SPIE Confrerence Micro and Nano-Materials Devices and Applications

NNL Abstract V2

Title: Light trapping for >30% tandem solar cells built on c-Si

Authors: Niraj N. Lal, Thomas P. White, Kylie R. Catchpole

Abstract (250 words)

Industrial silicon solar cells are rapidly approaching the 25% laboratory cell efficiency record that has stood for over 15 years. To further reduce the cost per Watt of solar energy, future industries will look towards technologies that go beyond 25%. Leveraging the success of c-Si solar cells, one such approach is to utilise high-bandgap earth-abundant semiconductors in top tandem cells placed above an underlying silicon cell. To achieve efficient tandems solar cells based on such materials, it is important to understand the effect of optical design on device performance.

We present key design parameters for optimising light distribution in these devices using simple analytical models. The parasitic light absorption of two transparent conducting layers is found to require top-cell efficiencies greater than 15% to achieve a break-even tandem efficiency of 25%. Low-pass intermediate reflectors are observed to be detrimental to tandem performance, and single-pass absorption is identified to be preferable to Lambertian light trapping with losses. Clear design principles are outlined to avoid these losses and simple light trapping mechanisms are proposed that distribute light effectively across the tandem cell.

We present detailed Figure of Merit calculations for various light trapping mechanisms, outline a broad overview of top cell requirements to reach specific target efficiencies, and identify key design recommendations that will enable the field to get there.

Summary (100 words)

Tandem cells based on high-efficiency c-Si solar cells can potentially lead to much higher solar cell efficiencies and lower costs of solar energy. Using simple analytical models we present key design parameters for optimising light distribution in these devices. Low-pass intermediate reflectors are observed to be detrimental to tandem performance, and single-pass absorption is identified to be preferable to Lambertian light trapping with losses. We present detailed Figure of Merit calculations for various light trapping mechanisms, outline a broad overview of top cell requirements to reach specific target efficiencies, and identify key design recommendations that will enable the field to get there.