**High-Efficiency Nanostructured Window GaAs solar cells**

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**Abstract**

Nanostructures have been widely applied to solar cells for antireflection coatings, light trapping absorbers, core-shell radial p-n junctions, back reflectors, etc. These devices have demonstrated enhanced short circuit current density (Jsc) due to advanced antireflection and light trapping effects. However, nanostructures also increase the surface area and the number of defects, which results in lower open circuit voltage (Voc), fill factor (FF) and efficiency. In spite of quite major efforts to solve these problems, they remain significant challenges to utilizing nano-structures to achieve higher efficiency. Here we demonstrate the application of a centimeter-scale array of nanocones on an AlGaAs window layer GaAs solar cell, resulting in a high Voc (~ 1V) and a high Jsc (24.4 mA/cm\(^2\)), leading to a 17.0 % energy conversion efficiency.

**Nano-window Solar Cell**

- Metal mesa
- Nanocone window
- p-GaAs Emitter
- n-GaAs Base

**Voc Improvement**

- Conventional nano-structure solar cells
- Nano-window solar cells

**F.F. Improvement**

- Shunts at valleys
- Insulation layer
- Metal mesa separates contact and nanostructures

**Jsc Improvement**

- A heterojunction window in III-V solar cell

**Nanocone Window GaAs Solar Cell Performance**

- **Absorption Enhancement**
  - Nanocone window
  - Planar window
  - Less than 3% reflection from 400 to 850nm

- **JV Characteristics**
  - Nanocone window
  - Planar window
  - Voc (V): 0.979 vs 0.982
  - Jsc (mA/cm\(^2\)): 21.23 vs 24.4
  - FF (%): 63.1 vs 71.1
  - Eff (%): 13.1 vs 17.0

- **Voc comparison (V – Voc)**
  - Cui et al., Nano Lett. 2008
  - Malanti et al., Nano Lett. 2011
  - Zhang et al., Nano Lett. 2010
  - Fan et al., Nat. Mat. 2009
  - Oh et al., Nano Lett. 2012

- **Off-axis Bandgap (V – Voc)**
  - 1.12 c-Si
  - 1.42 GaAs Caffe
  - 1.75 a-Si

**Conclusion**

We have demonstrated a novel nano-structured window solar cell architecture with an AlGaAs nanocone window layer on a GaAs planar junction, which achieved 17 % efficiency. This is the highest reported efficiency among all III-V nanostructured solar cells. Importantly, the nanostructured window design provides high quality planar junctions which avoid the fundamental Voc and FF degradation in traditional nanostructured junction solar cells. A record Voc of 1.003V was achieved. Optically, tapered nanostructures with perfect gradual change of reflective indices from air to bulk produce a nearly perfect, angle independent antireflection interface. Electrically, the nanostructured window with a wider bandgap confines the minority carriers within the junction and significantly reduces surface recombination. Enhanced light absorption and carrier confinement lead to high Jsc.