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Core-shell homojunction Si nanowire solar cells: Effect of shell growth and doping conditions on their photovoltaic properties

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Silicon nanowires (SiNWs) have been attracting a great deal of interest as a promising material for solar energy conversion to respond to the high demand for alternative renewable clean energy [1]. In contrast with planar cells, junctions in radial geometry of SiNW solar cells can maximize the light absorption by increasing the NW length and at the same time offer a short carrier collection path in the radial direction [2].To exploit the advantages of radial p-n junction, it is necessary to form a defined junction. Contrary to undefined junction depths formed by diffusion process and unstability of Si NWs/organic polymer hybrid solar cells, chemical vapor deposition (CVD) has the advantage of amenability to extremely precise control of shell thickness, doping concentration and crystal growth orientation.

Core-shell homojunction SiNW solar cells were fabricated, using a combination of metal-catalyzed electroless etching (MCEE) to form n-SiNW arrays and thermal CVD techniques for the growth of boron (B) doped p-type shell layers, to study the effects of shell growth and doping conditions on the photovoltaic properties. The short circuit current (I_{sc}) and fill factor (FF) closely depend on the shell growth time and the B_2H_6 gas flux. I_{sc} first increased and then decreased on increasing the shell growth time for the lower doping gas flux, while for higher doping gas fluxes I_{sc} monotonically decreased with increase of shell growth time. The increase in Isc is probably due to the formation of the appropriate depletion layer depending on the shell thickness and the B doping concentration. The decrease in Isc results from enhanced recombination of the photogenerated carriers due to high B doping.

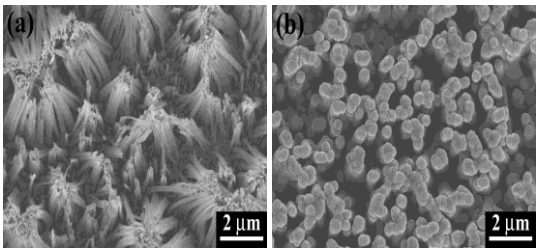

Fig.1. FESEM images of (a) the Si NW arrays and (b) the core-shell NW arrays formed using 0.5 sccm B_2H_6 gas flux for 5 min

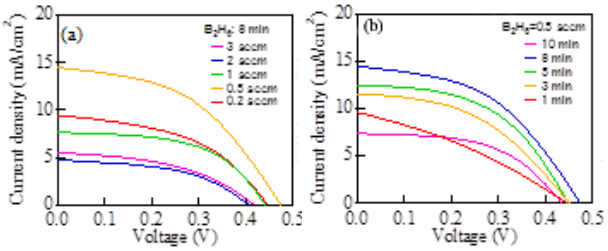

Fig.2. Current-voltage characteristics of (a) solar cells for different doping gas fluxes for shell growth time of 8 min and (b) solar cells for 0.5 sccm doping gas fluxes for different shell growth times under AM 1.5G illumination.

1. Barnham et al. Nat. Mater. 5, 161 (2006).
2. 2. Yoon et al. Appl. Phys. Lett. 96, 213503 (2010).