Formation of Crystalline CdSe Nanostructures

Burcin Erenturk, D. Venkataraman, Kenneth R. Carter*
NSEC and MRSEC

Research Motivation
- Light hits a solar cell in the form of photons, which excite, or ionize, the atoms within the N-type (donor) layer, throwing an electron to the P-type (acceptor) layer.

Polymer Poster Symposium

Solar Photovoltaics
- Ideal industrially produced solar cells are currently based on silicon wafers (38.5%).
- Due to a fast growing demand and a shortage in silicon production, the price of photovoltaic modules is still very high (US$ 4.2/Wh).
- Moreover, single-crystal silicon solar cells, which have a power conversion efficiency of more than 20%, are heavy and fragile, which prevents them from being used for mobile applications.

Soft Nanoimprint Lithography
- Differences taken in NO60 imprinted templates before and after the 2-μm pitch etch.
- The assembled sample had an average height of ~500 μm, width ~100 μm, and the average distance between nanowires was ~500 nm.
- The thinnest lines had a uniform height of ~500 μm, width ~100 μm, and an average distance between nanowires was ~500 nm.

Hexagonal CdSe
- For positive CdSe deposition, the potential applied was on a range of -560 mV to -410 mV.
- The acidity of the stock solution was 1.4 KCl for all depositions.
- A fixed time of 20 minutes was acquired for successful CdSe nanocrystals.
- From comparison of the hexagonal peak positions to those of CdSe, it was determined that hexagonal CdSe is being deposited at a potential of ~560 mV.

NO60 Template Lift-off
- Different substrate systems were investigated for the NO60 template removal after the CdSe deposition.
- The images were taken at an 8° substrate inclination/interpolated at 0°-90° mV/NO60 removal using a 0.5 M HNO3/CH3OH solution at a 8° tilting/tilting/tilting, respectively.

Atomic Force Microscopy (AFM)
- To optimize the CdSe deposition, the potential applied was varied on a range of 600 mV to -410 mV.
- AFM and SEM on CdSe electrodedeposited samples after the removal of NO60 in ethanol to characterize the height, width, and spacing of the crystalline nanostructures.

Ideal Configuration
- Nanostructured materials are considered one of the best ways to improve the efficiency of organic and hybrid solar cells.
- This project aims at growing layered, crystalline Cadmium Telluride (CdTe) nanorods for use in high-efficiency solar cells.
- CdTe is a promising semiconductor material for solar cells because:
  - Stability
  - Epitaxial Production Technique
  - Potential Efficiency above 40%.
- In a hybrid polymer-nanocrystal solar cell, resistance can typically decrease less than 10 mV.
- The solar cell needs to be at a minimum, 11 mV, to keep the absorption of photons, depending on the active material.

X-Ray Diffraction (XRD)
- XRD was taken on all CdSe electrodedeposited samples both before and after NO60 removal in order to characterize the nanocrystals.
- Through observation, it is evident that the removal process does not damage the CdSe nanocrystals.

Conclusions
- Accomplishments
  - Impinging lines spaced as small as 400 nm on IT0.80 using soft lithography.
  - Etching through the imping down to the IT0 and retaining the feature for the CdSe electrodedeposition to be possible.
  - Successful deposition of highly crystalline CdSe nanocrystals in the template on IT0 & TO.
  - Lifting off the NO60 template and preserving most of the CdSe nanocrystals.
  - Future Works
  - Spin Coating photoluminescent layer (PSH) onto substrates having only CdSe structures present.
  - Optimization of the NO60 removal.
  - Development of a PDMS mold with smaller features through the use of Electron Beam Lithography (EBL).
  - Production of a functioning photovoltaic cell.

Acknowledgements
- We thank the National Science Foundation for their support of the CURE-REU program (NSF CHE-064934). 
- Center for Hierarchical Manufacturing that provided infrastructural support for this work (CMMI-0531177).
- Rachel Cottell
- Dr. Isaac Morson
- Semen Sariar
- B.Hanife Venkataraman

Center for Hierarchical Manufacturing ∗ University of Massachusetts Amherst