Characterization of Ultra-thin Rare Earth Nickelate Films by Electron Tunneling

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Recognition

- Daniel Ouellette
- Junwoo Son
- Susanne Stemmer
- S. James Allen
- Worster Family

Personal Accomplishments

- Designed and implemented a cleanroom process
- Measured samples and analyzed data

Motivation

- Understand the nature of oxide interfaces at the Mott metal-insulator critical point.

- Mott transition describes a change from metal to insulator due to electron - electron interactions. The electrons “freeze” in the insulating state.

- Phase change electronics: Mott field effect transistor

Approach

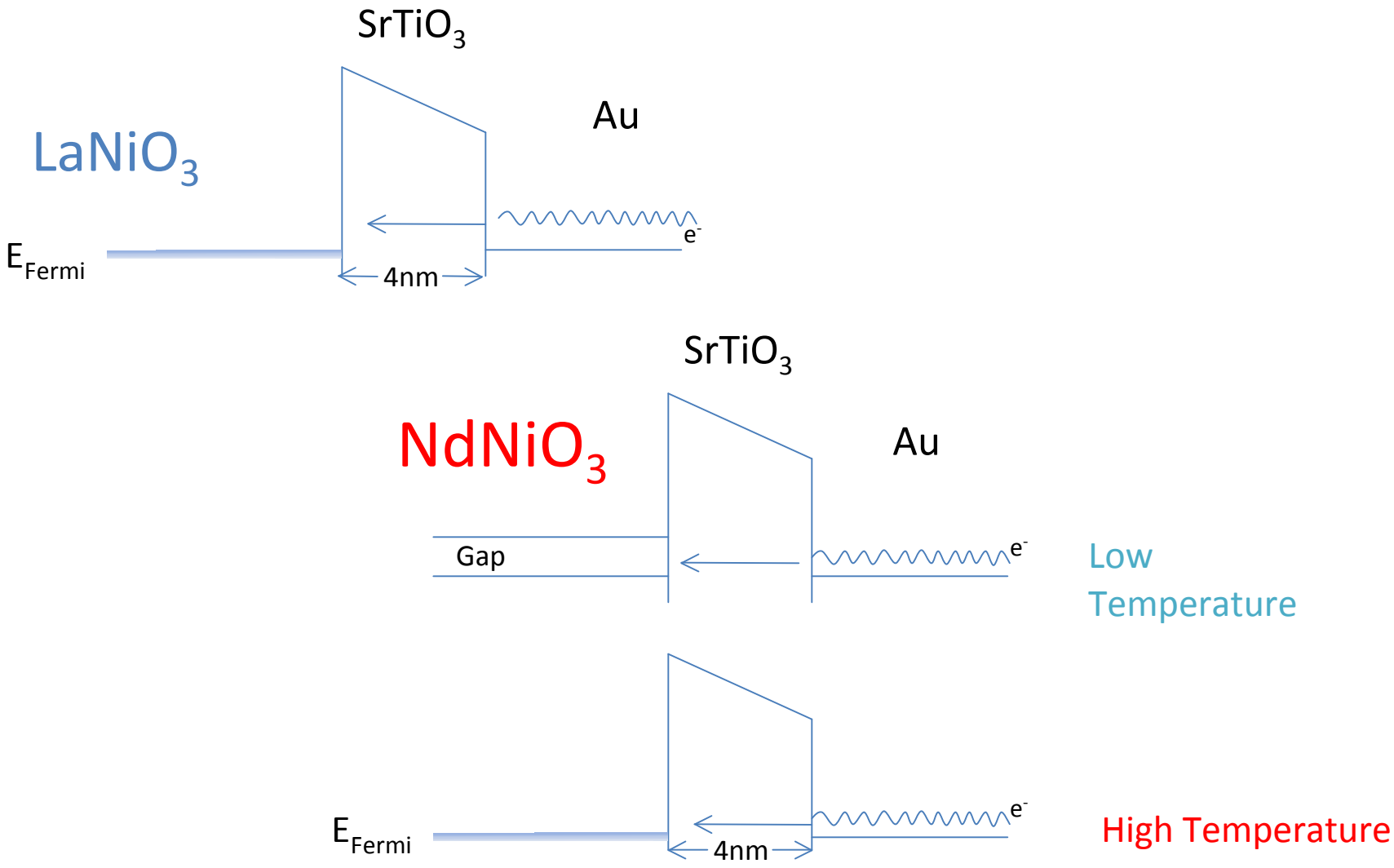
- Use tunneling spectroscopy to explore the conducting and/or insulating states in Mott films.

- Choose two films on either side of the "quantum" critical point:

  $LaNiO_3$ metallic side

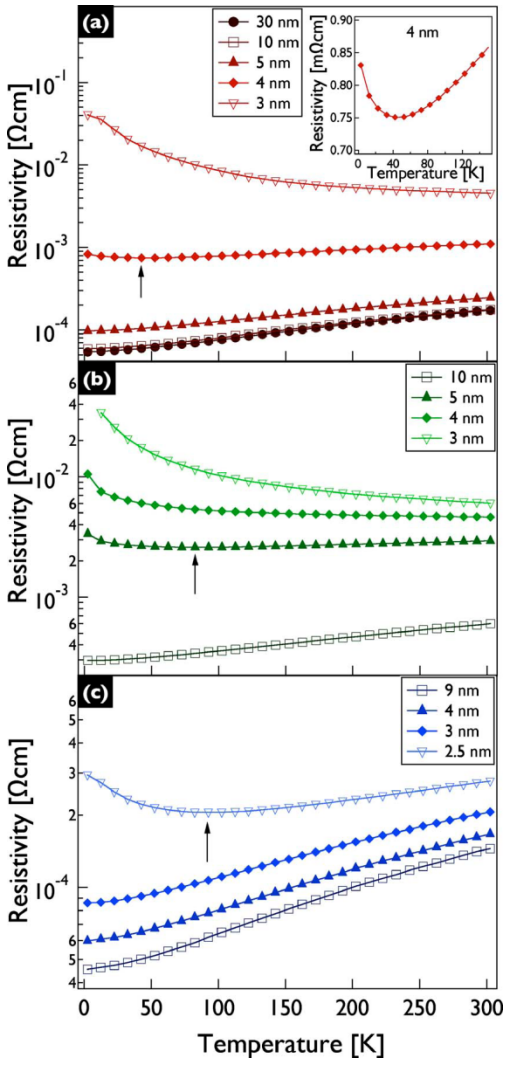
  $NdNiO_3$ insulator side

Tunneling spectroscopy

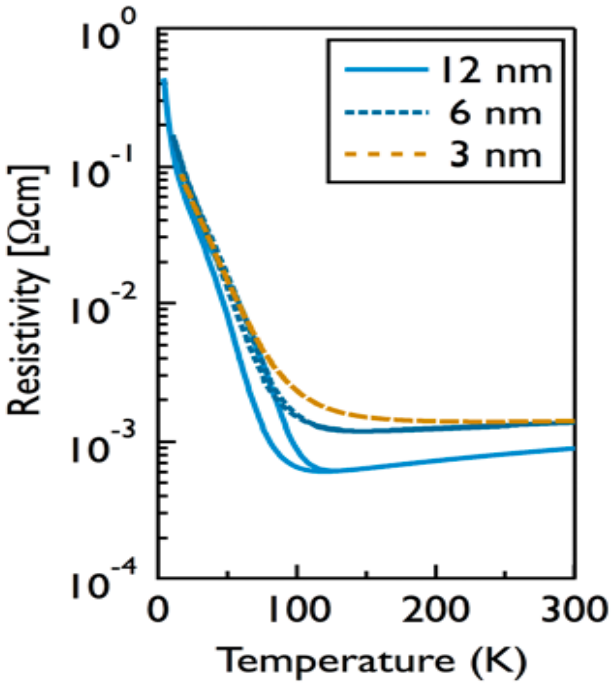


Resistivity $LaNiO_3$ vs $NdNiO_3$

$LaNiO_3$



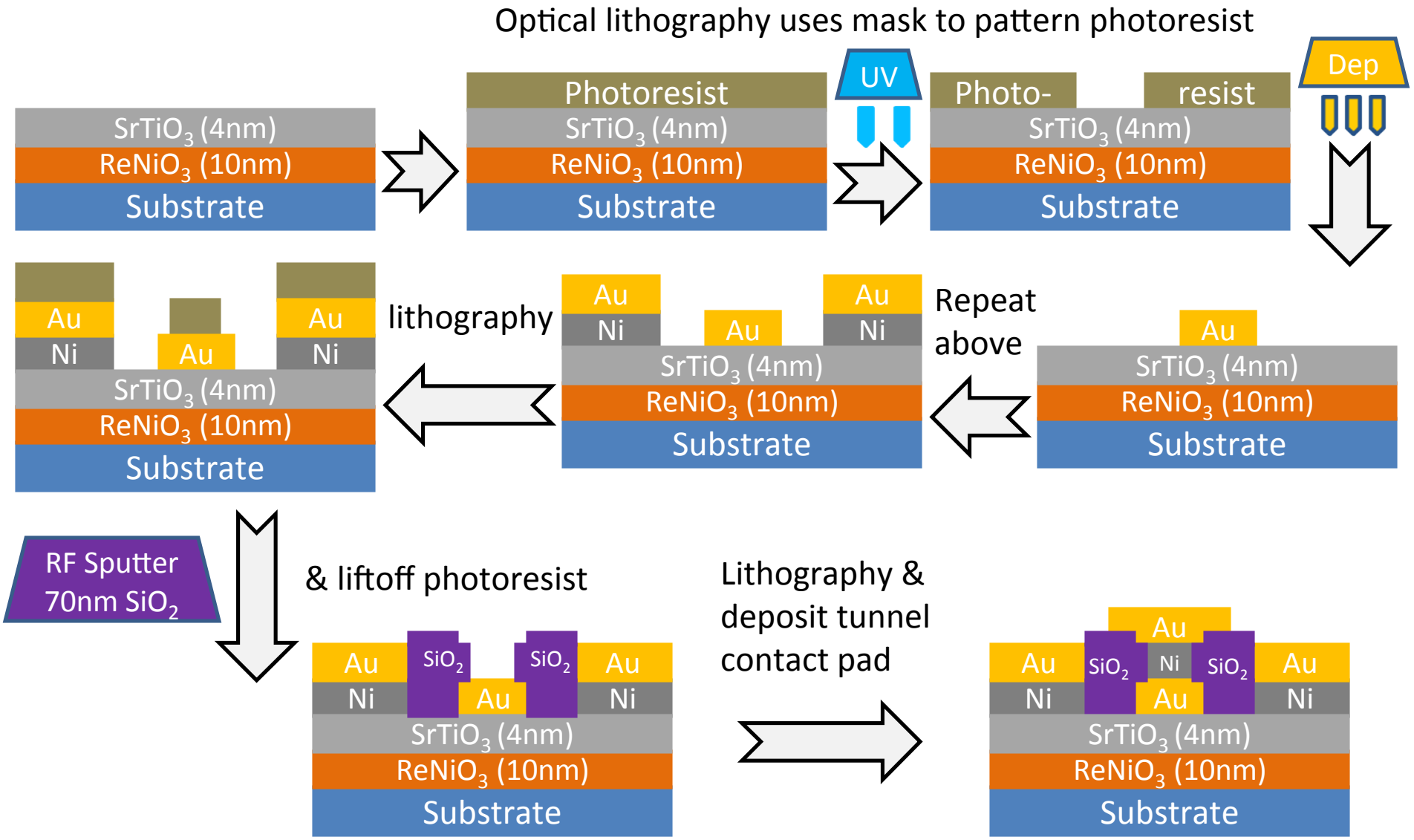
$NdNiO_3$



Substrate:
a)$(LaAlO)_{30.3}(Sr2AlTaO)_{60.7}$
b)DyScO3
c)LaAlO3

Figures courtesy of Junwoo Son

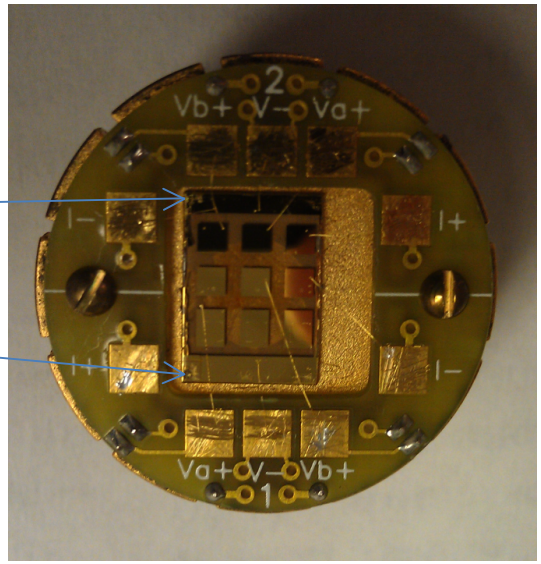
Process Flow

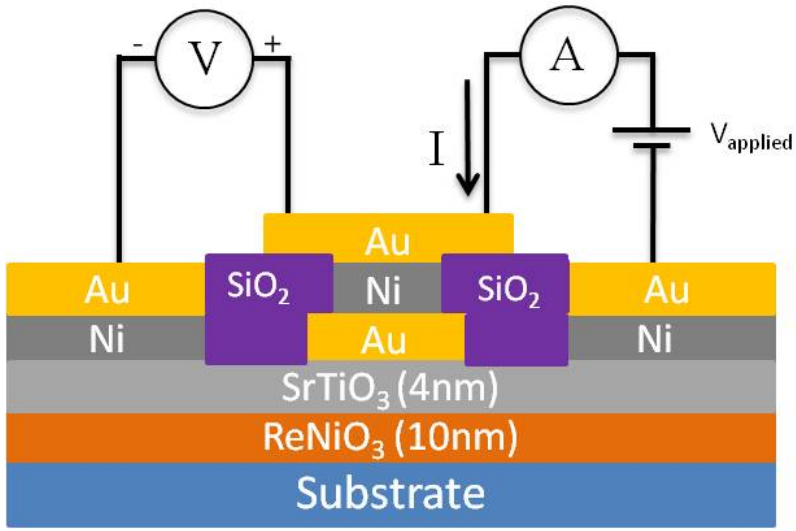


Measurements

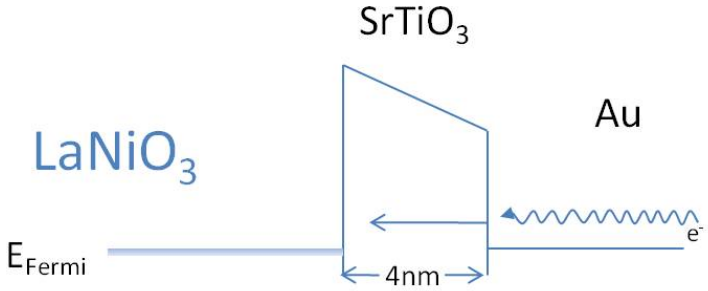
- Two or Three terminal measurement
  - Source voltage Au/Ni ohmic contact to Au tunnel contact
  - Measure voltage difference between other ohmic contact and tunnel contact

Ohmic contacts

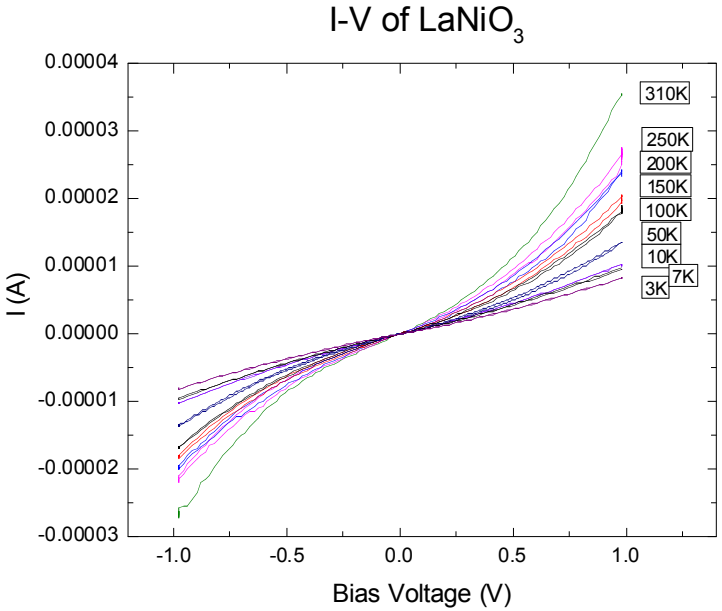


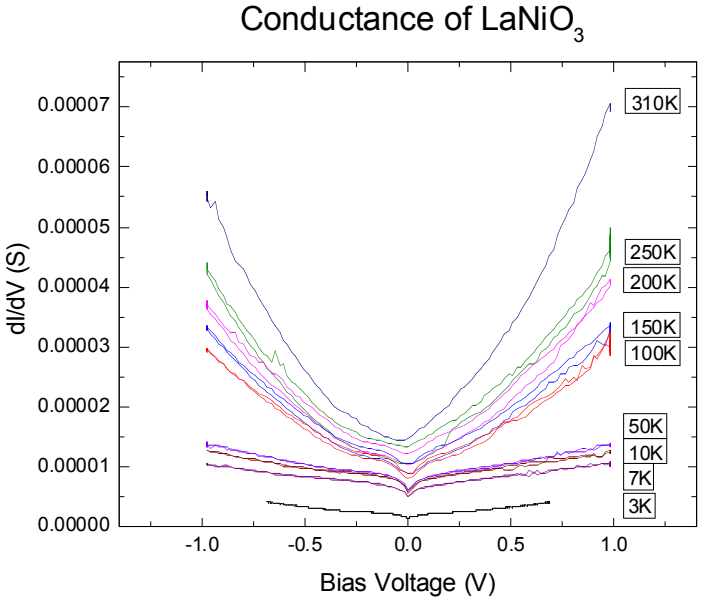


$LaNiO_3$ Tunneling



- Sweep bias voltage while measuring current and dI/dV
  - dI/dV shows that a gap is trying to develop in available states at the Fermi energy





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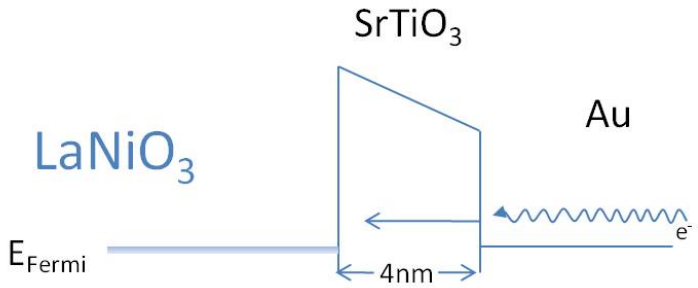
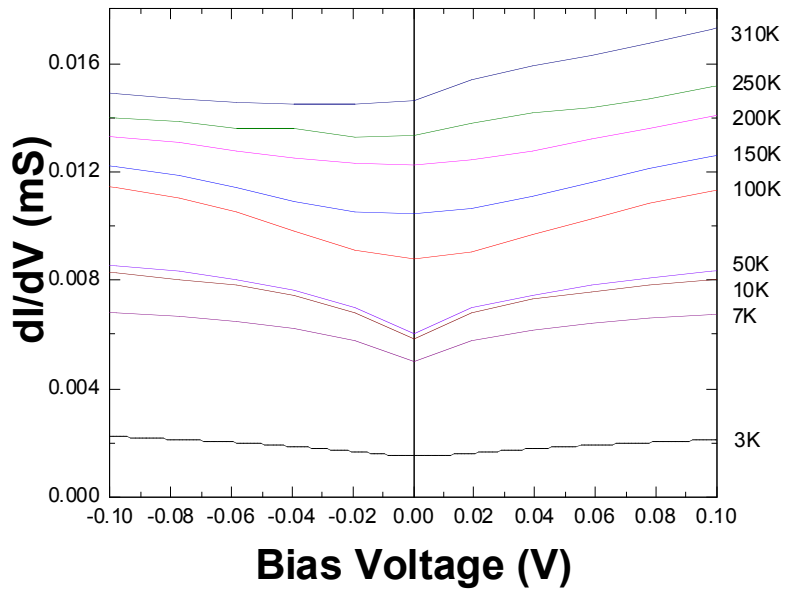


Is this due to electron-electron interactions in the presence of disorder (Anderson localizaion)

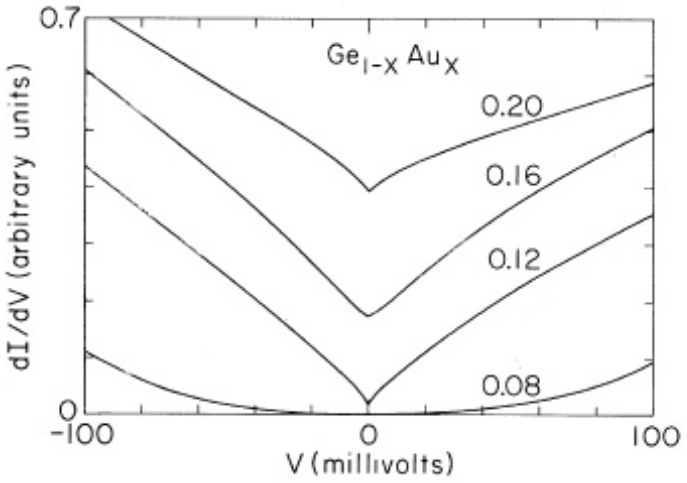
Or

Is this due to electron - electron interactions and incipient Mott transition to an insulator

Conductance of $LaNiO_3$

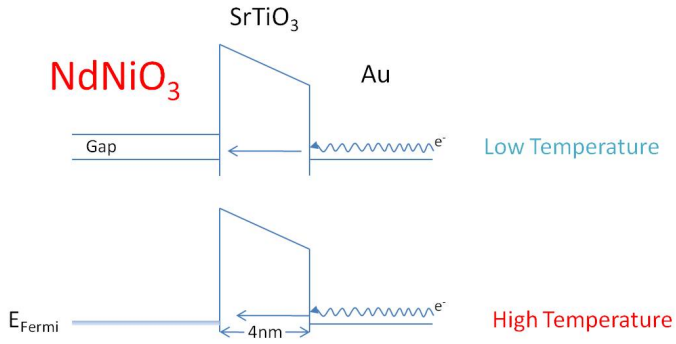


Disordered Film at T=2.5K
Anderson localization



McMillan and Mochel (1981)

$NdNiO_3$ Tunneling



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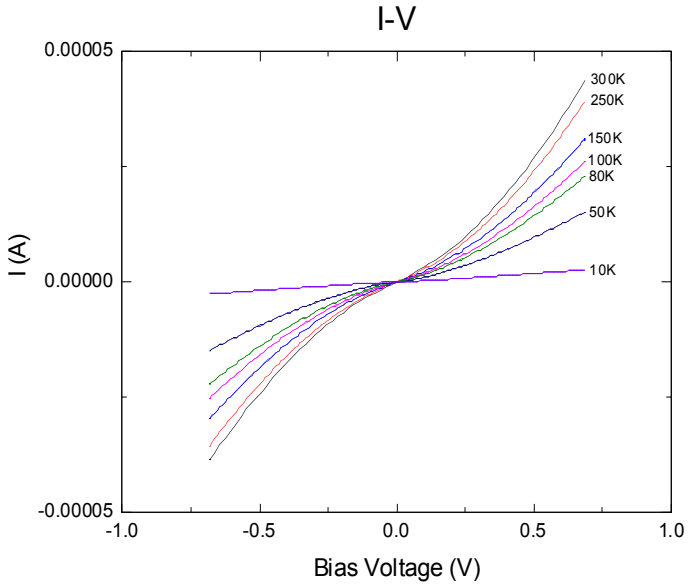

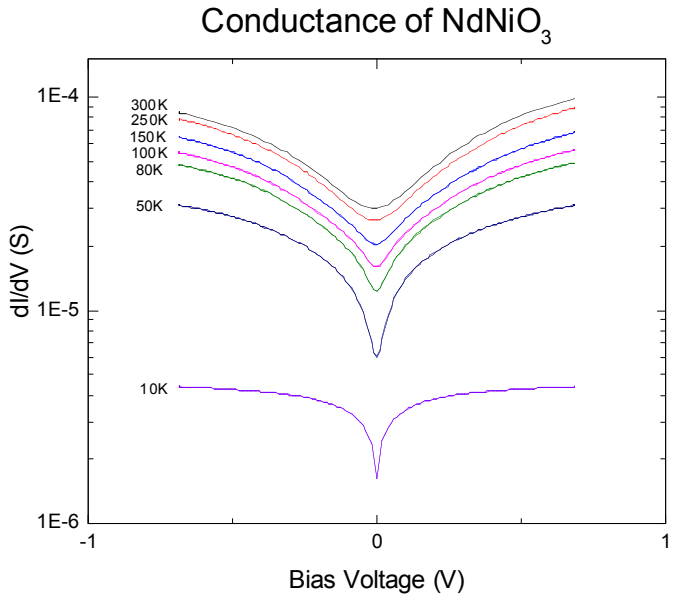

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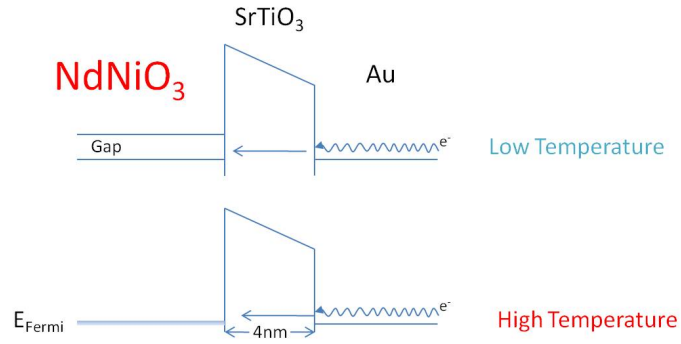

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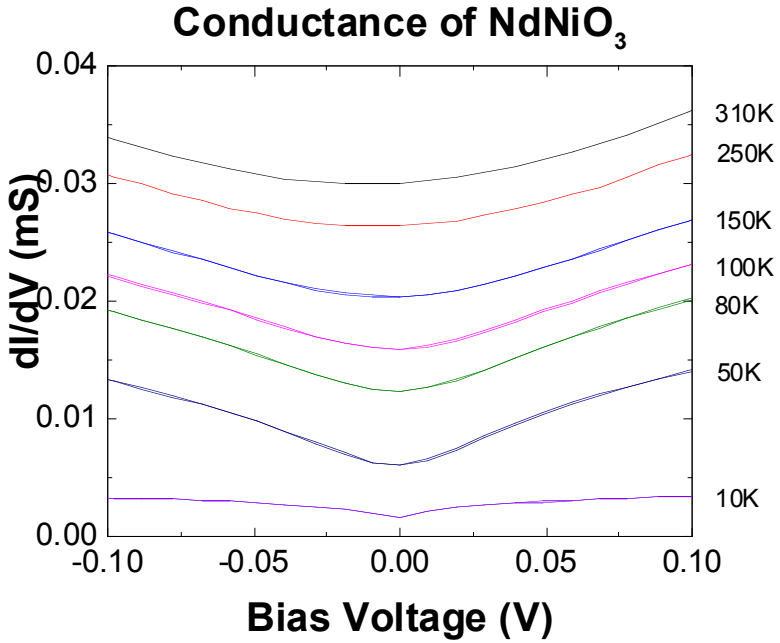

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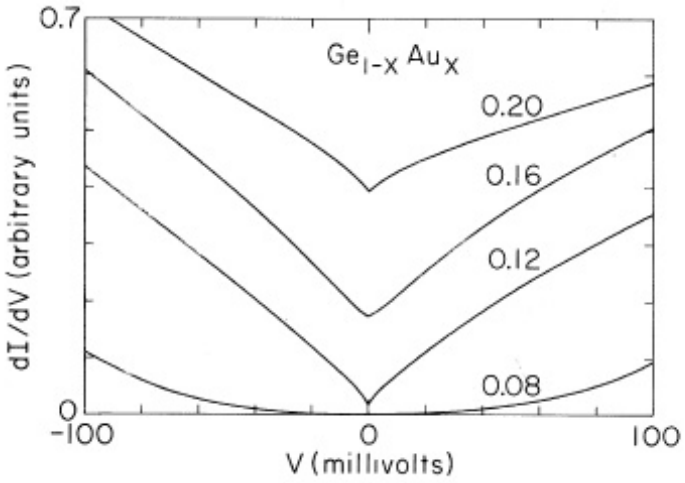
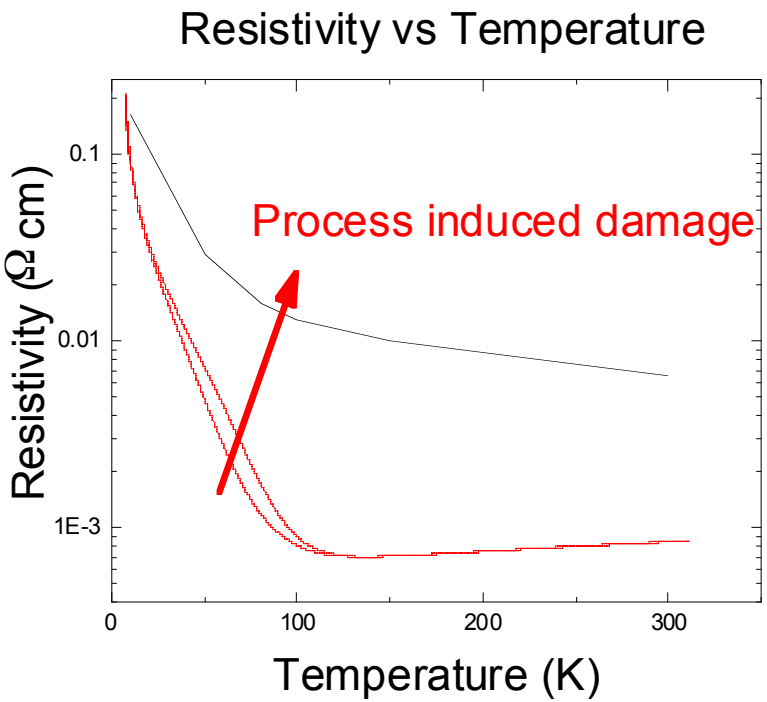


McMillan and Mochel (1981)

$NdNiO_3$ Resistivity



$NdNiO_3$ are fragile !!

New process underway !

Conclusion

- Developed a tunneling spectroscopy into Rare-earthNiO_3's
  - Measurement System
  - Process to make good tunnel junctions

- Measured zero bias tunnel anomalies caused by electron - electron interactions
  - Are they Mott pseudo gaps?
  - Need better $NdNiO_3$ to figure this out

Future Work

- Get the tunneling device to work in high quality $NdNiO_3$
- Better devices with $LaNiO_3$
- Measure tunneling into $NdNiO_3$ in a magnetic field ($NdNiO_3$ is an antiferromagnet).

Thank You!