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Comparison of Beam-Based Failure Analysis Techniques for Microsystems-Enabled Photovoltaics

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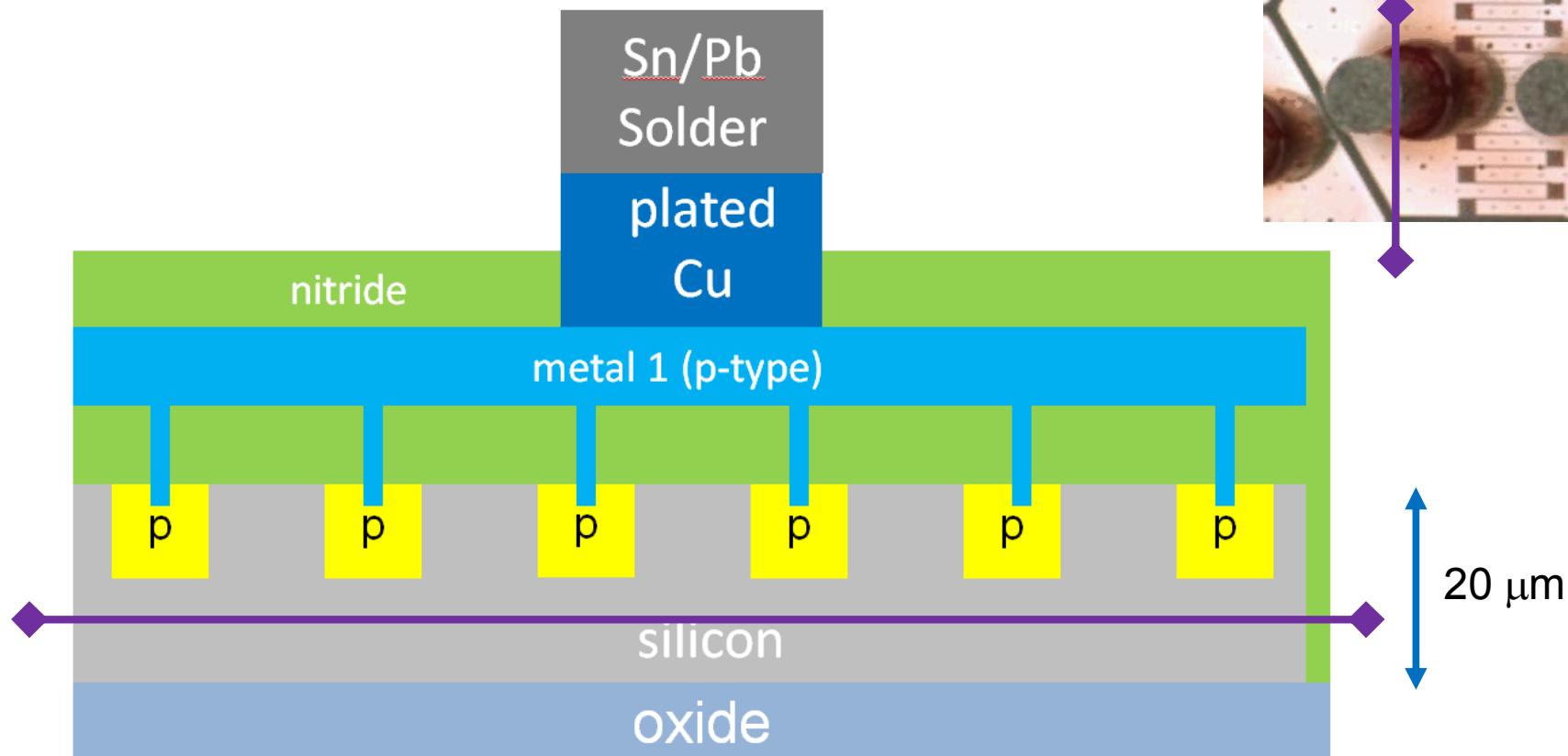
Presentation Outline

- MEPV Overview
- Defect Localization Techniques
- Comparison of Beam-Based Techniques
- Conclusion

What is a MEPV?

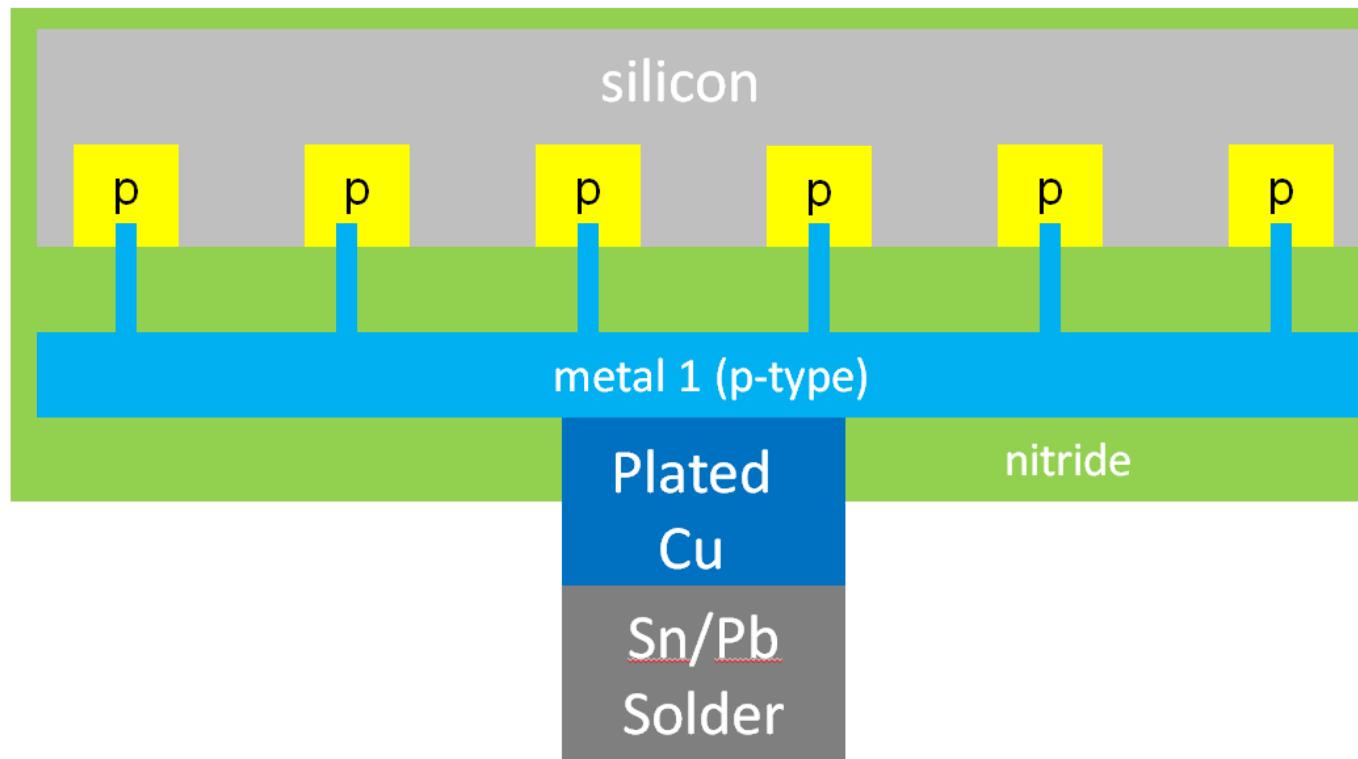
MEPV = microsystems-enabled photovoltaic

Initial fabrication on silicon-on-insulator wafer

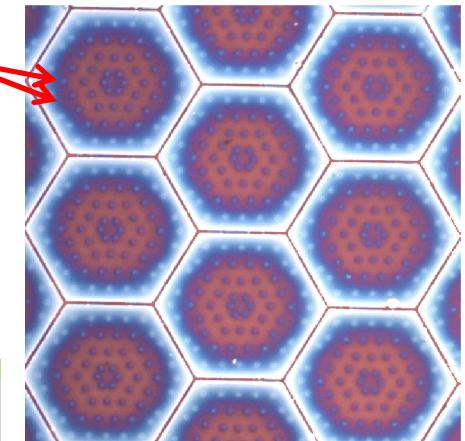


How are MEPVs Made?

Silicon layer is released and reattached to final substrate

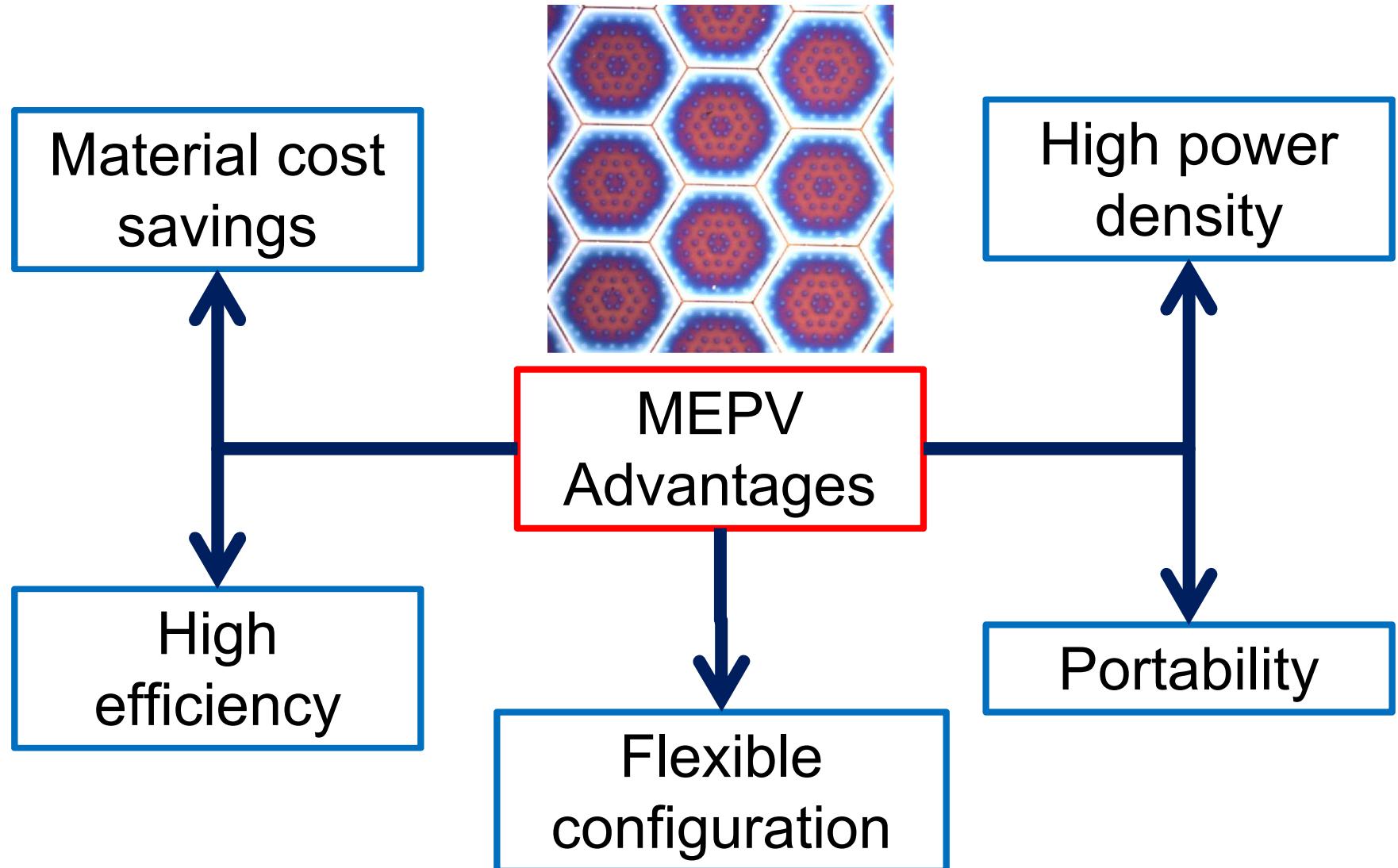


etch release
holes

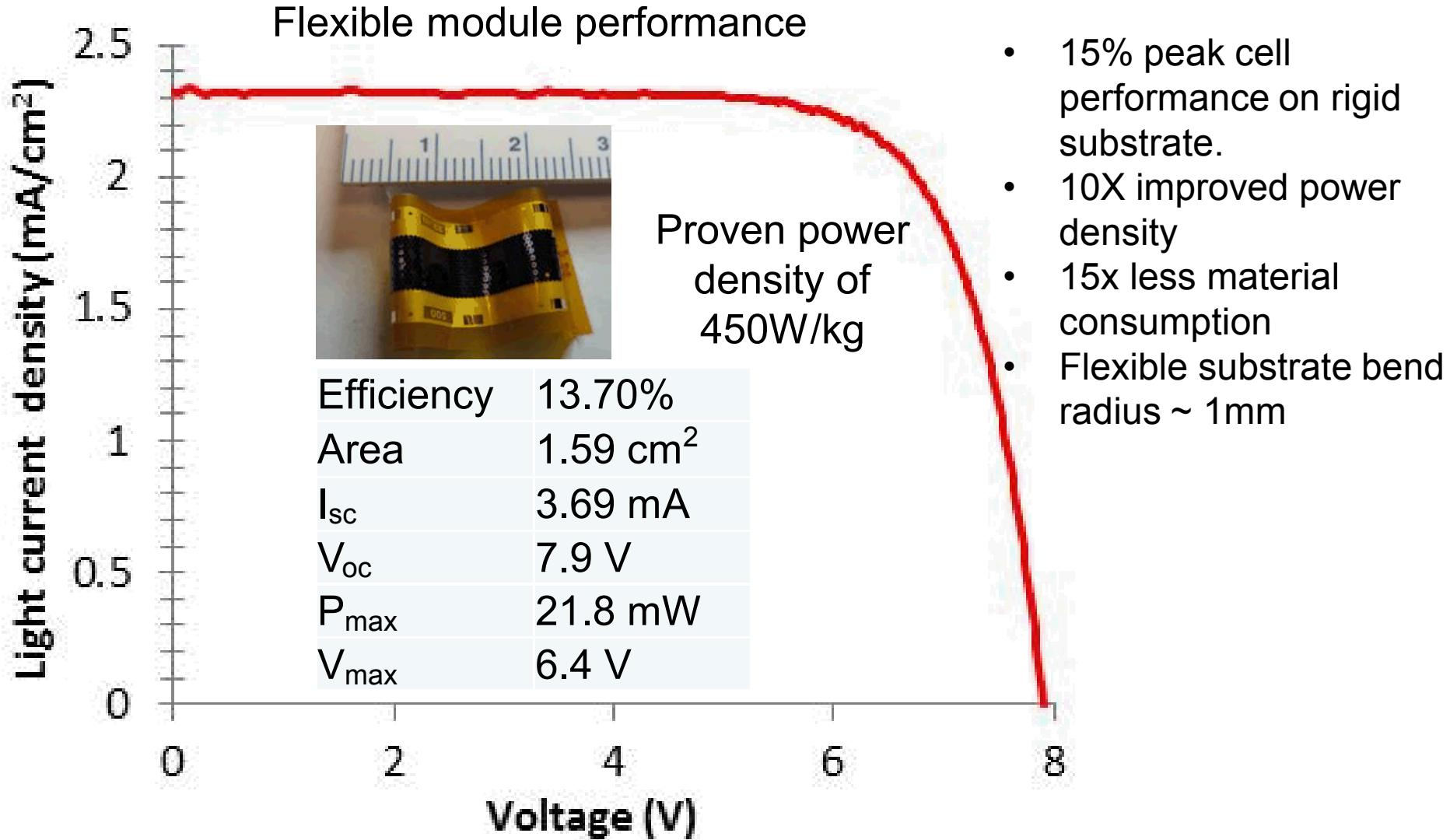


1 mm

Why MEPVs?



MEPV's have achieved ultra low silicon usage and high power density

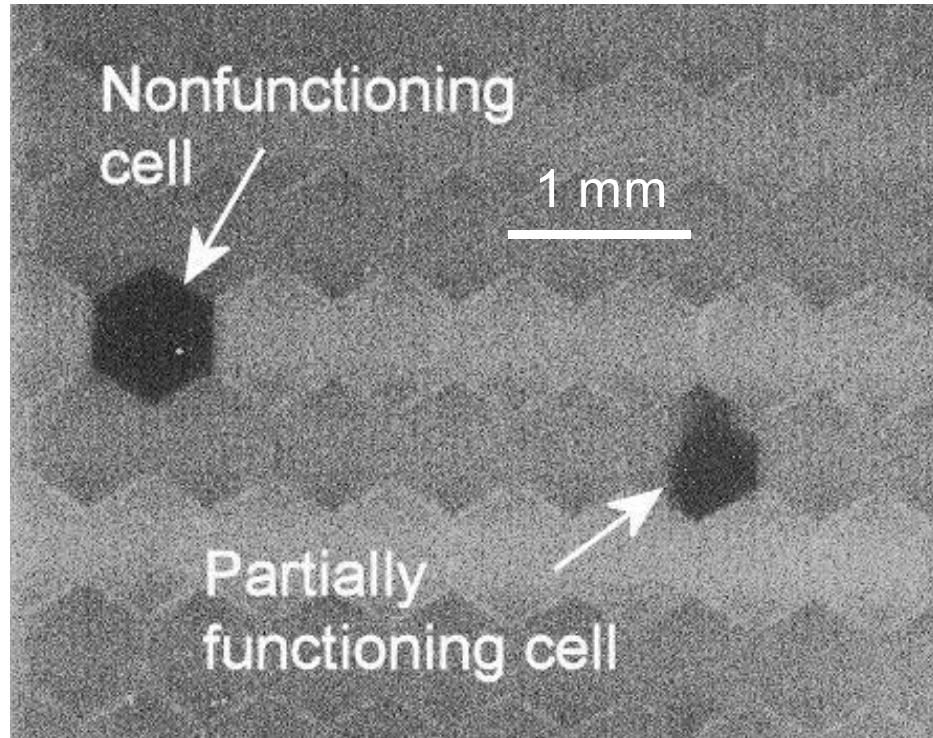
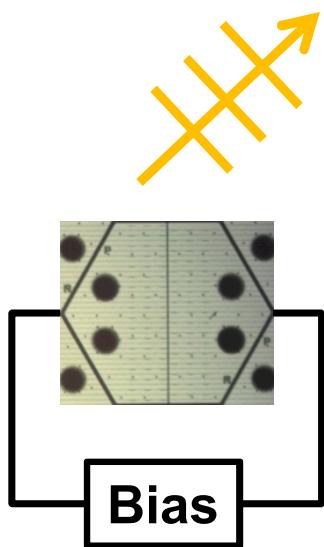


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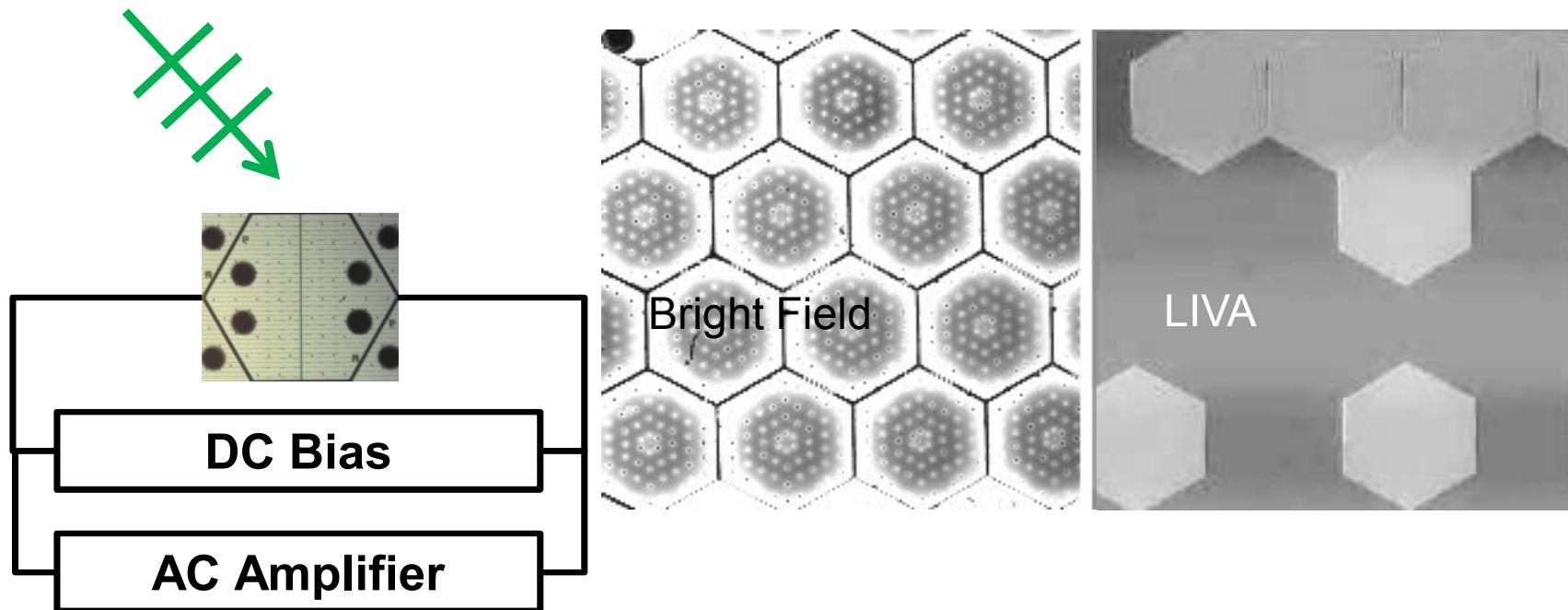
FA Techniques: Electroluminescence

EL image of array of interconnected MEPV



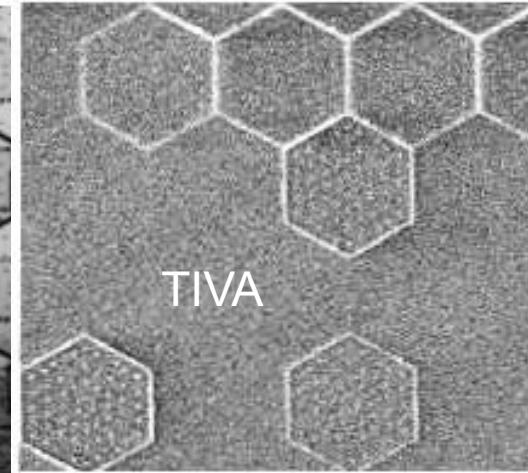
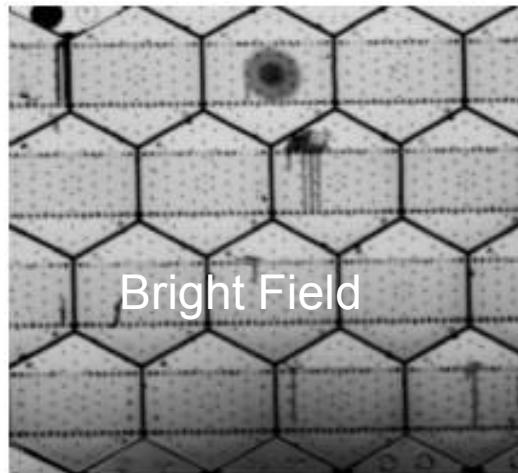
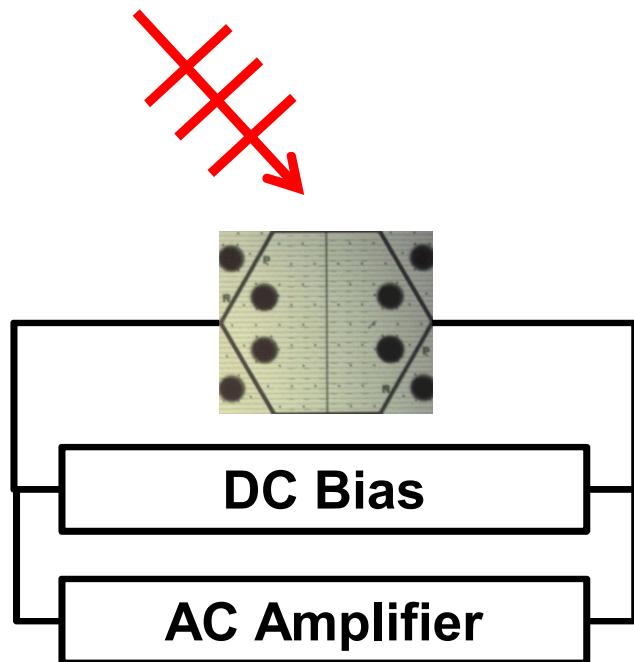
- Operation: Bias device and collect photons
 - **Forward Bias**: determine **functionality**
 - **Reverse Bias**: localize high **leakage currents**

FA Techniques: LIVA



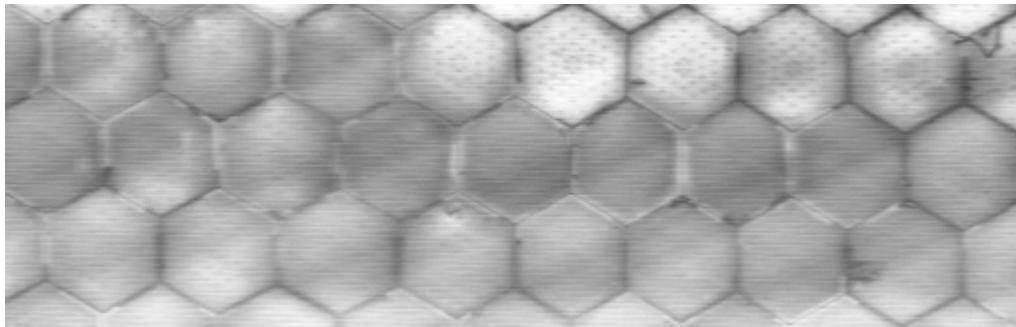
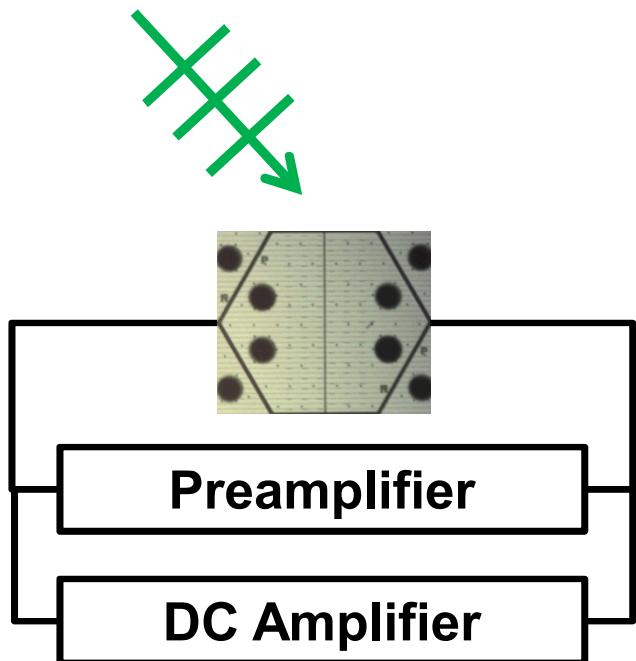
- **Wavelength:** Photon energy > bandgap
- **Operation:** Plot AC amplifier output vs. laser position
- Determines functionality of cell

FA Techniques: TIVA



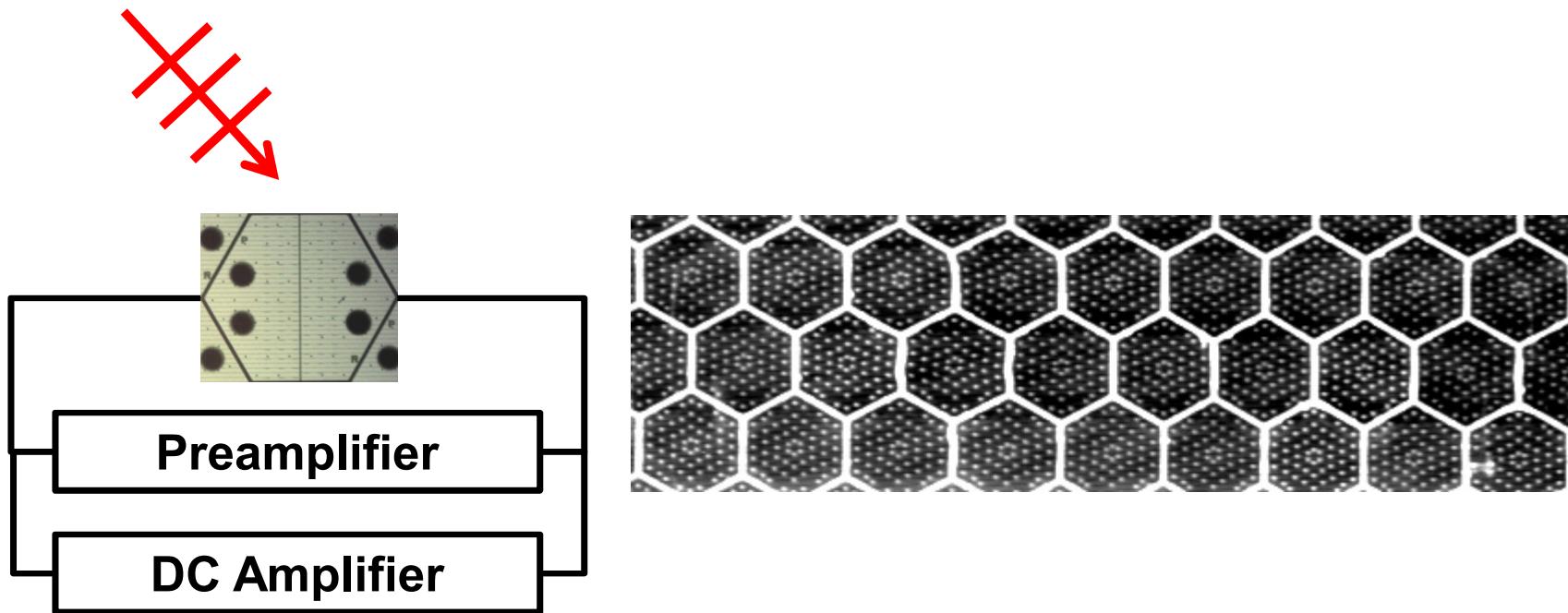
- **Wavelength:** Photon energy < bandgap
- **Operation:** Plot **AC** amplifier output vs. laser position
- Determines **electrical connectivity** and identifies leakage paths

FA Techniques: Above-Band-Gap OBIC



- **Wavelength:** Photon energy > bandgap
- **Operation:** Plot DC amplifier output vs. laser position
- Determines localized efficiencies

FA Techniques: Below-Band-Gap SEI

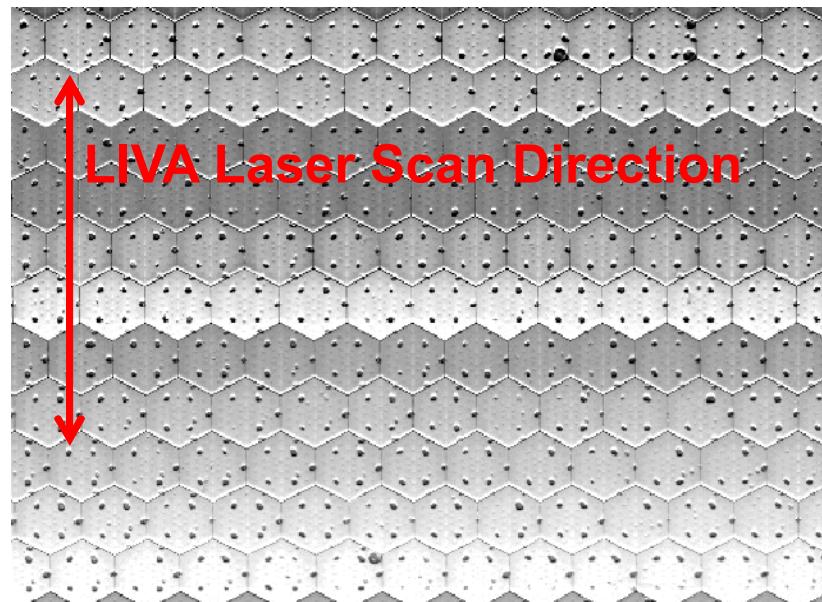


- **Wavelength:** Photon energy < bandgap
- **Operation:** Plot AC amplifier output vs. laser position
- Determines **electrical connectivity** and **identifies leakage paths**

Presentation Outline

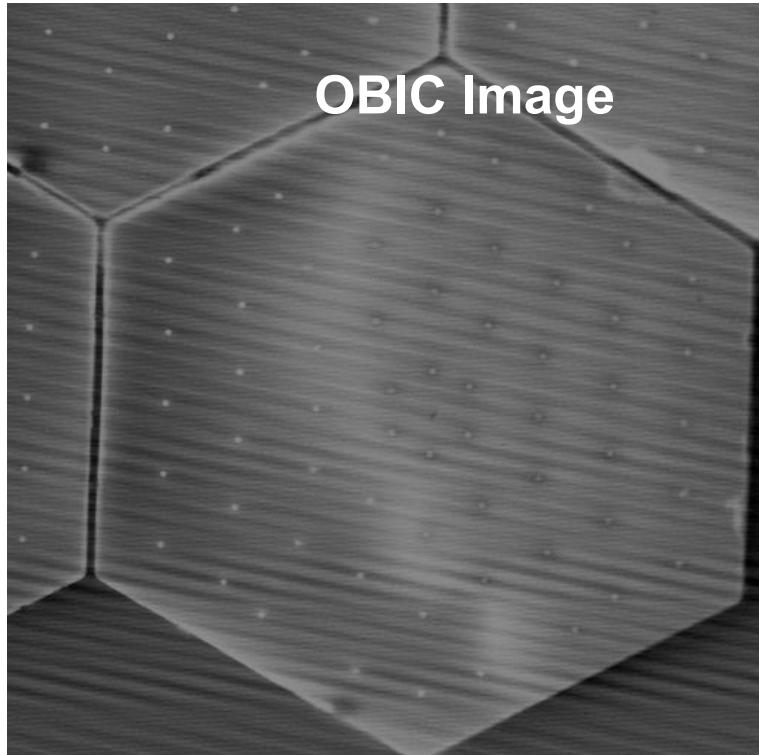
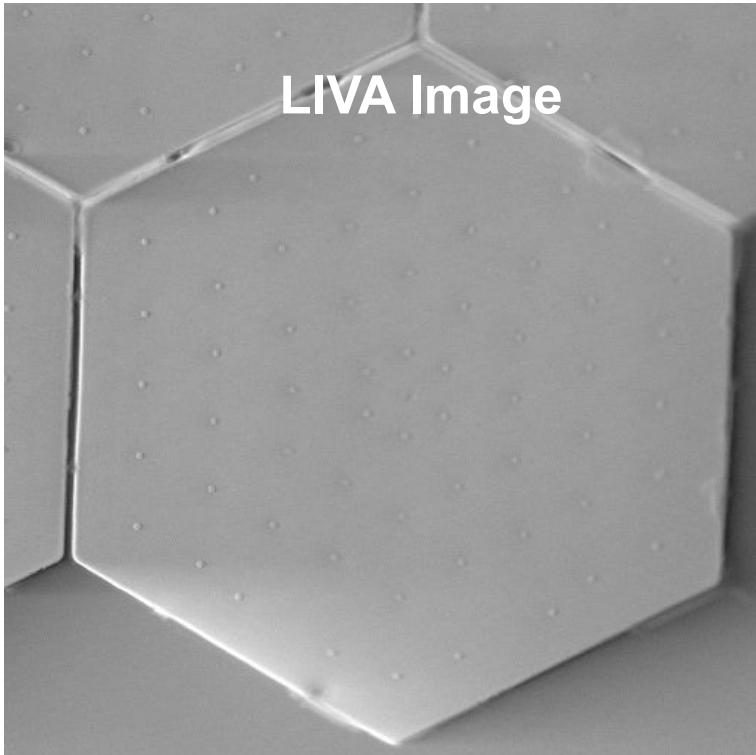
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Downside of LIVA



- LIVA's ability to identify different performance depends on scan direction.
- Above-band gap OBIC does not have this issue.

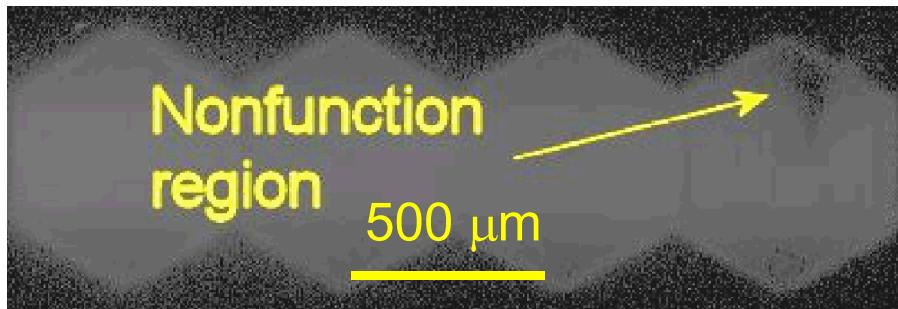
LIVA vs. Above-Bandgap OBIC



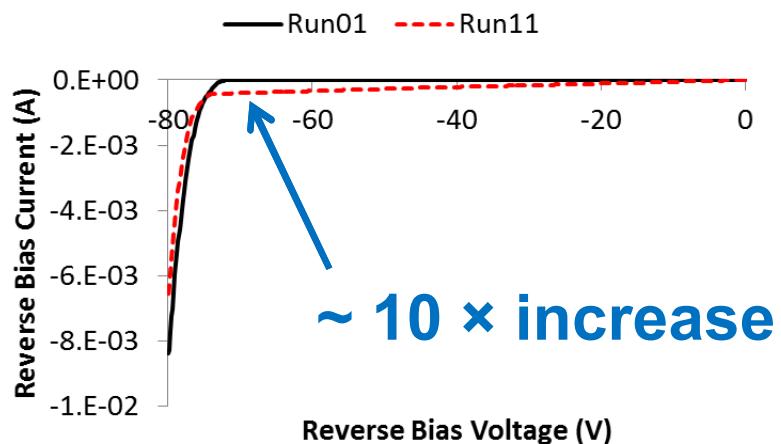
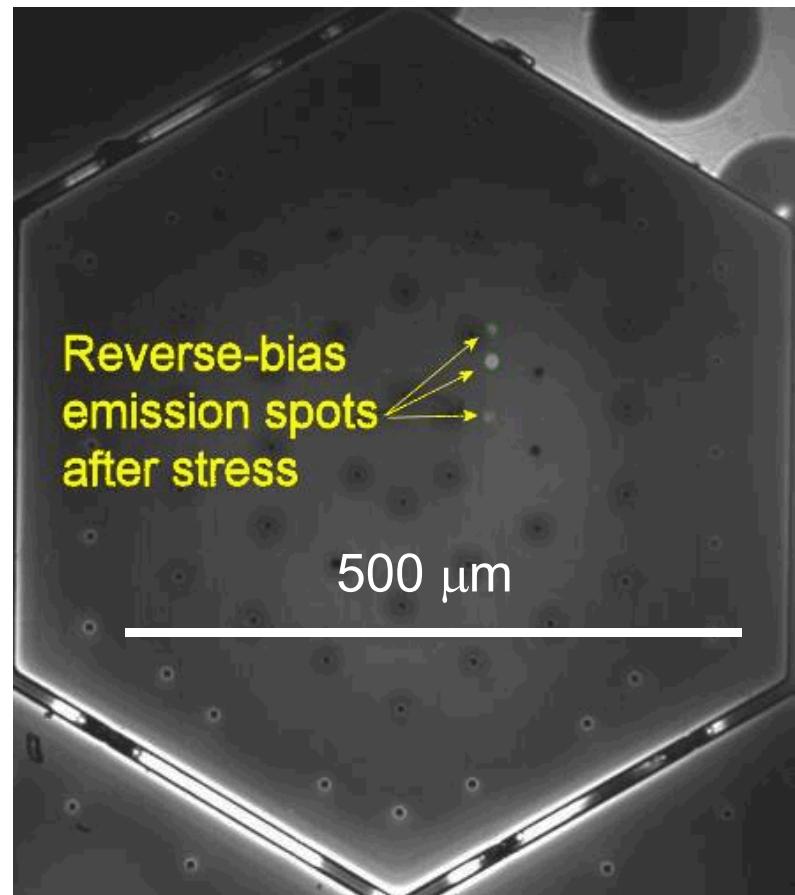
- **LIVA** can only confirm **cell functionality**.
- **Above-bandgap OBIC** is able to **discern localized efficiency** within the cell.

High Reverse Bias Stress: Post-Stress FA

Forward Bias EL

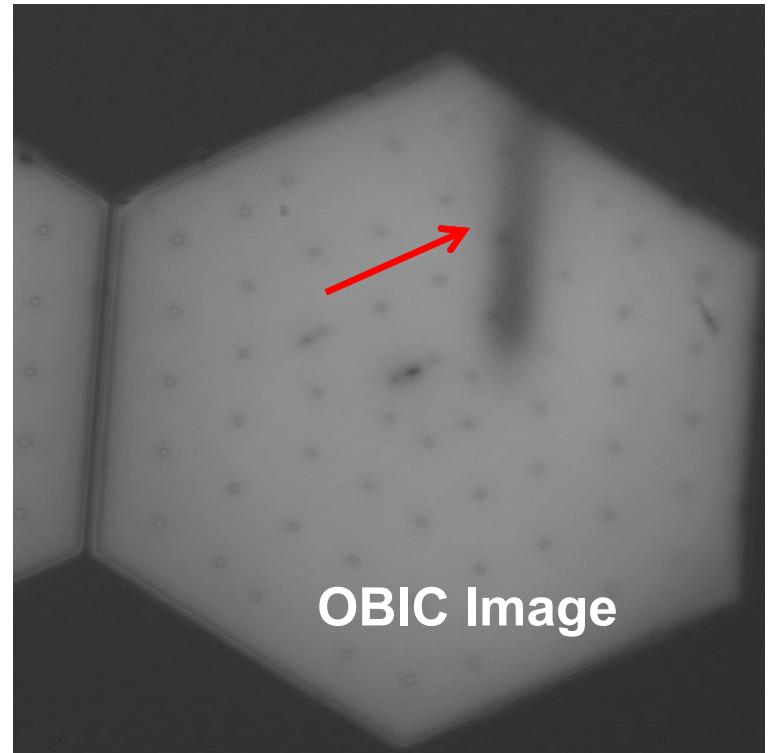
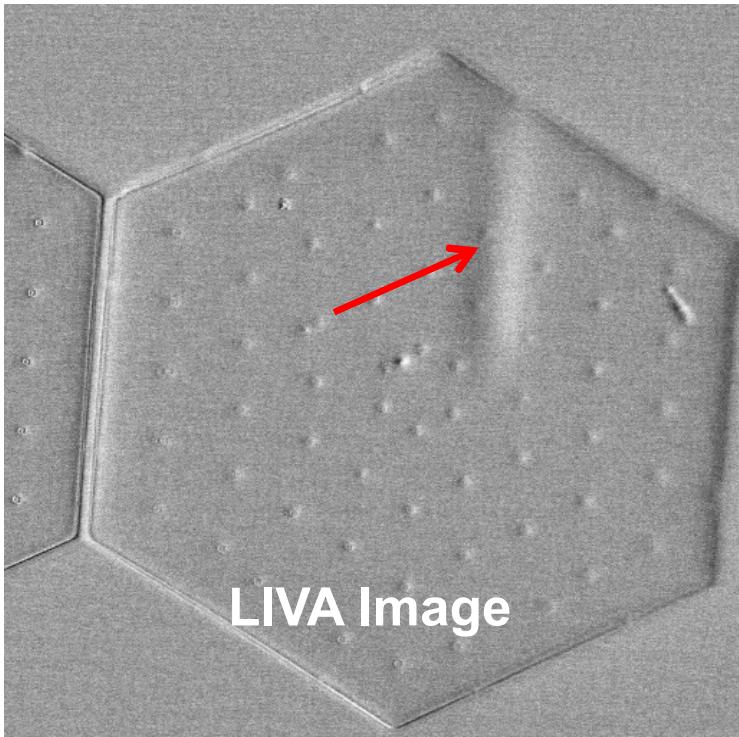


Reverse Bias EL



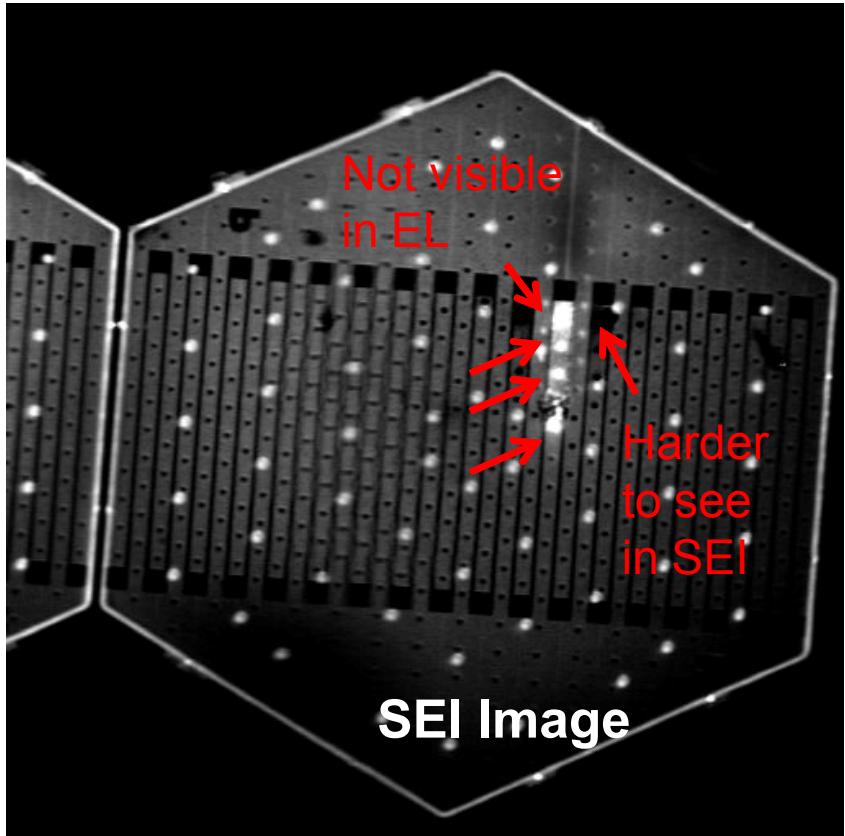
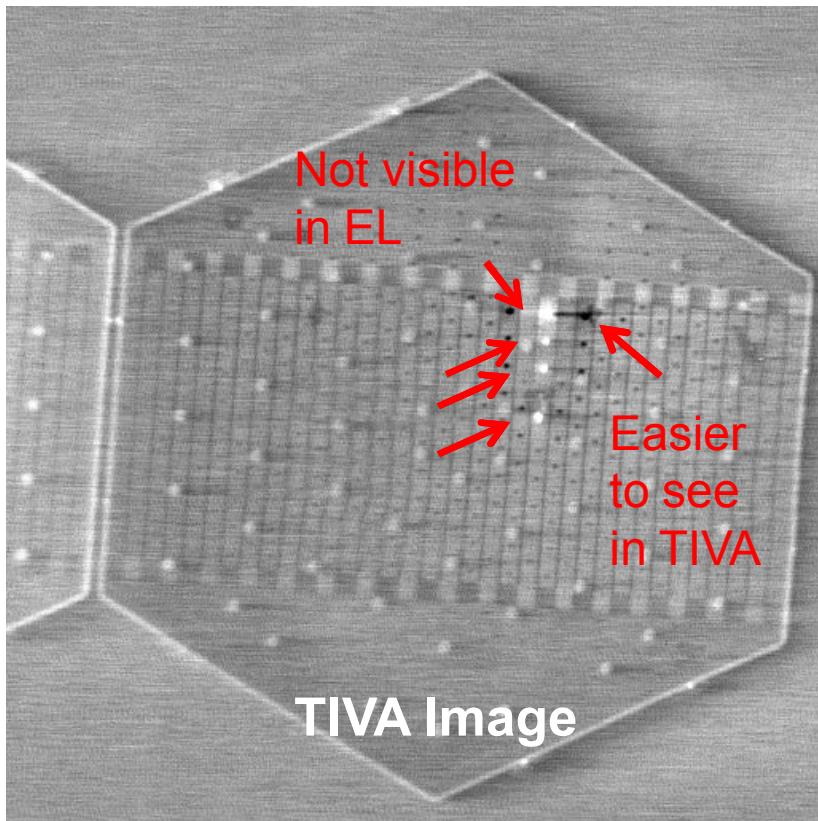
- Breakdown site localized with **EL**.
- Strong EL signal suggests **avalanche breakdown**.

LIVA vs. Above-Bandgap OBIC



- Both LIVA and Above-Bandgap OBIC were able to identify defect.
- Matches Forward-Bias EL result.

TIVA vs. Below-Bandgap SEI



- Both **TIVA** and **Below-Bandgap SEI** were able to identify more leakage paths than reverse bias **EL**
- Additional contact damage more visible in **TIVA**.

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Conclusions

- MEPV is a microfabricated solar cell with dimensions suitable for CMOS FA
- In general DC amplification (OBIC/SEI) more effective than AC amplification (LIVA/TIVA)
 - Possibly due to lack of transistor amplification
 - Some defects more visible in TIVA than SEI
 - OBIC offers additional fidelity compared to EL, LIVA does not.
- Beam-based techniques coupled with EL are effective defect localization methods for MEPV