Radial Junction Thin Film Solar Cells on VLS-grown Si Nanowires

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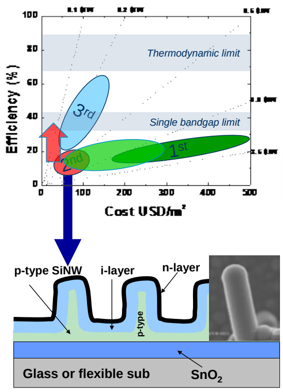
Radial junction thin-film solar cells grown over silicon nanowires (SiNWs) offer an opportunity to decouple the path of light absorption and carrier separation. Combining advanced radial junction designs with mature Si thin-film deposition techniques represents a promising road towards a new generation of high performance thin film photovoltaics. High throughputs of SiNWs can be produced via a vapor-liquid-solid (VLS) method. In order to produce SiNWs matrix at a relatively low temperature, we work on a group of low-melting-point alternative catalysts, including indium (In), tin (Sn), and bismuth (Bi) to catalyze SiNW growth in a PECVD system on glass substrates. These catalysts introduce only shallow levels in c-Si and show evidence of removal from the SiNWs by in situ hydrogen plasma treatment. Based on these technologies, we have been able to demonstrate an 8.2% conversion efficiency and showcased **an effective catalyst-doping in the SiNWs core for radial junction cell fabrication**.

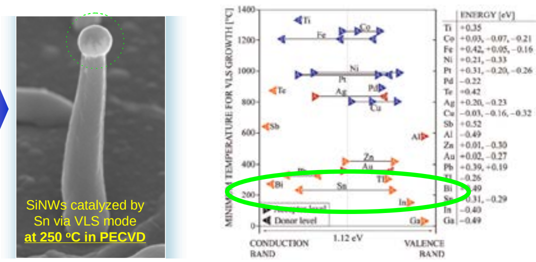
Why Radial Junction (RJ) Photovoltaics?

- Fabricate Si thin film solar cell in RJ architecture to promote performance
  - Si nanowire matrix for strong light harvesting
  - Economy in the step of TCO texturing
  - Allowing thinner absorber for higher defect tolerance and stability
- Combine mature & low-cost thin film technology with VLS SiNW growth
  - Vapor-Liquid-Solid (VLS) bottom-up represents a low-cost approach
  - Low temperature and compatible to the standard thin film deposition in PECVD system
  - **All-in-situ fabrication: ideally one-pump-down**



Advantages of using low-melting-point alternatives catalysts:

- Low-temperature growth down to 235 °C for Sn and 167 °C for In
- No mid-gap recombination centers, as introduced by Au



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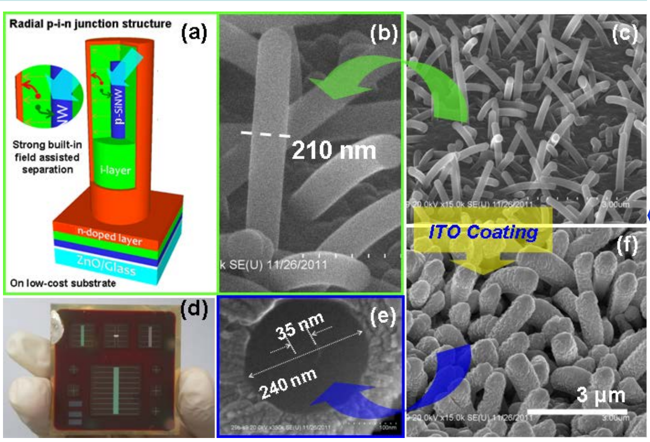
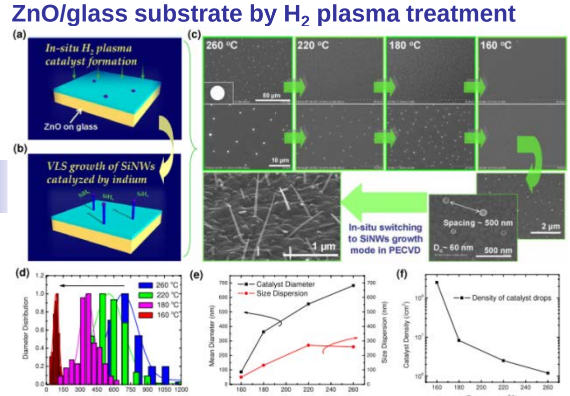


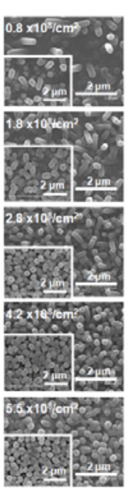
Effective distribution control of catalyst drops on ZnO/glass substrate by H_2 plasma treatment

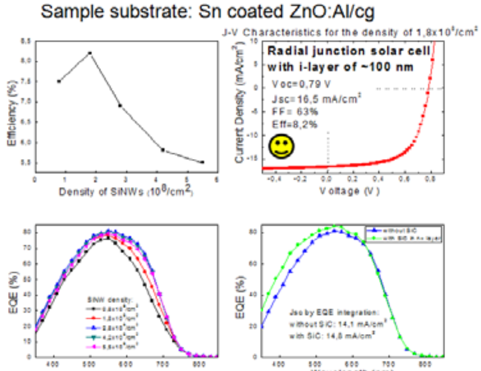


For details, see L. Yu, et. al. Nanotechnology, 23, 194011 (2012)

Effect of density variation

Sample substrate: Sn coated ZnO:Al/cg





- **Record efficiency of 8.2% is demonstrated**
- **Use of high bandgap SiC in the n+ layer helps to obtain better spectral response in the low wavelength region.**

Other References
[1] Solar Energy Materials & solar cells, 94, 1855 (2010) [2]. Prog. Photovolt: Res. Appl. 10,1002/pip.1245 (2011)
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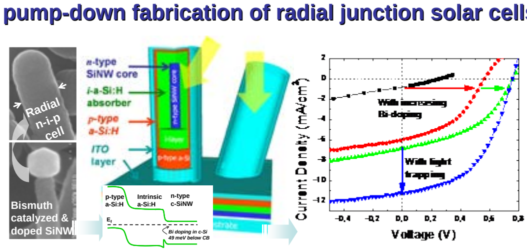
Bismuth-catalyzed & doped Si nanowires for one-pump-down fabrication of radial junction solar cells



- ✓ Demonstrate the Bi-catalyst doping in the SiNW cores for radial junction solar cells, with Voc=0.76 V and high Jsc boosted by strong light trapping effect
- ✓ Exempts the use of toxic phosphine gas, procedure simplification and cost reduction

For details, see L. Yu, et. al. Nano Letters 12, 4153−4158 (2012)

Conclusions & Perspectives:

- VLS-grown SiNWs have been explored to build up a new generation of high performance radial junction thin film solar cell.
- Aiming at a radial single junction cell to > 11%, and >15 % for radial tandem junction structure.