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Uniformity of Aluminum Oxide Barrier Conductivity as Obtained by Ambient Temperature C-AFM Mapping

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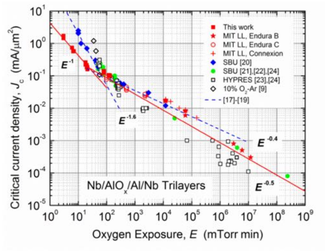
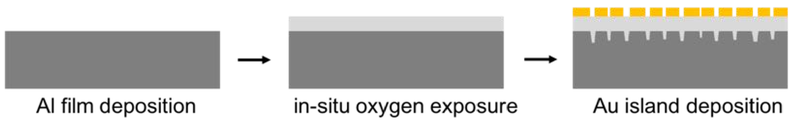
Motivation:

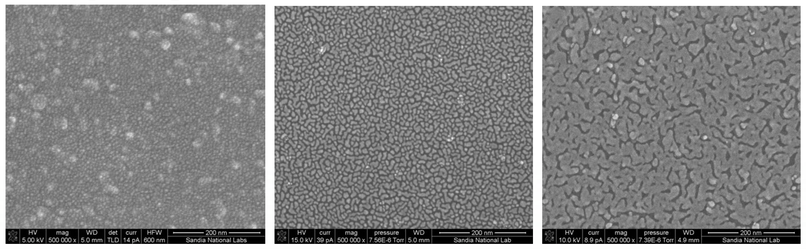
- Critical current density in AlO_x junctions decreases non-linearly with oxygen exposure
- What are the causes for critical current density drop?
- Can non-uniformities of the AlO_x barriers be imaged with conductive AFM?



Approach:

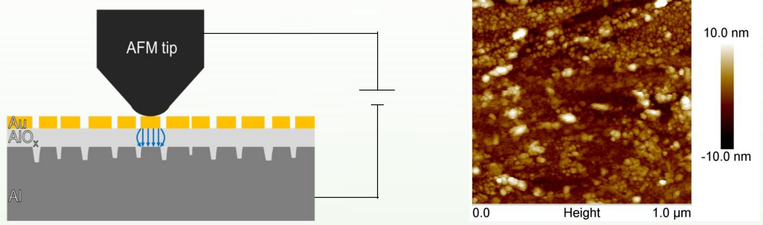


- Al films are evaporated onto Si substrates and exposed to oxygen in-situ in a dynamic flow
- Au islands are deposited subsequently, capping small areas and preventing further oxidation
- Oxygen exposure: 5 mTorr min and 10 mTorr min



2 nm Au film | 4 nm Au film | 7 nm Au film

- Au film of 4 nm leads to the most uniform island formation

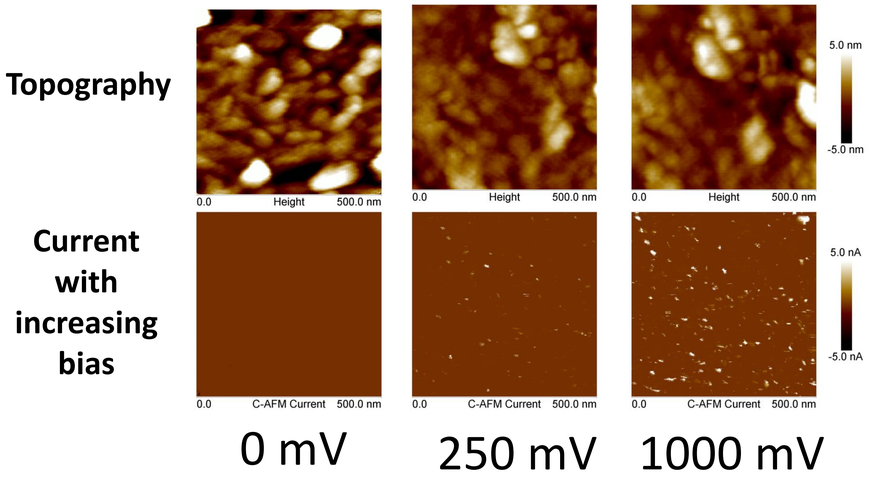


- Conductive AFM scanning across islands results in localized current measurement, exposing non-uniform current distribution

Conductive Atomic Force Microscopy:

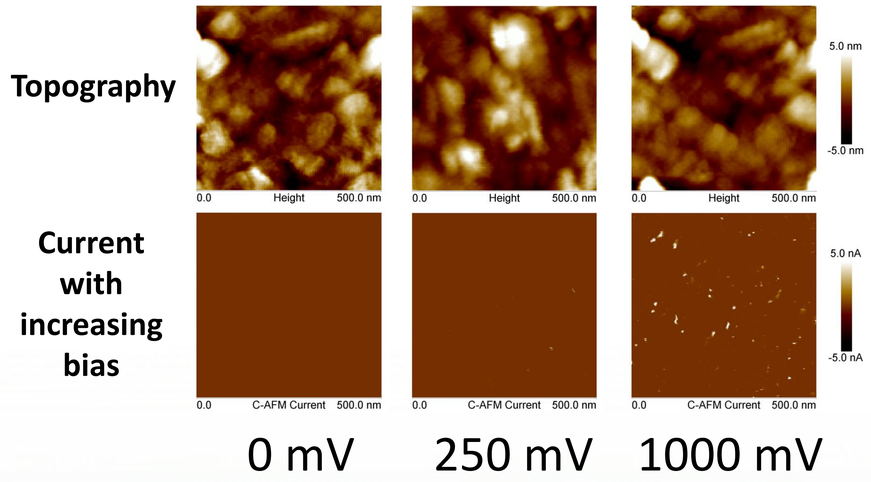
Oxygen Exposure: 5 mTorr min

- Increasing applied bias results in the detection of localized areas of higher electronic conduction or "hot spots"
- "Hot spot" density increases with applied bias
- "Hot spots" do not appear to be correlated with underlying Al/AlOx morphology



Oxygen Exposure: 10 mTorr min

- Increasing applied bias results in the detection of localized areas of higher electronic conduction or "hot spots"
- "Hot spot" density increases with applied bias
- "Hot spots" do not appear to be correlated with underlying Al/AlOx morphology
- Higher oxygen exposure requires higher bias to reveal "hot spots"



Summary:

- C-AFM allows for the study of non-uniform electronic conduction in AlO_x thin films
- Localized areas of electronic conduction are observed that do not appear to correlate with underlying Al/AlOx morphology
- Higher oxygen exposure, corresponding to thicker AlOx, requires higher bias to observe localized areas of electronic conduction

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