GaAs power-over-fiber receivers at cryogenic temperatures

- Previously, we studied III-V PV cells at high temperatures under an ARPA-E program
- Key takeaways
  - *Conversion* efficiency drops rapidly as T increases due to exponential increase in dark current
  - *Quantum* efficiency remains high due to long diffusion lengths
  - Devices behave well up to 500°C, obeying conventional models with minimal modifications

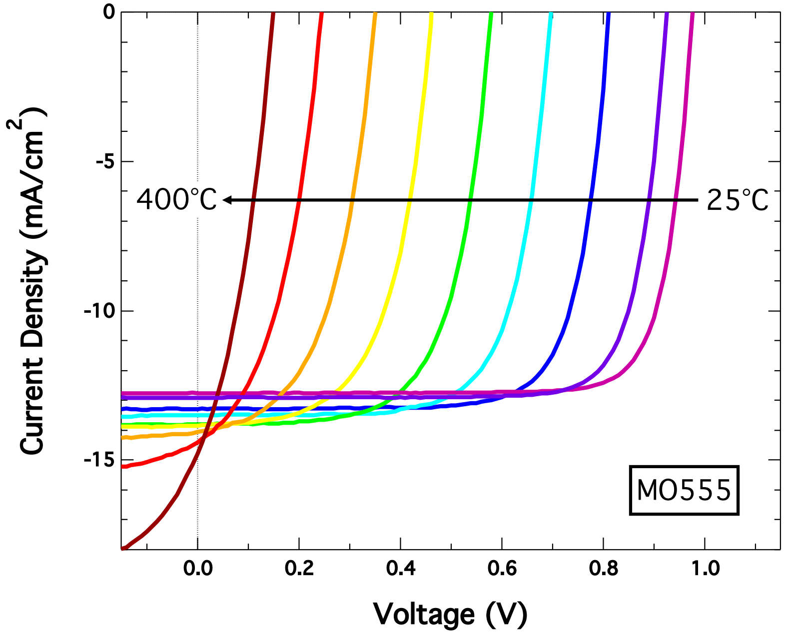


Fig. 11. Temperature-dependent LIV measurements of the GaAs solar cell taken at a light intensity of 1 sun under the AM1.5D spectrum. As the temperature is increased, we observe an increase in J_{SC} and decrease in V_{OC}.

$$J = J_{01}\left(e^{q(V-JR_S)/kT}-1\right)+J_{0_2}\left(e^{q(V-JR_S)/2kT}-1\right) + \frac{(V-JR_S)}{R_{\text{shunt}}} - J_L \quad (3)$$

$$J_{01} \;\alpha\; T^3 e^{-E_g/kT}$$

$$J_{02} \;\alpha\; T^{3/2} e^{-E_g/2kT}.$$

Perl et al. IEEE JPV 2016

ILLINOIS
Minjoo Larry Lee, mllee@Illinois.edu

GaAs power-over-fiber receivers at cryogenic temperatures

- Room temperature- efficiency up to 60% reported for laser photovoltaic power conversion!
- Opportunity for ultrahigh power conversion efficiency (>60%) at liquid Ar temperature
  - Note: III-V lasers are significantly more efficient at cryogenic than at room temperature!

Fafard, Simon, et al. Applied Physics Letters 109.13 (2016): 131107.

Minjoo Larry Lee, mllee@Illinois.edu

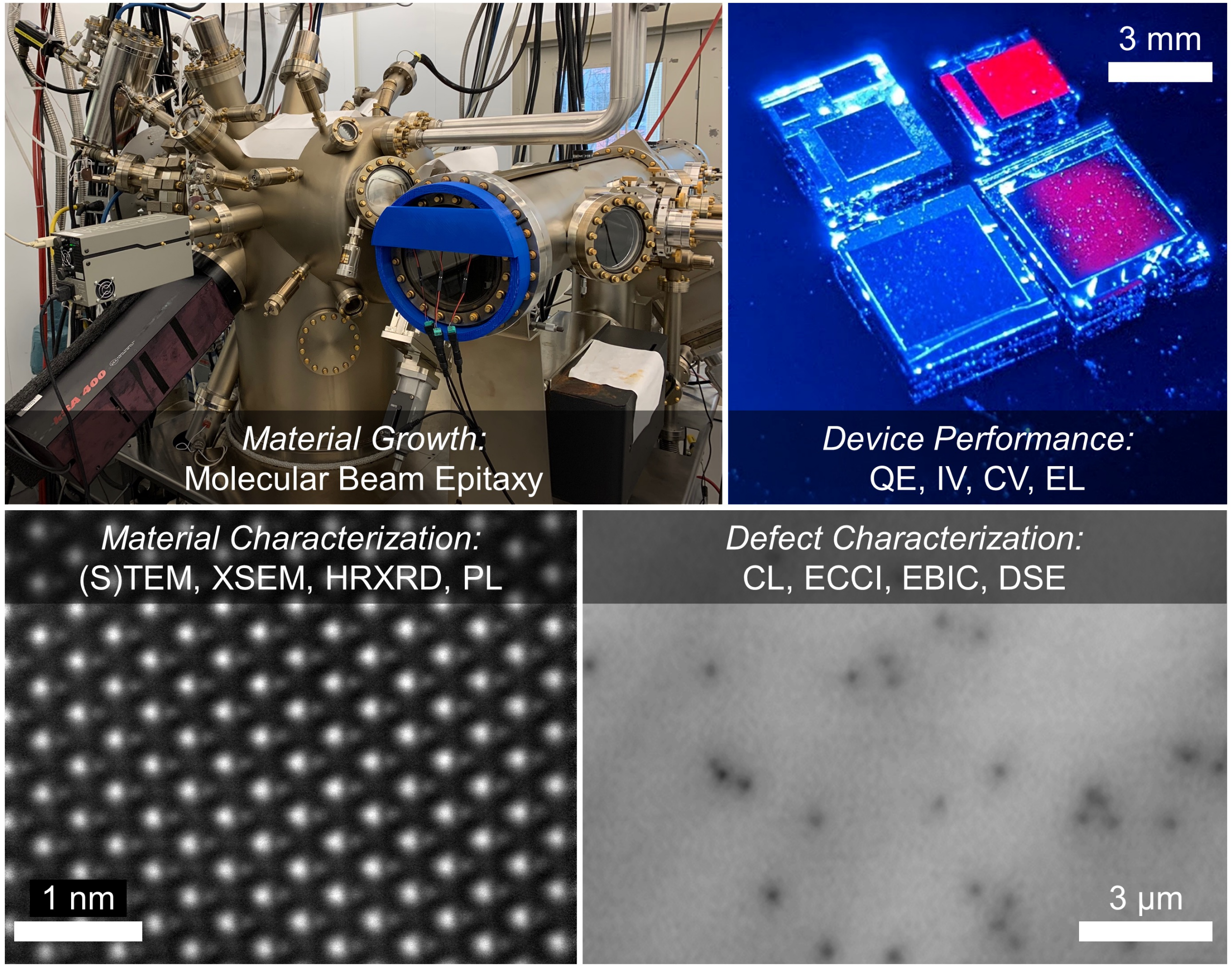
Key areas of investigation

- Design and fabrication of single- and multi-junction devices with useful voltage operating points for:
  - Powering digital and/or analog electronics
  - Biasing detectors
- What are theoretical and practical limits of conversion efficiency at ~87K?
- Can we harness strong photon recycling effects at cryogenic temperatures?

Minjoo Larry Lee, mllee@Illinois.edu

Methods used in my lab

- MBE for photovoltaic cell growth
  - Shared MOCVD also available
- Characterization of composition, strain, defects, transport, optical properties
- Device fabrication, testing, modeling



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Minjoo Larry Lee, mllee@illinois.edu