Problem & Motivation

- Shockley-Queisser limit: ~33.7%
- Goal: increase the range of photon wavelengths a solar cell can absorb
  - Multi-junction solar cells
  - Multi-quantum well (MQW) structures
- Best single junction solar cell: GaAs
  - Interest in QWs from GaAs and related alloys (e.g., AlGaAs, InGaAs, GaAsP, etc.)
Multi-Quantum Well (MQW) Solar Cells

- Staggered quantum wells in place of intrinsic layer
- Photons with $E < E_g$ can be absorbed by quantum wells
- $I_{ph} \uparrow$ but $V_{OC} \downarrow$
- Side processes
  - Thermal escape
  - Quantum tunneling

MQW GaAs/AlGaAs Device Structure

- Top Contact
- p-Al$_{0.49}$Ga$_{0.51}$As (50 nm, $N_A = 7.0 \times 10^{19}$ cm$^{-3}$)
- p-GaAs
- $N_A = 5.0 \times 10^{19}$ cm$^{-3}$
- MQW Region
- 0.5 µm
- n-GaAs
- $N_D = 2.0 \times 10^{19}$ cm$^{-3}$
- Bottom Contact
- p-GaAs/Al$_{0.33}$Ga$_{0.67}$As

ECE ILLINOIS
Quantum Well Thickness

- 13 QW, 1 nm $\text{Al}_{0.35}\text{Ga}_{0.65}\text{As}$ barrier layers
- Best efficiency: 50 nm GaAs QW layers
  - $V_{OC} = 0.959$ V
  - $J_{SC} = 0.155$ mA/cm$^2$
  - FF = 49.6%
  - AM1.5 Efficiency = 7.636%
Simulation Results

- 13 distinct QWs
- Most energy conversion is occurring at the junction
- Best GaAs cell: 28.8%
- Theoretical Limit: ~32%
- This MQW Design: 7.64%
MQW solar cells are possible but have many challenges
- Trade-off between barrier and QW thicknesses
- Combatting decreased $V_{OC}$ due to QWs

Future considerations
- Many degrees of freedom: # of QWs, barrier composition, etc.
- Non-uniform QW arrangements
- Combine with other improvements
  - Back surface field (BSF) layer
  - Anti-reflective coatings
Thank you!

Questions?