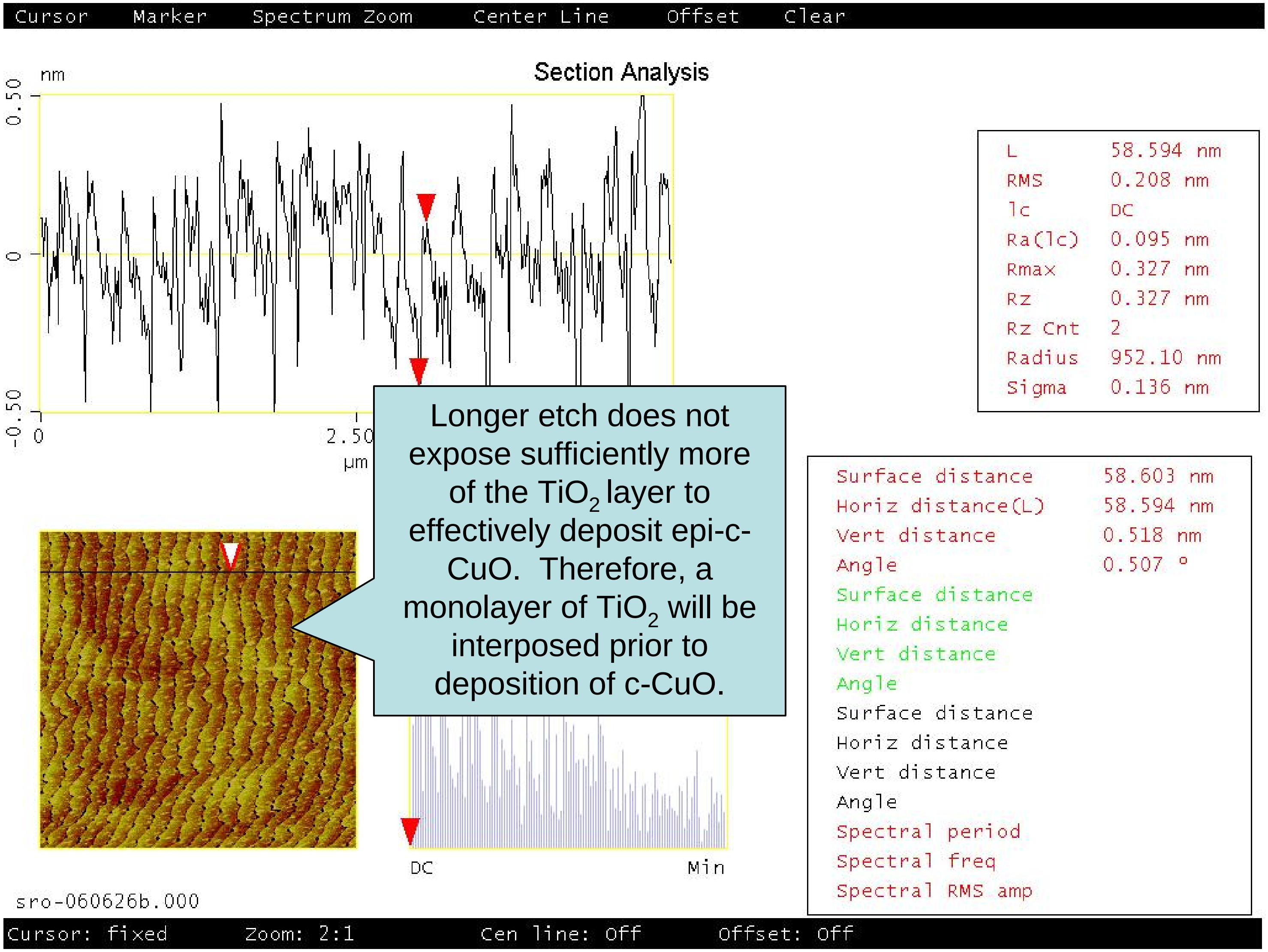
SRO on STO (HF etch 30 s)



SRO on STO (HF etch 40 s)



Longer etch does not expose sufficiently more of the TiO_2 layer to effectively deposit epi-c-CuO. Therefore, a monolayer of TiO_2 will be interposed prior to deposition of c-CuO.

II. Theory & Modeling

- No further modeling studies were performed this quarter. We have established computationally that cubic CuO will be structurally stable.
- Over the next two quarters of this year, we will explore using CASTEP in an attempt to predict the structural properties of thin CuO layers separated by NiO films to determine if a “cubic” multilayer of these two compounds is energetically stable.
- In addition, we will begin computational studies of the band structure and density of states of cubic CuO which would be critical in establishing the potential magnetic and superconducting properties of cubic CuO. This will require purchase of appropriate software.

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III. Plans for “Device” Fabrication and Measurements 3-4Q06

- Above depicts a stack layer to measure dielectric and magnetic properties of c-CuO
- Measurements: Dielectric constant of c-CuO determined by C-V characteristics and magnetic properties via magnetocrystalling bias coupling as revealed by ultrasensitive Kerr magnetic-optic detection unique to Stanford.
- The results of these measurement will apply to design device configurations to probe for superconductivity.

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