

Subjunction Spatial EL Characterization for III-V Space Solar Cells

Rivka Stasavage¹, Kyle Virgil¹, Abigail Meyer¹, Don Walker¹, Yao Y. Lao¹

¹The Aerospace Corporation, El Segundo, CA

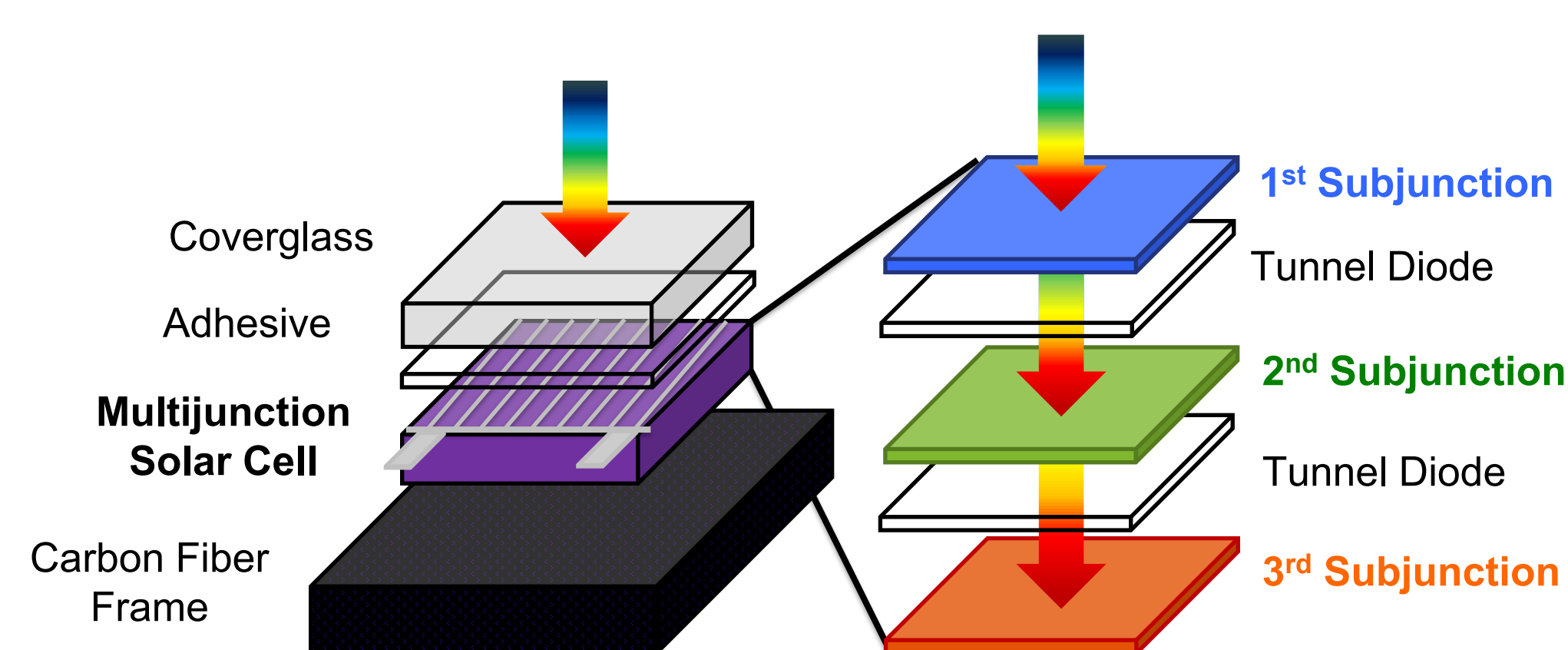
Motivation and Background

Large Area Characterization

- Large area space solar cells show significant spatial variance in electrical performance
- Standard spectral electroluminescence (EL) techniques assume uniformity across devices

Subjunction Level Performance

- Space solar panels depend on multijunction III-V architectures, although electrical performance variation across subjunctions is not thoroughly understood
- Space radiation damage uniquely impacts each subjunction, but standard EL imaging techniques only characterize the full device stack



Need: Spatially resolved EL characterization at the subjunction level

Methods

- Using EL measurements we can acquire key solar cell parameters based on the diode equation and spectral reciprocity equation:

$$I = I_0 * \left[\exp\left(\frac{qV}{nkT}\right) - 1 \right]$$

Ideal Diode Equation

V - Voltage
 I_0 - Saturation current
 n - Ideality factor
 q - electron charge
 k - Boltzmann constant
 ϕ_{EL} - EL intensity
 QE - Quantum Efficiency
 ϕ_{bb} - Black body emission

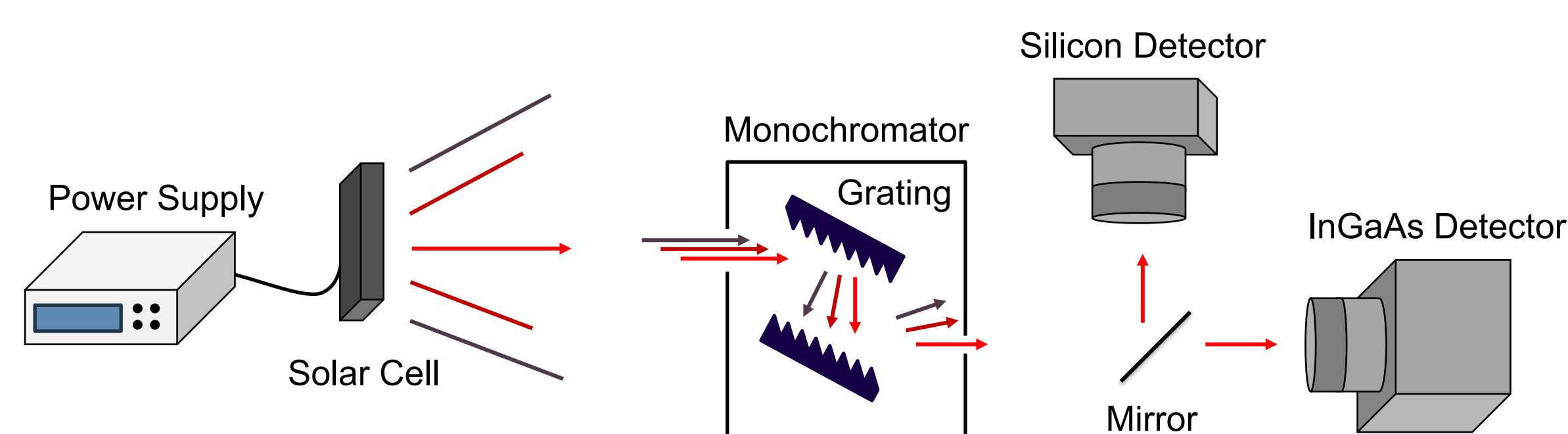
$$\phi_{EL}(E) = QE(E) * \phi_{bb}(E) * \left[\exp\left(\frac{qV}{kT}\right) - 1 \right]$$

Spectral Reciprocity Equation

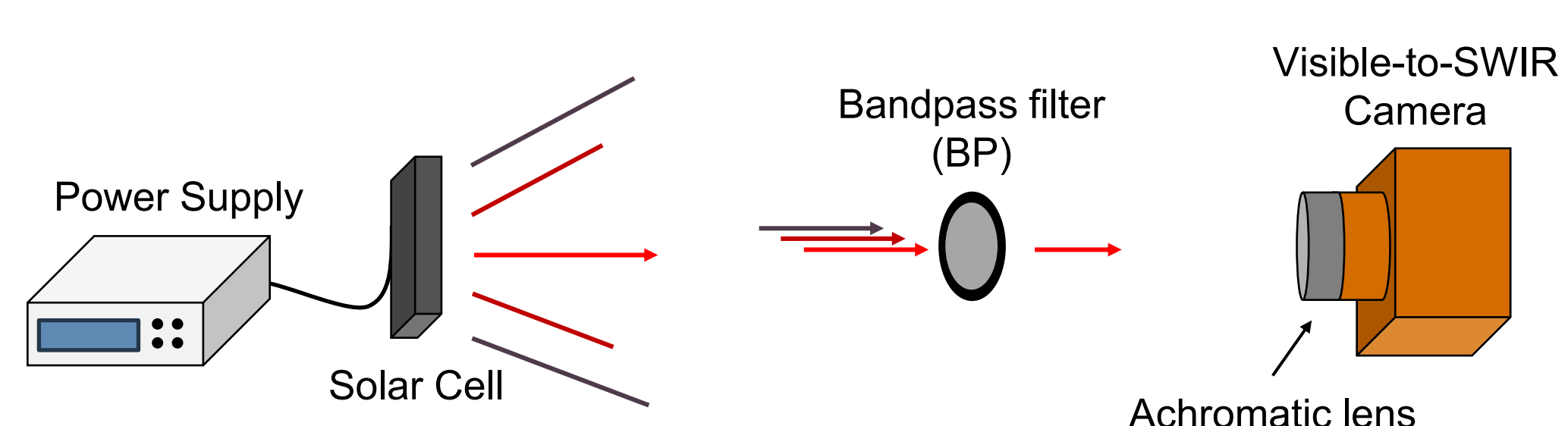
- Solving the spectral reciprocity equation for device voltage gives the dark electrical performance curve, from which we can extract saturation current and ideality factor.

- To capture electroluminescence, we use two different measurements:

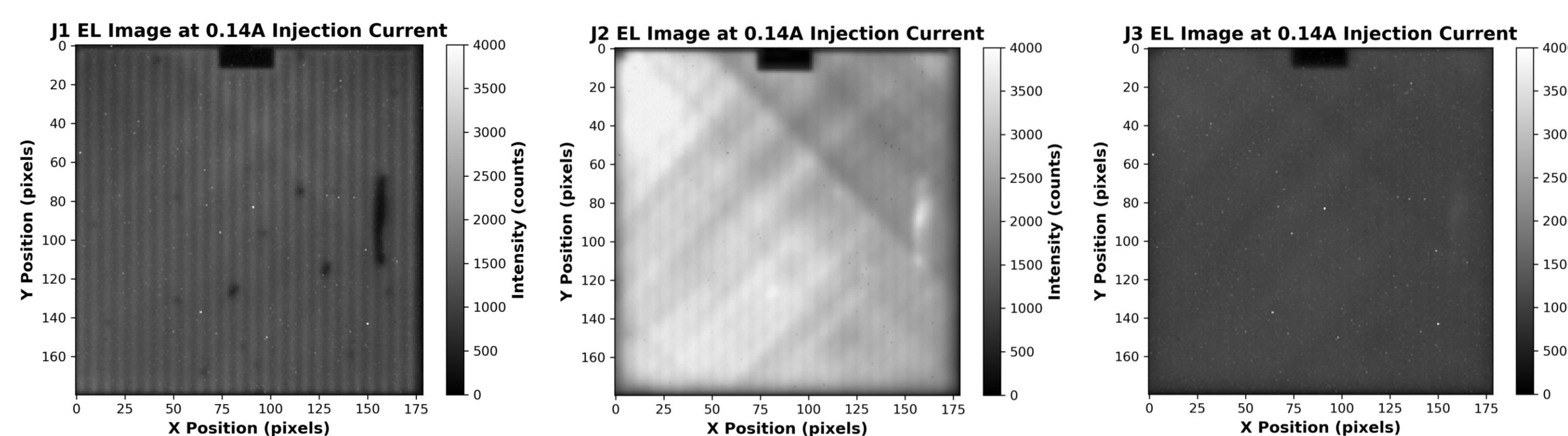
Spectral Electroluminescence Technique



Imaging Electroluminescence Technique

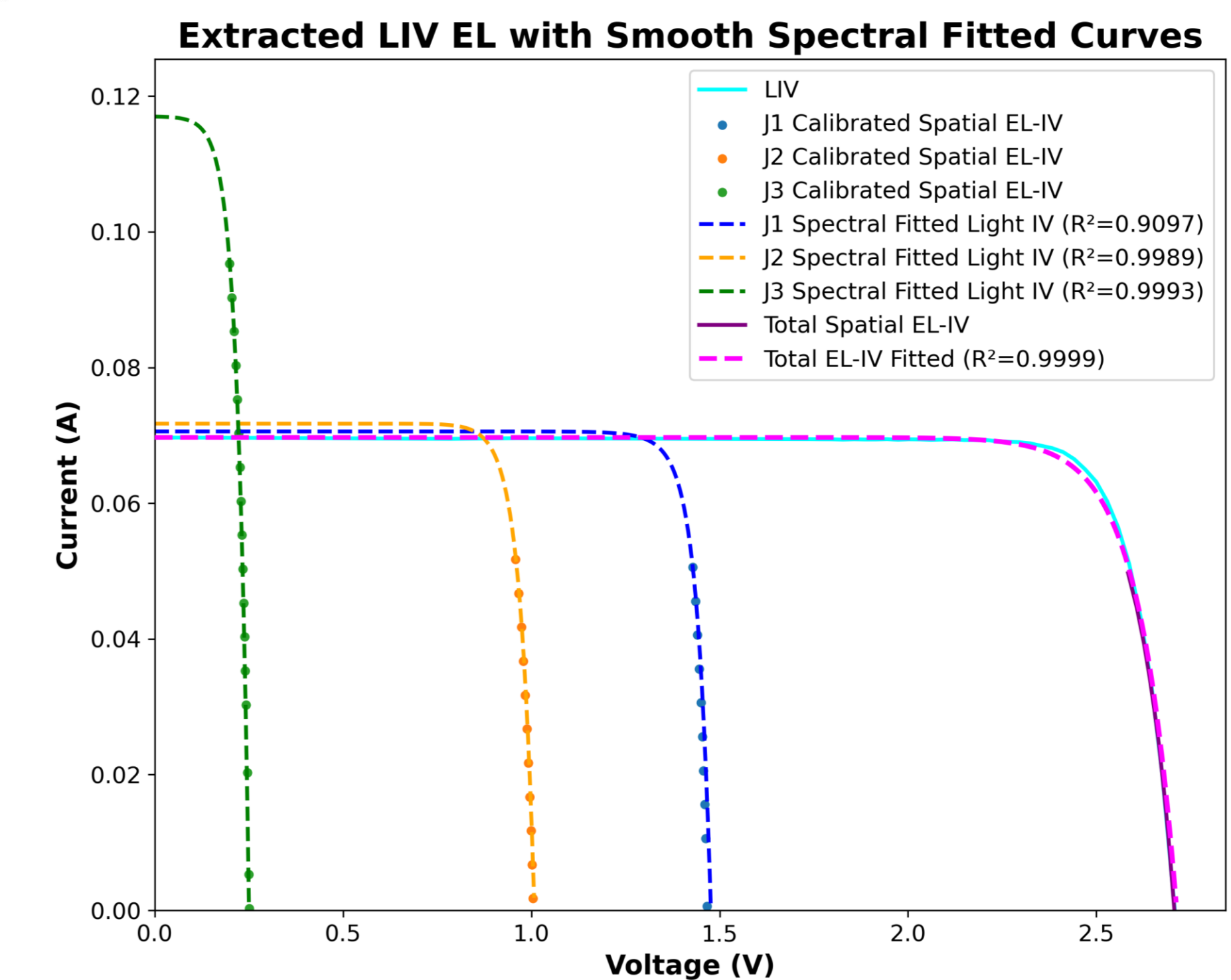
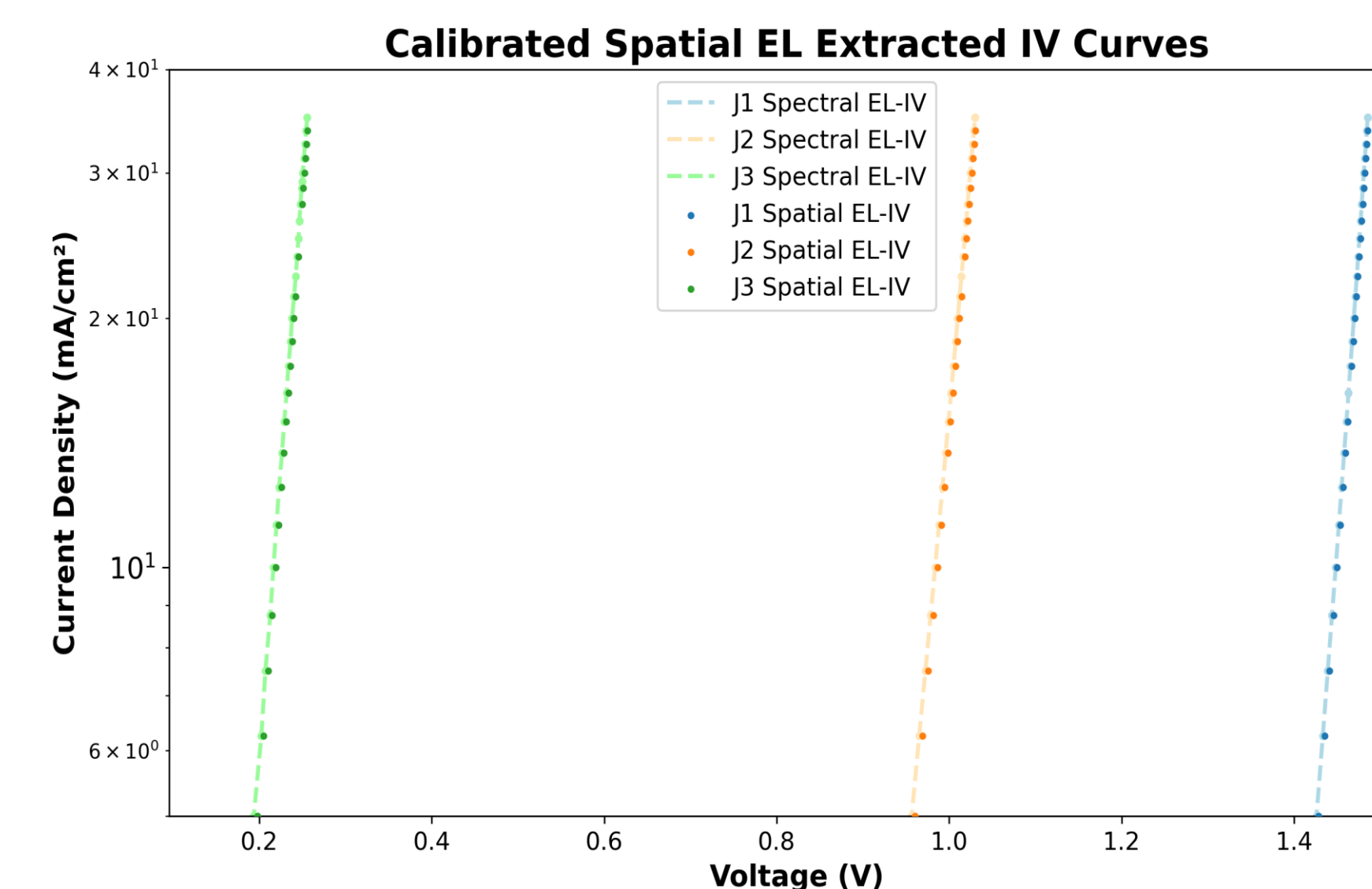


Subjunction Level Characterization



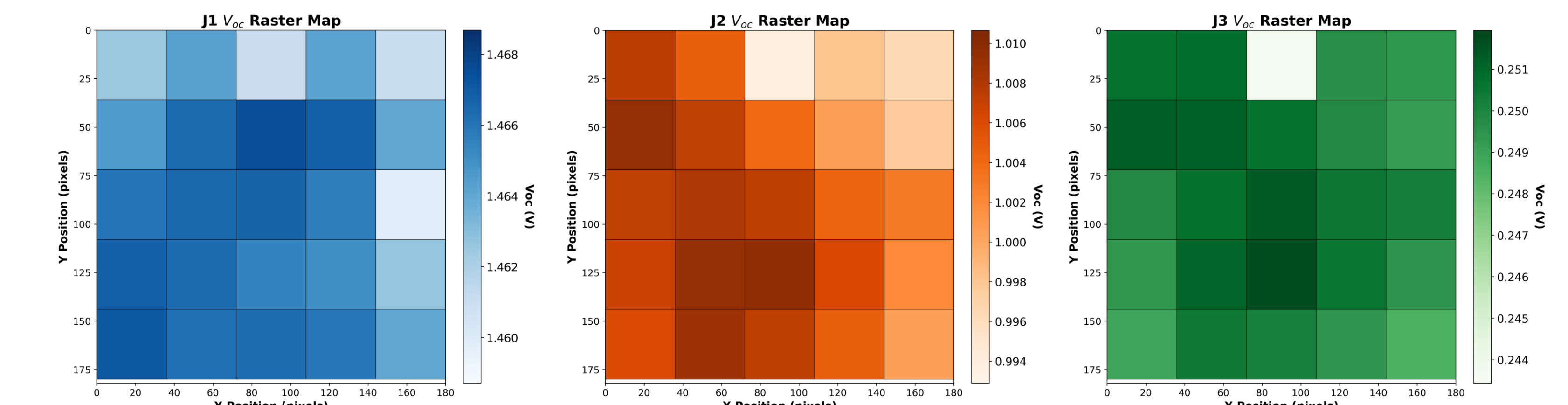
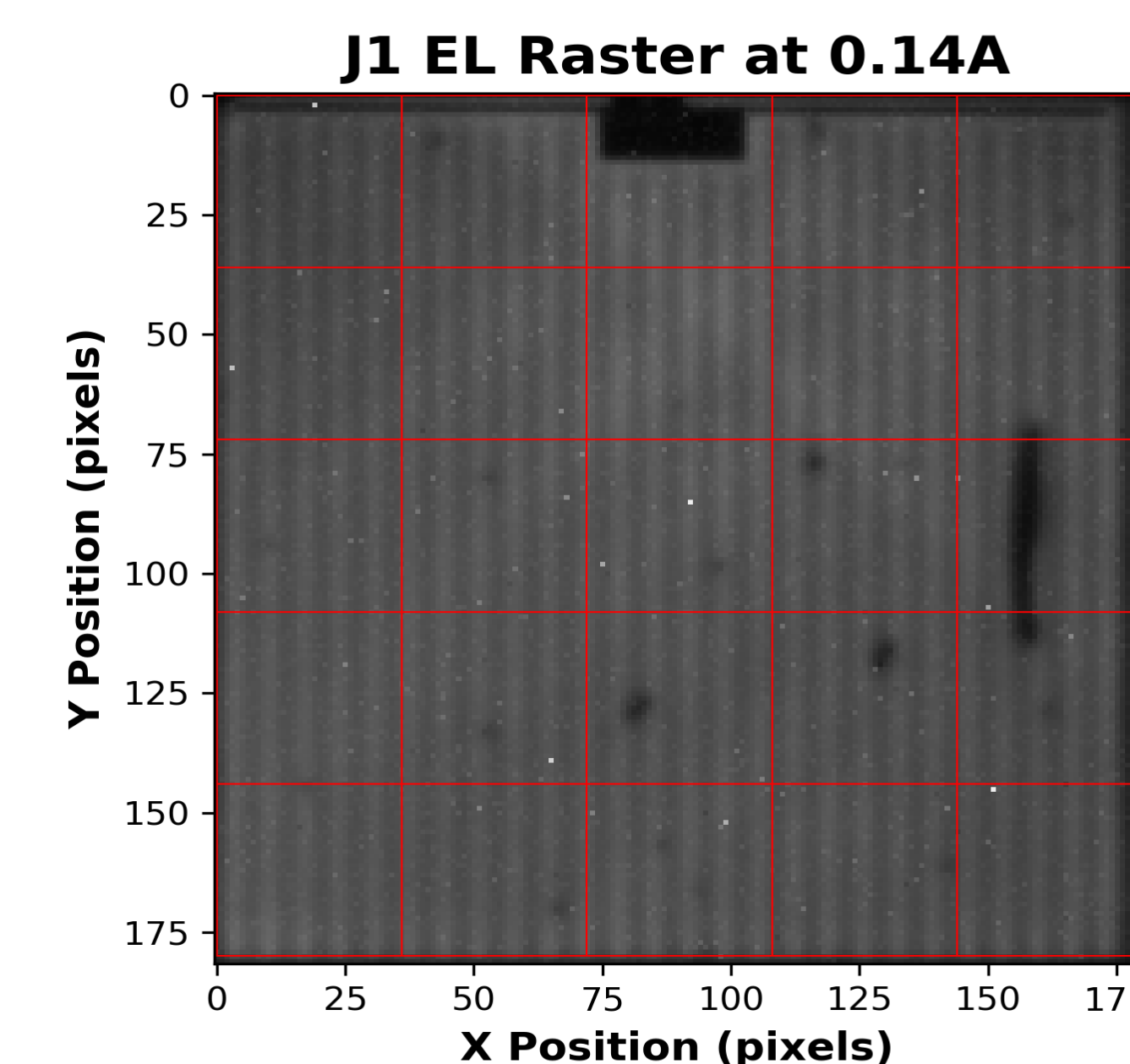
- EL images are captured of each subjunction, revealing defects across layers

- Subcell IV curves and diode parameters are extracted from the EL images
- These results are typically limited to full device analysis in traditional solar cell characterization
- The spatial EL technique can closely reproduce data from our trusted spectral system after calibration

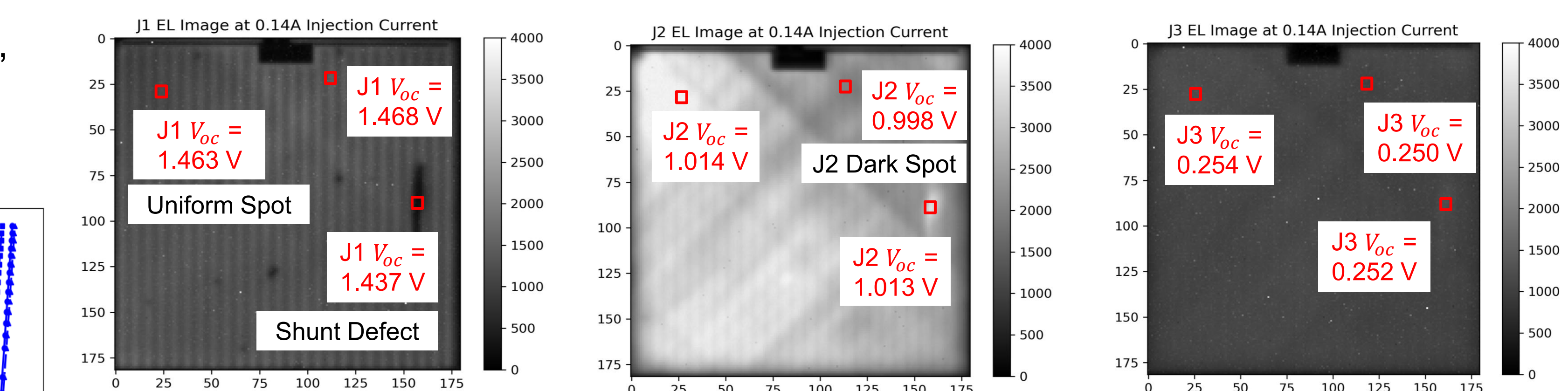
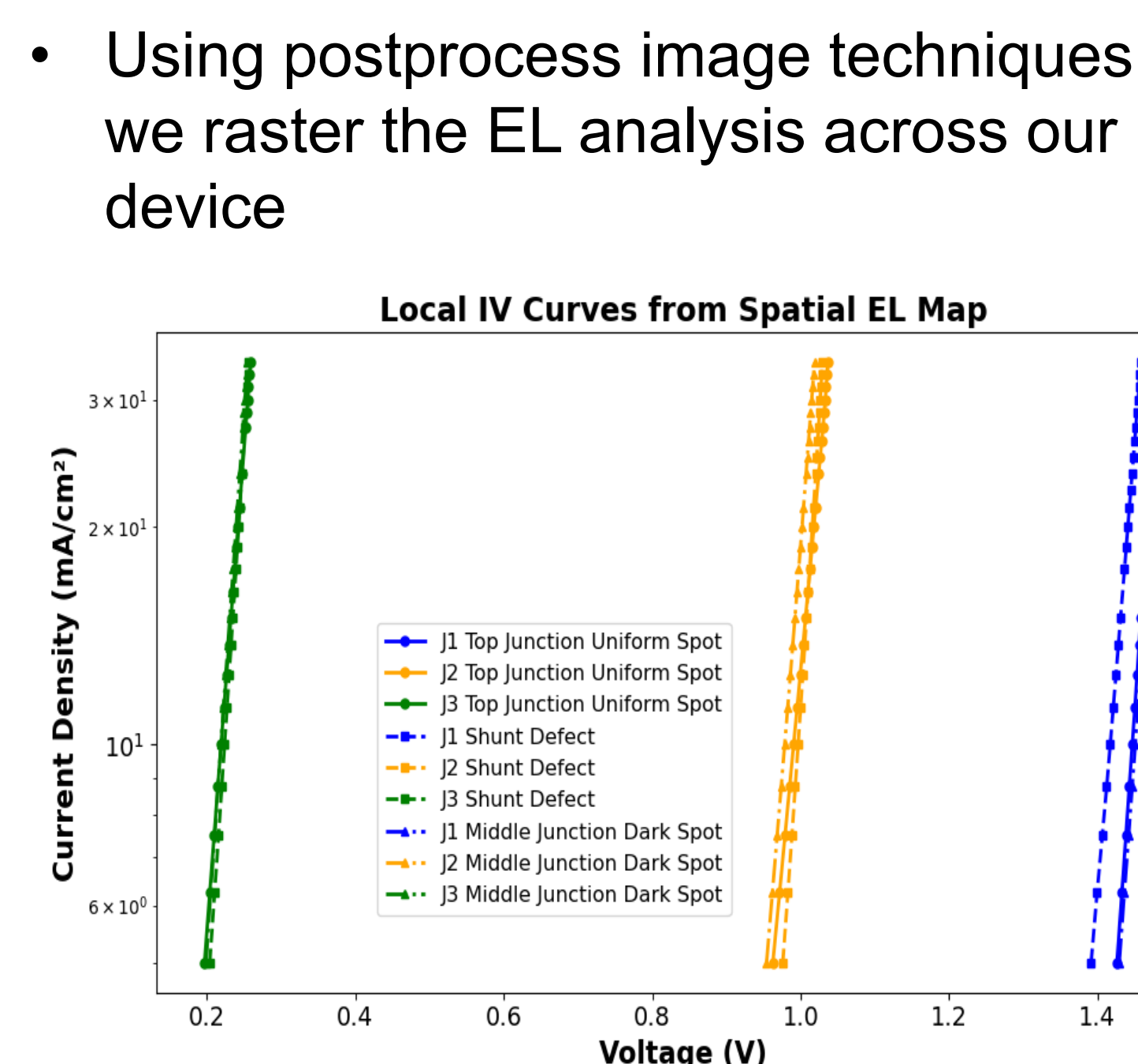


Spatial EL Analysis

- This spatial technique reveals spatially nonuniform electrical behavior at the subcell level



- Quantitative maps depict the spread of key diode parameters like V_{oc} to better understand localized cell performance



- Specific regions of interest can be examined to directly compare spatially variable IV characteristics at the subcell level

Conclusion and Future Work

Conclusions

- This technique provides quantitative subjunction characterization of key solar cell parameters through EL extracted IV curves
- The analysis can be rastered across devices and performed locally to quantify subcell level spatial variance and resulting effects on device performance

Future Work

- Further quantitative spatial maps will be developed for key solar cell parameters such as I_0 (saturation current) and n (ideality factor)
- Large area space solar cells will be characterized to reveal the impacts of spatial EL variance on electrical performance
- BOL and irradiated space solar cells will be analyzed using the EL imaging technique