Student Paper

Infrared Absorption of Thin Film – Nanowire Hybrid Structures

Bright Chijioke Iheanacho[abc,] Minoli Pathirane[abc,] and William S. Wong[abc]

[a] *Department of Electrical and Computer Engineering, University of Waterloo, Waterloo, Canada, biheanacho@uwaterloo.ca,* [b]*Waterloo Institute of Nanotechnology, Waterloo, Canada,* [c] *Giga-to-Nanoelectronics Centre, University of Waterloo, Waterloo, Canada.*

The current advancements in solar cell and photodetector devices have shown the importance of the nanoscale geometry on light management, with recent reports demonstrating enhanced optical absorption using nanostructured materials and nanowires. The modifications, ranging from surface texturing to thin-film coated nanowires, have been used to improve the absorption of conventional materials such as hydrogenated amorphous silicon (a-Si:H) thin films. Most reports have shown improvement of the absorption up to the band-edge of the a-Si:H films while significant absorption beyond 780 nm has not been demonstrated. Extending the frequency response into the infrared wavelengths would enable low-cost infrared detectors and enhanced solar cell devices for Si-based devices.

An a-Si:H thin-film/nanowire hybrid structure has been integrated onto a single platform having optical light absorption with a wavelength range between 300 nm to 2.5 μm. The hybrid structure was fabricated by direct integration of a-Si:H thin film coatings by plasma-enhanced chemical vapor deposition onto a disordered zinc oxide (ZnO) nanowire mat. The ZnO nanowires were synthesized by hydrothermal growth at 85°C in a bath containing zinc nitrate hexahydrate and hexamethylenetetramine solutions on a ZnO thin-film seed layer. Conformal a-Si:H thin films up to 1.2 μm thick were coated on the disordered nanowire ensemble. Optical measurements show that the hybrid thin-film/nanowire structures have enhanced absorption in the infrared (IR) wavelengths from 900 nm to 2.5 μm compared to planar amorphous silicon films. For all thicknesses of amorphous silicon, the spectra also showed an enhancement in absorption intensity in the visible frequencies above comparable planar film.

Preliminary analysis suggests the enhanced absorption is due to scattering within the hybrid 3-D structure where the frequency response is a function of the coated nanowire diameter, the nanowire length, and the nanowire density. This scattering interaction leads to an increase in the effective thickness of the thin-film coating within a 3-D structure. Preliminary models of the scattering process as well as external quantum efficiency measurements will also be presented to further explain and quantify the observed IR optical response in the 3-D a-Si:H hybrid structure.