Thrust: High Performance and Multijunction Cells

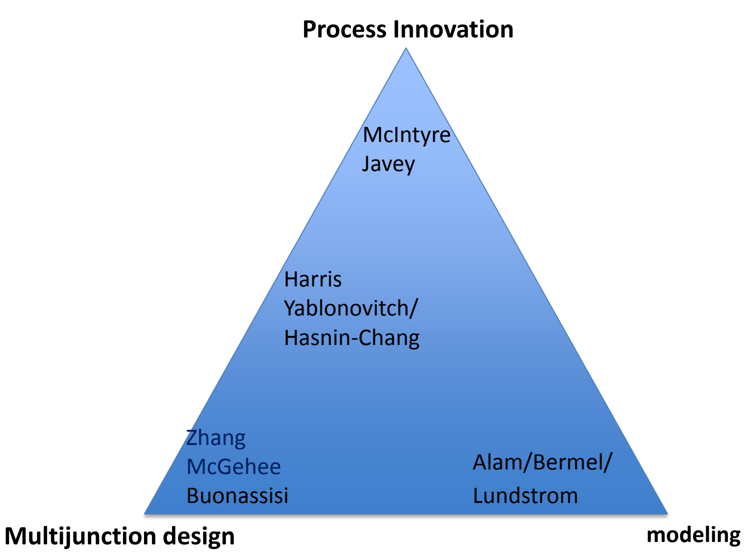
Grand Challenges and Key Problems

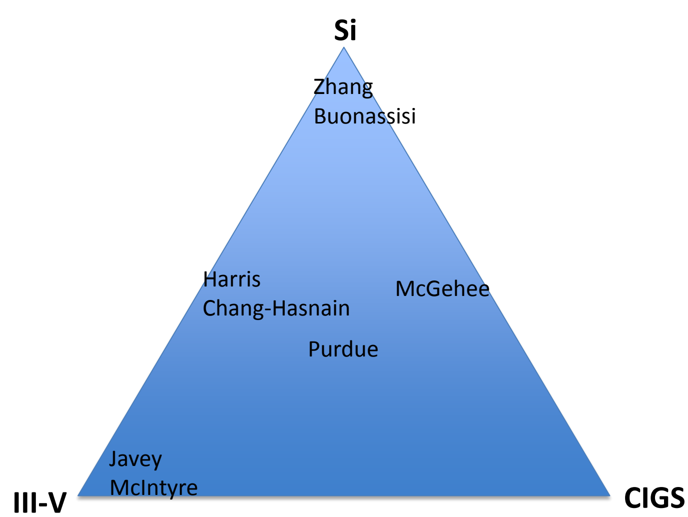
The goal of this thrust is to explore new growth processes, material systems, and device architectures for offering high device efficiencies at low processing costs. In particular, two parallel approaches are being explored, one relying on reducing the processing costs of III-V single junction solar cells and the other exploring tandem device architectures based on Si bottom cells. III-V compound semiconductors have exhibited the highest performance efficiencies for single-junction cells, currently at 28.8%. However, their $/watt module costs have been estimated by NREL to be currently >10x of those of Si cells. This high cost mainly arises from the initial epi-growth substrate, and the MOCVD process. This presents a fundamental challenge for the field and demands the need for developing disruptive growth and processing technologies that would drastically lower the cost without sacrificing the device efficiencies. In parallel, tremendous opportunities are present in exploring tandem cells based on Si (or CIGS, CdTe, or III-V) bottom cells to enhance the efficiency of the existing PV technologies, but with careful consideration of the costs to ensure a balance approach is developed. Cost analysis, device modeling, and experiments are being performed in parallel in a collaborative manner to ensure success.

Current Projects:

The current projects in the thrust can be summarized based on their

1. Lowered processing cost for III-V
    a. New process/growth technologies (Javey, McIntyre)
    b. Non-epi substrates (Javey)
    c. Ultrathin films, down to 100 nm (Harris)
2. New Tandem cell structures based on Si, CIGS, and III-V bottom cells (Buonassis, McGehee, Yablonovitch/Hasnin-Chang, Zhang)
3. Modeling (Lundstrom/ Bermel)





Potential Growth of BAPVC

- More cost analysis of the explored research projects in collaboration with NREL. Currently 2-3 of the projects within the thrust have had cost analysis discussions with NREL. More projects can follow this path.
- Exploring the device processing and manufacturability of the new III-V growth technologies, such as the thin-film VLS process.
- Exploring surface passivation effects and back-contact reflectors for the new III-V growth technologies, such as the thin-film VLS process.
- Better understanding (experiments and modeling) of the types of defects that their correlation to performance for the new III-V growth technologies, such as the thin-film VLS process.
- Development of high bandgap (III-V, II-VI, perovskite or other) solar cells for performance in tandem devices
- Defect mitigation during silicon cell fabrication, for improved multijunction bottom-cell performance.
- Defect recognition and characterization in high-quality Czochralski silicon for high-efficiency PV devices.
- Light management in tandem and other high performance solar cells.
- Development of tunnel junctions, recombination layers, polymer electrolytes, or other transparent contacts that will enable current matching between silicon solar cells and a high bandgap solar cell.