Electrodeposited Au-CdTe-Au nanowires: solution-based control over Cd/Te stoichiometry

Lamar Mair*[1], Kwan Skinner[2,3], Carrie L. Donley[4], Richard Superfine[3,5]
[1]Curriculum in Applied Sciences and Engineering, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA 72599
[2]Department of Electrical and Computer Engineering, Duke University, Durham, NC, USA 27708
[3]Department of Physics and Astronomy, [4]Chapel Hill Analytical and Nanofabrication Laboratory, [5]Department of Computer Science, University North Carolina at Chapel Hill, Chapel Hill, NC, USA 27599

*Corresponding author: Lomair@email.unc.edu

Electrodeposition is an inexpensive, convenient, and versatile method for fabricating a wide array of metallic, semiconducting, polymeric, and multilayered films. Depositing these films into the pores of anodized aluminum oxide (AAO) membranes is a simple and efficient technique for fabricating micro- and nano-scale particles, rods, and wires. Specifically, CdTe has been recognized as an attractive solar cell material[1,2]. Controlling the wire composition inherently makes possible tuning of the electrical and optical properties of these compound semiconductor components.

Wires are fabricated by constant potential electrodeposition into the pores of Whatman Anodisc (AAO) templates. A 400nm Ag film is first evaporated onto one side of the template, creating a working electrode onto which subsequent electrodeposition takes place. The template is then placed in a standard three-cell electrochemical cell; a sacrificial Ag layer is deposited into the pores of the template. Au is deposited from a commercially available plating solution (Orotemp 24 RTU Rack, Technic Inc.) at -900mV with respect to a standard 3M Ag/AgCl electrode. Subsequently, CdTe is deposited at a constant potential of -580mV from an aqueous solution of 0.30M $CdSO_4$, 0.50M H_2SO_4, and varying concentrations of TeO_2. By tuning the concentration of TeO_2 in solution we are able to predictably vary the stoichiometry of the CdTe wire segments. Following deposition of CdTe a final Au layer is deposited at -1300mV, after which the Ag working electrode and Ag sacrificial layer are etched in HNO_3 and the AAO template is etched in 1M NaOH. The resulting Au-CdTe-Au wires are rinsed five times in ethanol and stored in the same.

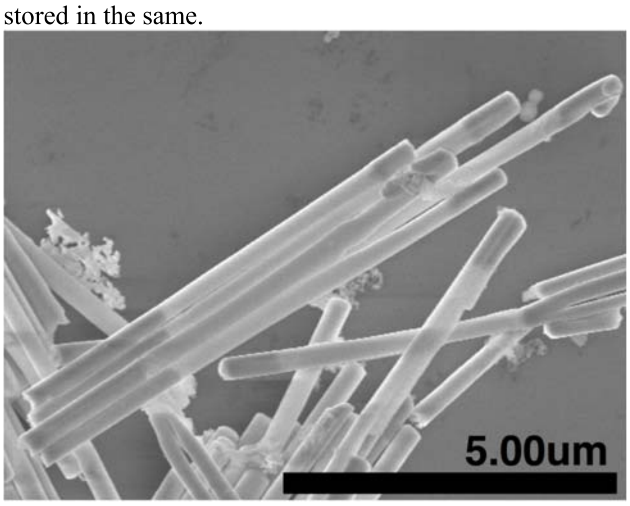

Figure 1: SEM image indicating Au-CdTe-Au wires deposited into the pores of Whatman Anodisc templates (200nm), released, and deposited onto a Si substrate.

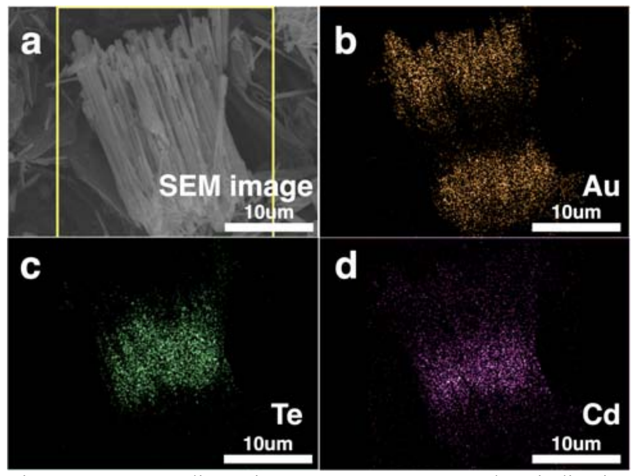

Figure 2: Energy-dispersive x-ray spectroscopy data indicating spatial distribution of elements Au, Te, and Cd. (a) SEM image of a Au-CdTe-Au wire bundle, (b) region of Au concentration, (c) region of Te concentration, (d) region of Cd concentration. This clearly indicates spatial confinemnt of Au and CdTe wire segments.

We have grown wires using solutions containing 6mM, 4mM, 2mM, and 0.5mM TeO_2. CdTe deposition takes place in a solution of 25ml and, so as to eliminate the possibility of Te depletion, the deposition current is monitored; to the same end, 10ml of CdTe plating solution is removed from the bath and replaced by 10ml of new plating solution once for every 1C of charge deposited. Wire compositional data was obtained by depositing the wires on a 12.7mm diameter graphite mount (Ted Pella, Redding CA) and performing energy-dispersive x-ray spectroscopy (EDS) experiments on the wires. The results indicate that solutions of 6mM TeO_2 produce wires which have Cd/Te atomic ratios of ~25/75, while solutions of 0.5mM TeO_2 produce wires which have Cd/Te atomic ratios of ~45/55. Wires produced using solutions of 4mM and 2mM TeO_2 were also studied and this data is shown in Figure 3. Furthermore, we study the current-voltage characteristics of these composition adjusted wires.

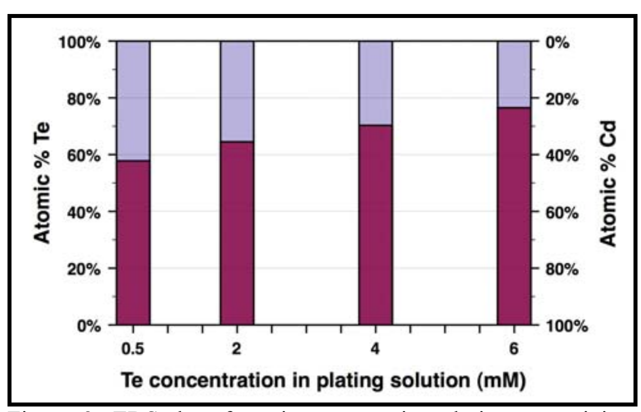

Figure 3: EDS data for wires grown in solutions containing various Te concentrations shows how wire composition depends on Te concentration in solution.

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[2] I. Gur, N.A. Fromer, M.L. Geier, A.P. Alivisatos, Air-Stable All-Inorganic Nanocrystal Solar Cells Processed from Solution, *Science* 310 (462), 2005.