Conduction mechanisms in cupric oxide films and nanowire networks

Shrividya Ravi, Alan Kaiser, Chris Bumby

The MacDiarmid Institute for Advanced Materials and Nanotechnology

Victoria University of Wellington
Te Whare Wānanga o te Ūpoko o te Ika a Māui

Introduction

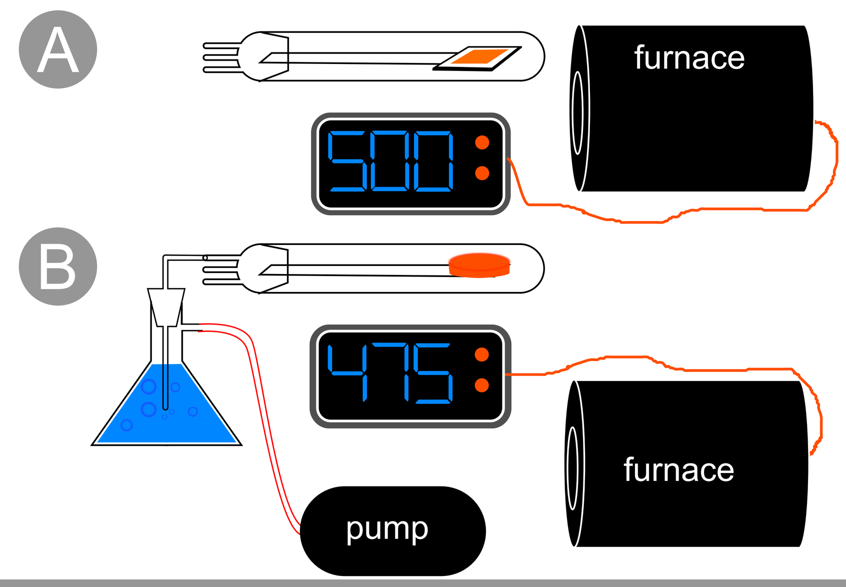
- Cupric Oxide or CuO is a p-type semiconductor with an indirect bandgap between 1.2 eV [1] and 1.40 eV [2]. CuO exhibits mobilities upto 5 $cm^2 V^{-1} s^{-1}$ [2].
- CuO nanowires can be fabricated by heating copper foil/ buttons in air [1].
- Our aim is to compare the dominant conduction mechanisms of majority carriers in polycrystalline CuO films ('bulk') and CuO nanowire networks.

Fabrication

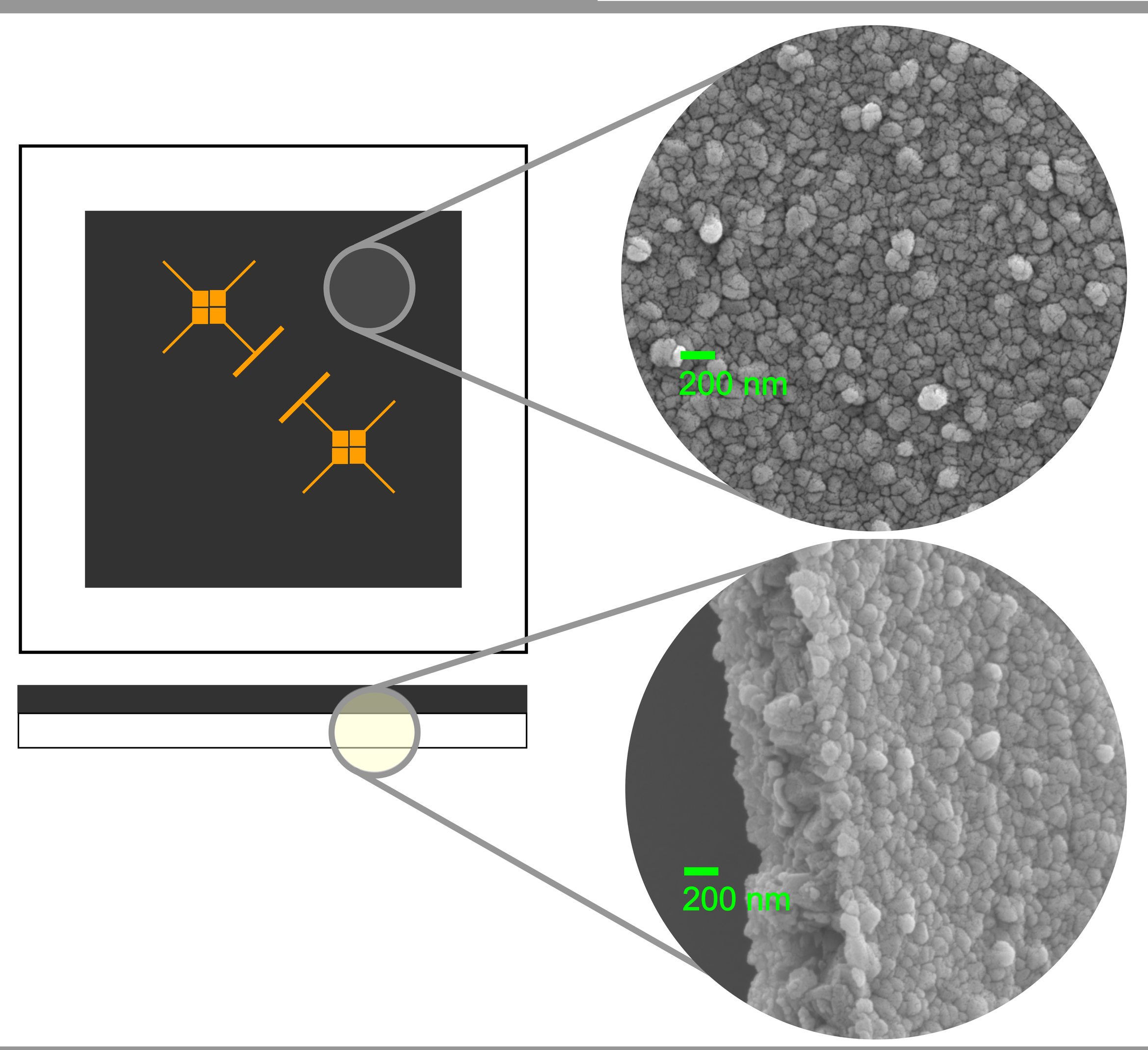
- Fabrication of CuO thin films (A) and nanowires (B) is carried out by thermal oxidation of copper in a tube furnace.

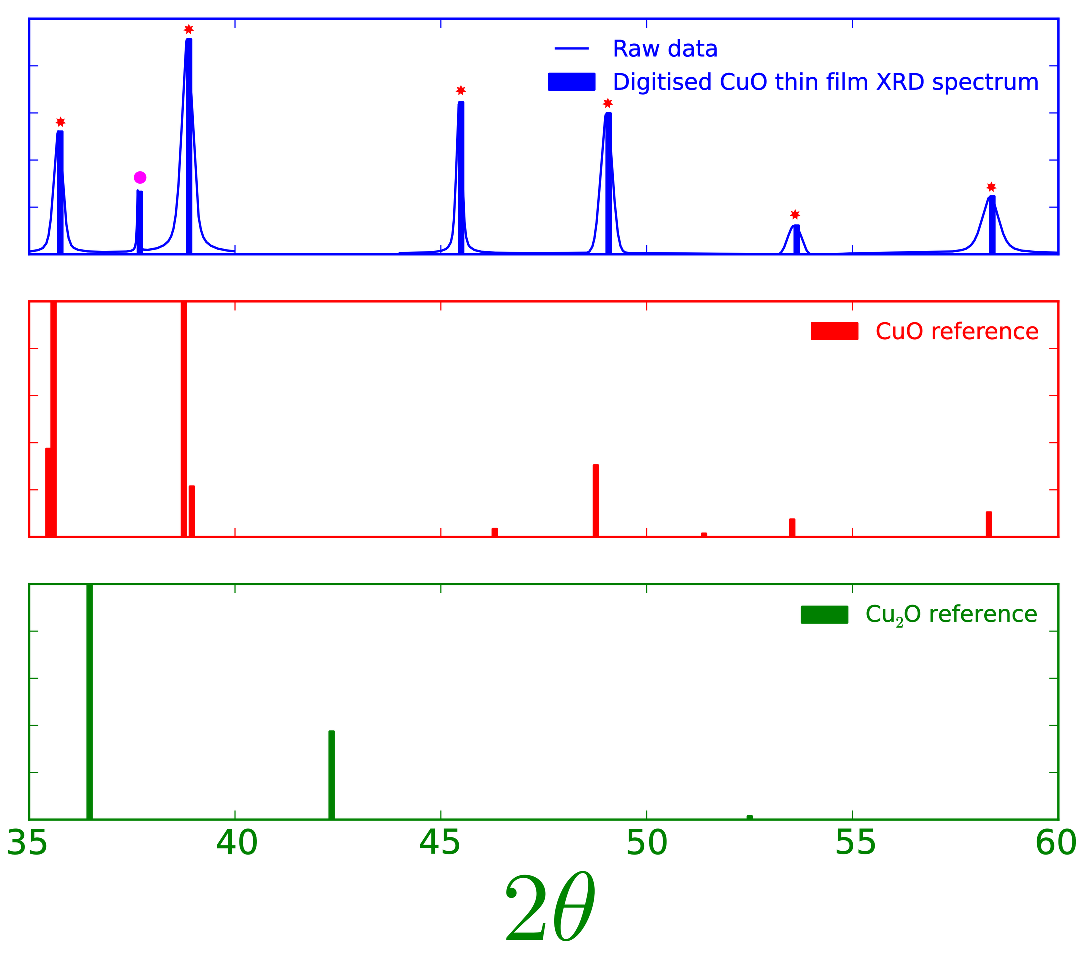
- CuO thin films are made by annealing ~1 micron thick copper (thermally evaporated on sapphire) at 500 C for 2 hours.

- CuO nanowires are made by annealing small copper buttons in 'wet' air at 475 C for ~ 2 hours.



CuO thin films





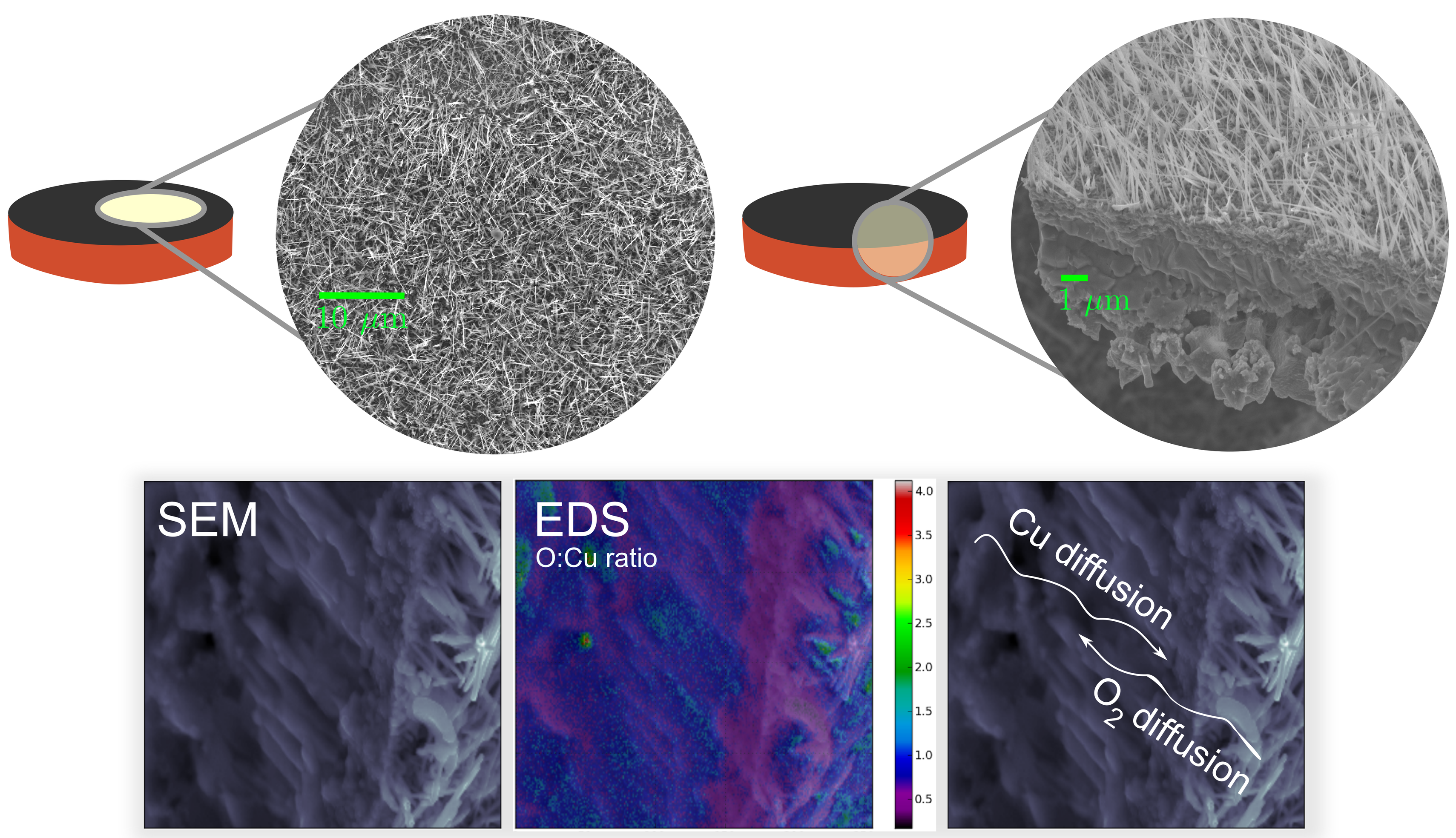
- Scanning electron microscopy (SEM) images on the far left show a clean polycrystalline film.

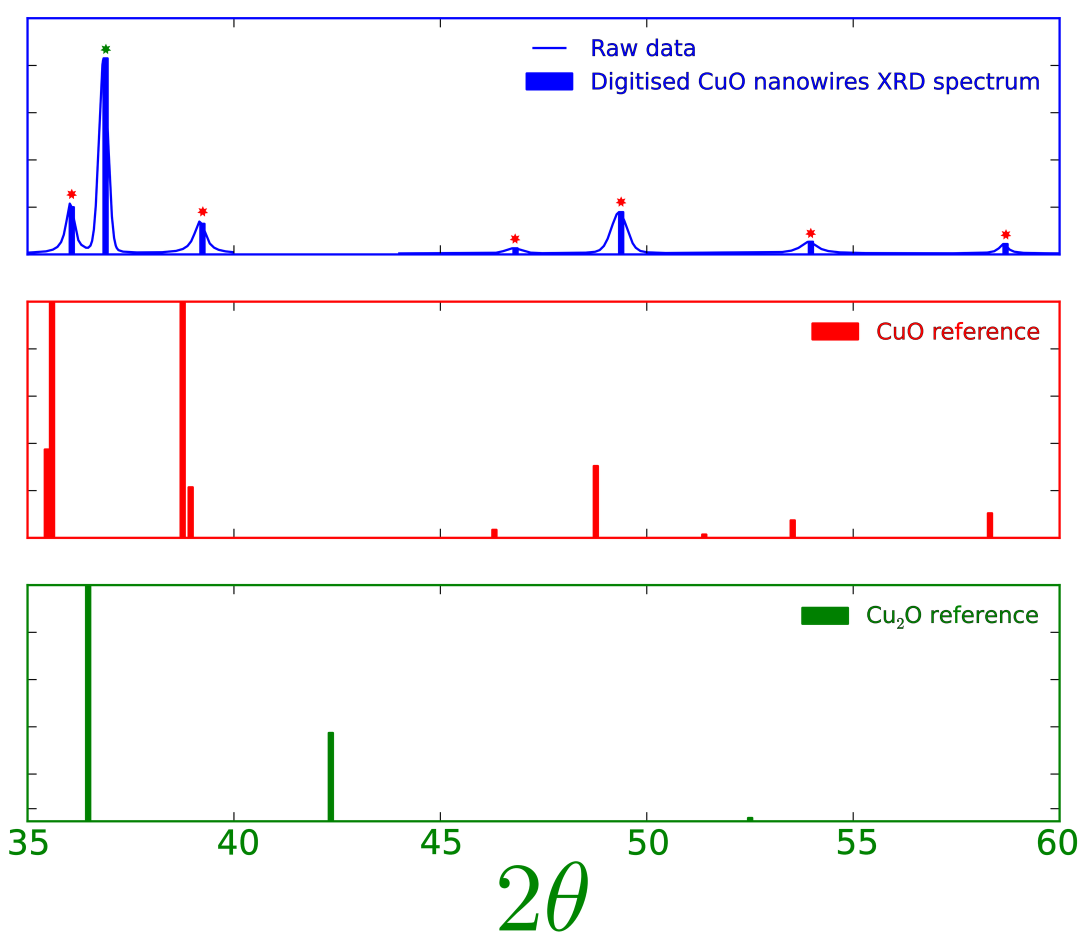
- The X-ray diffraction (XRD) spectrum was profile-fitted with Pseudo-Voigt or Lorentzian lineshapes. A digitised spectrum was then created from the fitted peak positions and normalised intensities.

- A comparison of the CuO thin film XRD spectrum with reference spectra show that it is entirely comprised of monoclinic CuO. The peak highlighted with a '•' is from the (1,1,0) reflection of the sapphire substrate.

- In order to obtain conduction data from the thin films, a simple two electrode geometry was patterned using photolithography. Chrome/gold contacts (shown in schematic) were thermally evaporated on the exposed pattern before lift-off.

CuO nanowires





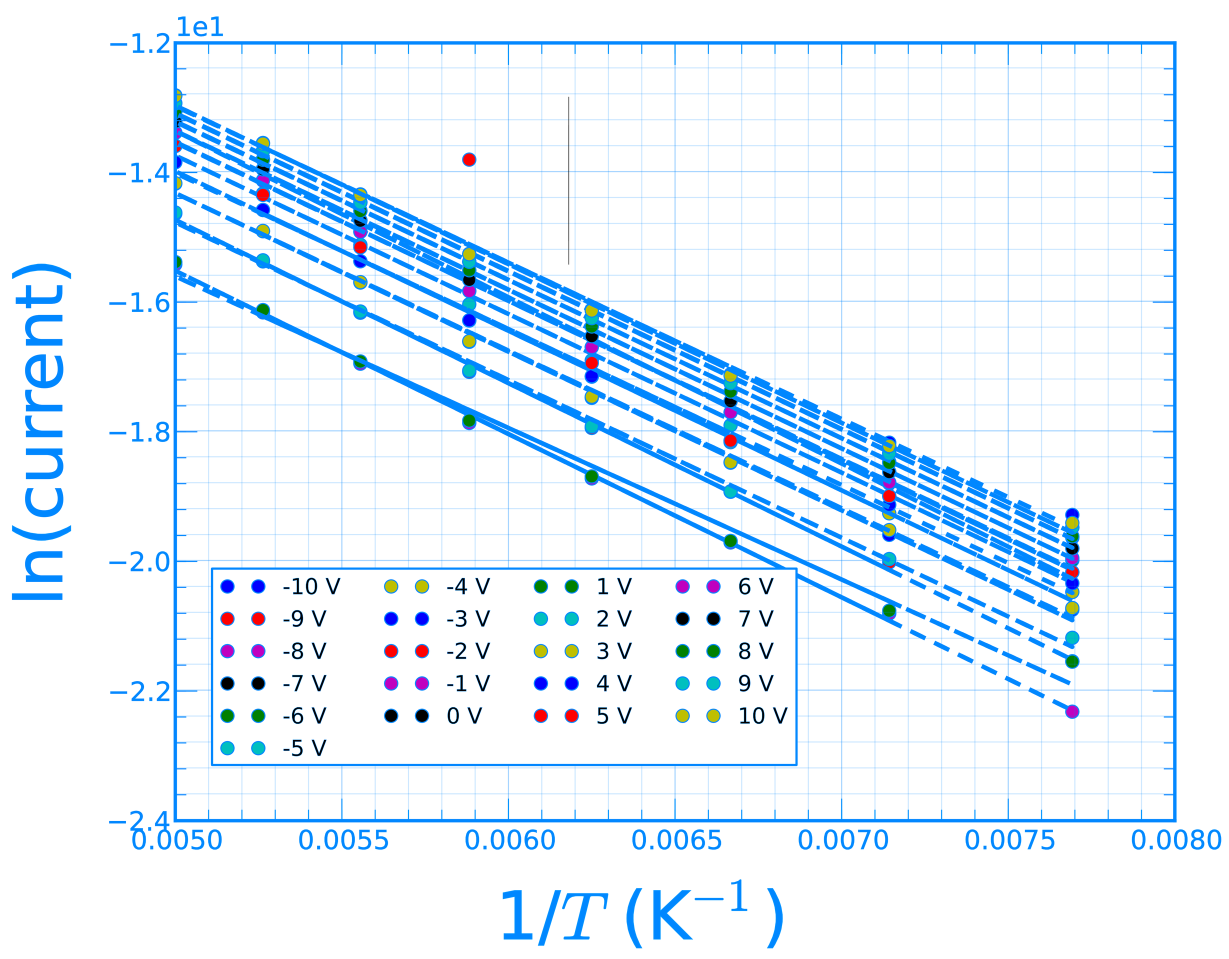
- The presence of nanowires after oxidation is indicated by a matt black surface.

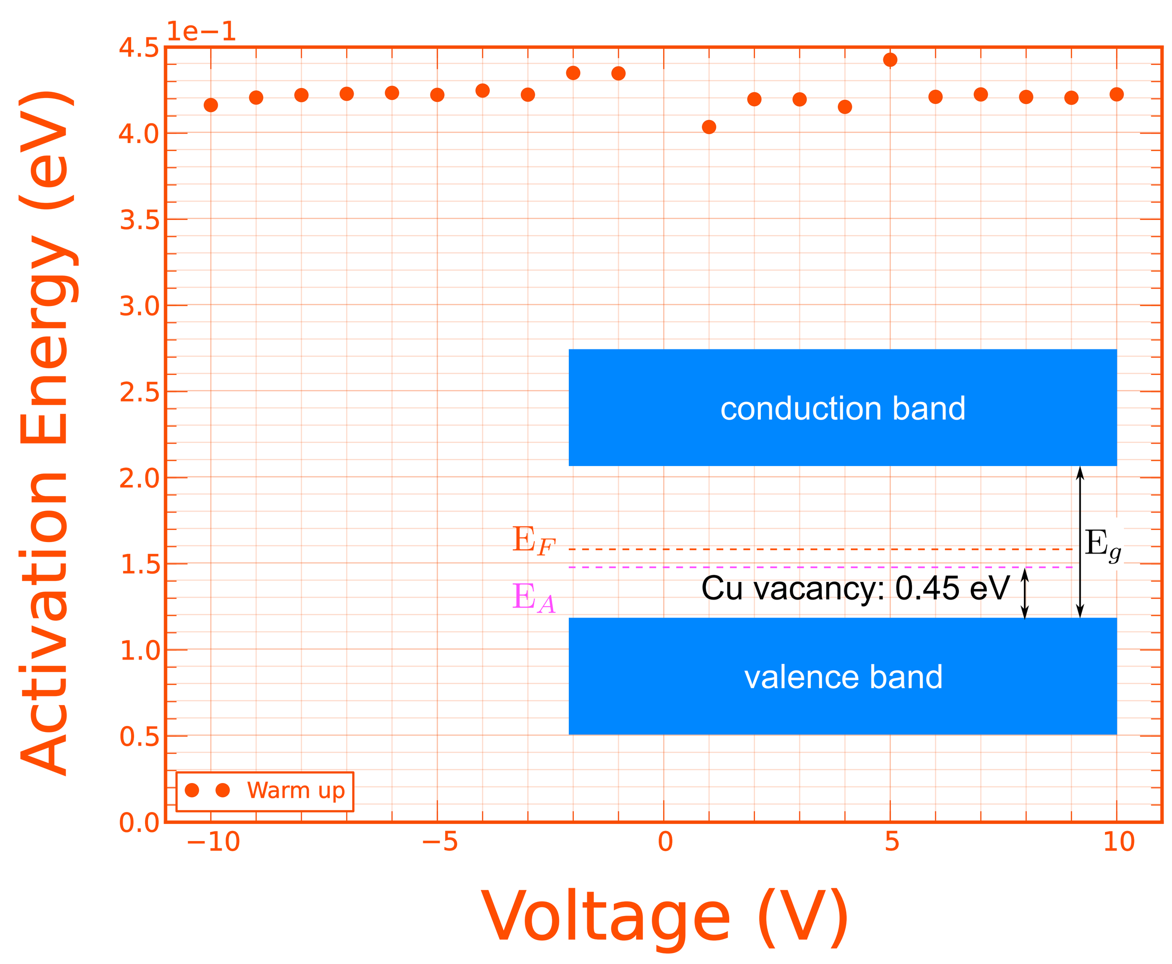
- SEM images on the far left show a nanowire forest growing from a thick polycrystalline oxide layer.

- Energy dispersive spectroscopy (EDS) suggests that the bulk of the polycrystalline layers are CuO while the 'seeding' oxide layer is copper rich Cu_2O.

- The digitised XRD spectrum for CuO nanowires shows a mixture of the two phases of copper oxide.

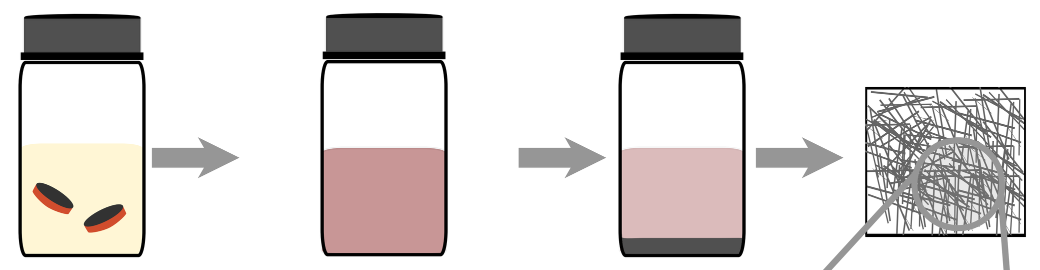
Conduction I





Temperature-dependent current measurements reveal an activation-type behavior for polycrystalline CuO. The average fitted activation energies for a range of different voltages is 422 meV. This value corresponds to activation from a deep level trap state caused by a copper vacancies in the lattice.

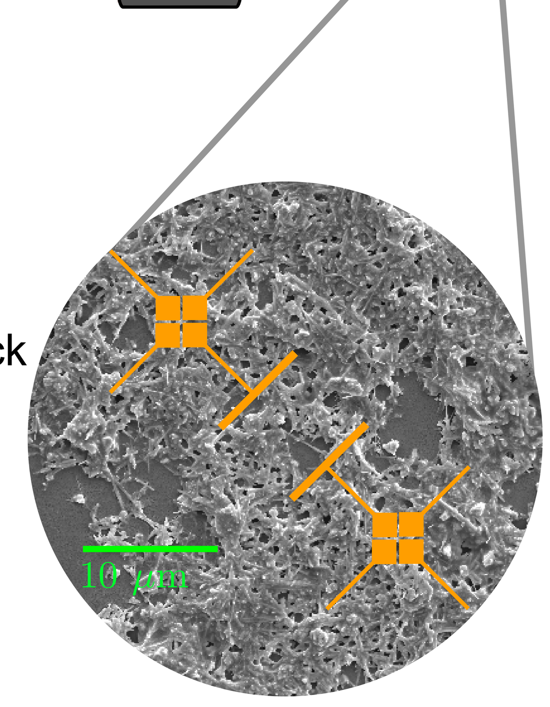
Conduction I



- Oxidised copper buttons are sonicated in acetone/ ethanol.

- The supernatant is decanted and cast as a thick film on sapphire.

- CuO nanowire concentration in the as well as electrode geometry and appropriate contact metals have not yet been optimised for measurements of the nanowire network.



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[1] Jiang et al. *Nano Letters* **2** (12) 2002.
[2] Liao et al. Nanotechnology **20** 2009.