Thrust: Photon Management and Transparent Conductors

Key Challenges
The thrust spans two major areas: light management and transparent electrodes for solar cells. The key challenges are several folds:

1. Develop materials and structures to couple maximum sunlight into the solar cells and to achieve near-complete absorption of above bandgap photon with significantly reduced usage of absorber materials.
2. Develop low-cost highly transparent (~95%) and low sheet resistance electrodes (<5 ohm/sq) for solar cells with n- and p-type contact capability.
3. Develop process to implement the above materials and structures in practical scalable solar cell manufacturing.

Existing Projects in our Thrust
- *Theory and Simulation of Photon Management in Nanostructured Solar Cells*, Shanhui Fan (Stanford)
- *Solar Cell Efficiency Enhancement via Light Trapping in Resonant Dielectric Sphere Arrays*, Harry Atwater (Caltech)
- *Large-Area, Fast, and Electric-Field Assisted Continuous Coating for Nanostructured Photon Management*, Ning Wu (Colorado School of Mines)
- *Percolating Transparent Metallic Electrodes for Solar Cells*, Mark Brongersma (Stanford)
- *Ideal Transparent Conductors for Full Spectrum Photovoltaics*, Wladek Walukiewicz (LBNL)
- *New P-type Transparent Conductors*, Joel Ager (LBNL)
- *Graphene Electrode Eng. for Photovoltaic Application*, Kaustav Banerjee (UC Santa Barbara)

Potential New Areas of Interest
- *Extension*. Thus far, photon management is mainly aimed for enhancement of short circuit current. There are exciting opportunities to explore photon management to reduce photon entropy loss to increase open circuit voltage.
- *Integration*. Integrate photon management together with electrical transport to fully engineer the structure to enhance solar cell efficiency as a whole. In addition, there are significant opportunities to integrate the materials in the transparent conductor projects with the design and modeling efforts in the photon management projects. For example, transparent electrodes may be designed as an efficient structure for light management purposes. Alternatively, one may incorporate advanced optical design to reduce the loss in transparent electrode while maintaining its electrical properties.
- *Manufacturability*. Photon management will only be viable, if it can be implemented in a cost effective way. Study the integration of new photonic structures and transparent electrodes into practical scalable solar cell manufacturing.