

Micro-transfer Printing for Eye-Safe Laser Power Converters

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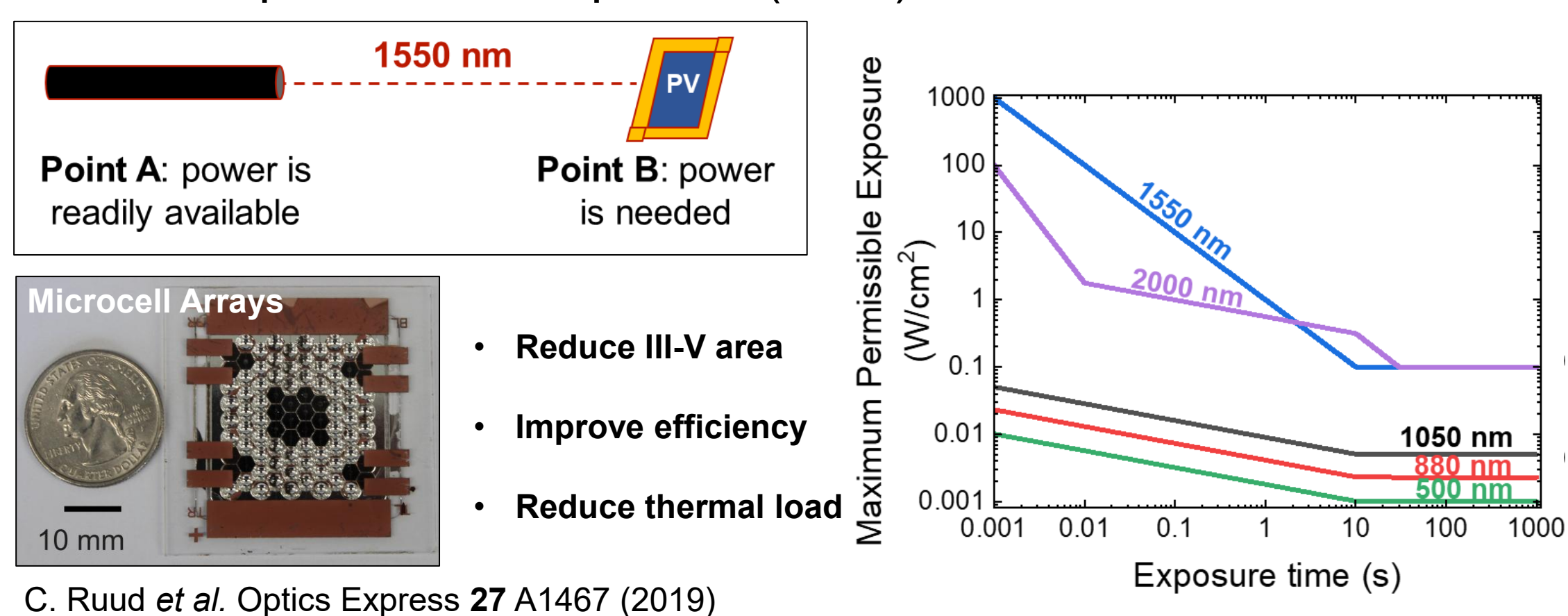
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OBJECTIVE

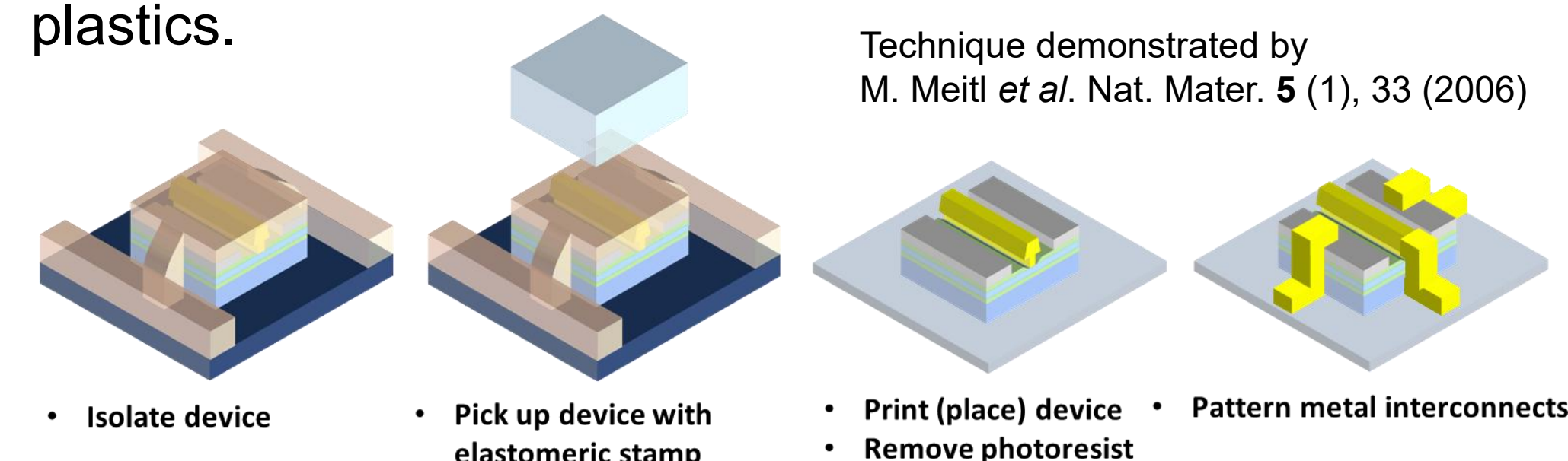
Characterize GaSb devices subjected to citric acid-based lateral etchant to enable heterogeneous integration through micro-transfer printing.

MOTIVATION

GaSb-based photovoltaics are of interest for laser power converters as they can operate with wavelengths with higher maximum permissible exposure (MPE).

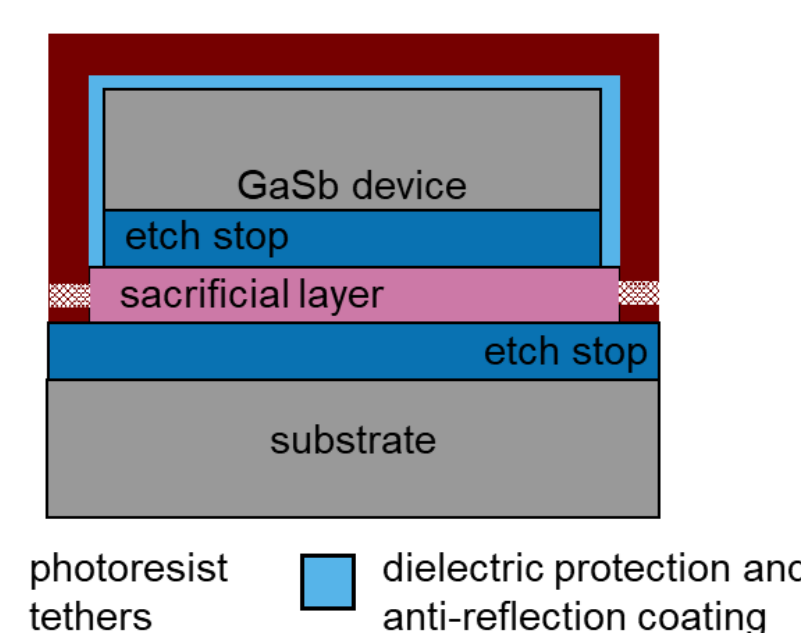


Micro-transfer printing can enable microcell arrays and heterogeneous integration with silicon, sapphire, glass, or plastics.

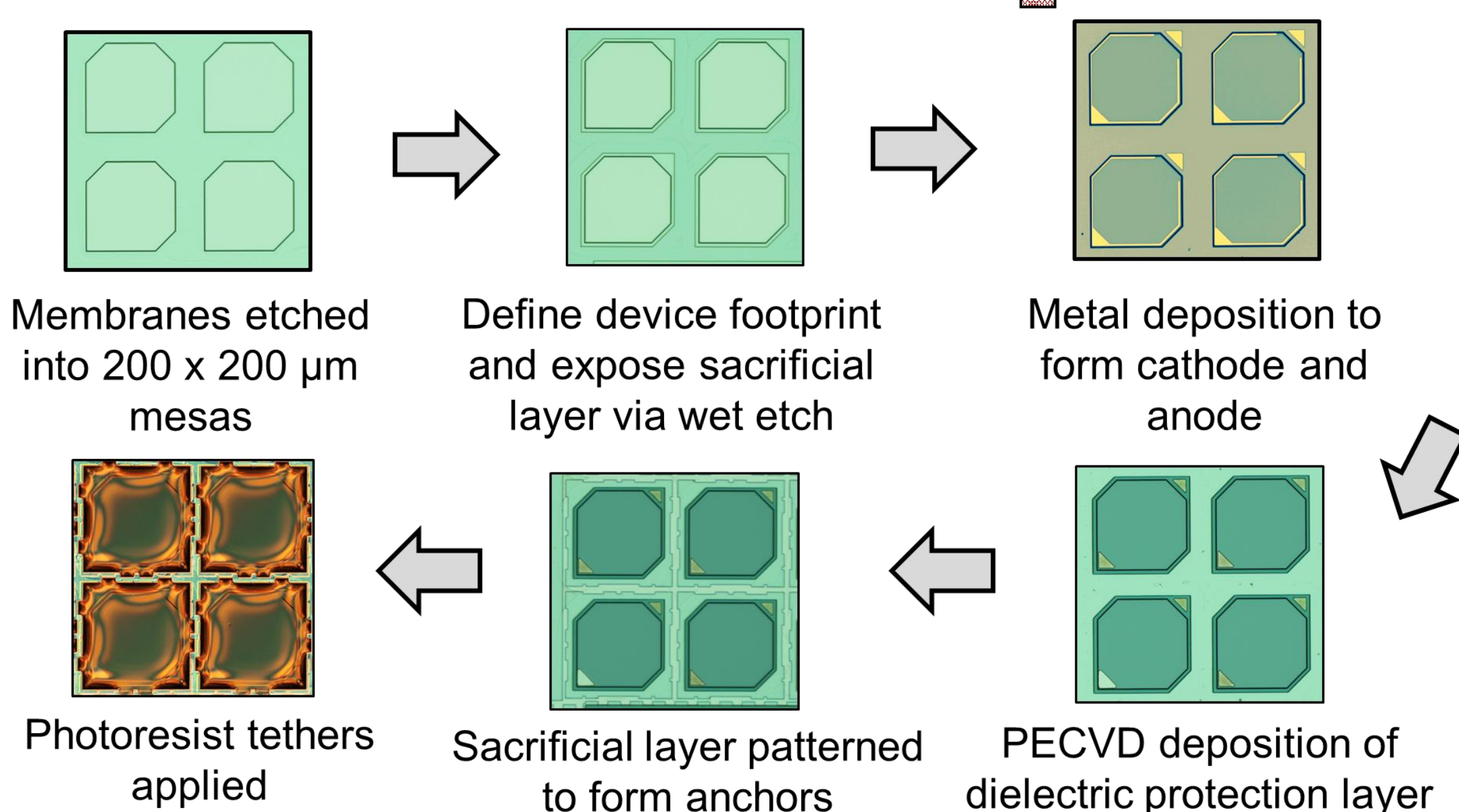


EXPERIMENT

GaSb devices are grown by molecular beam epitaxy (MBE) on top of an etch-release stack and fabricated into 200 x 200 μm^2 microcells.

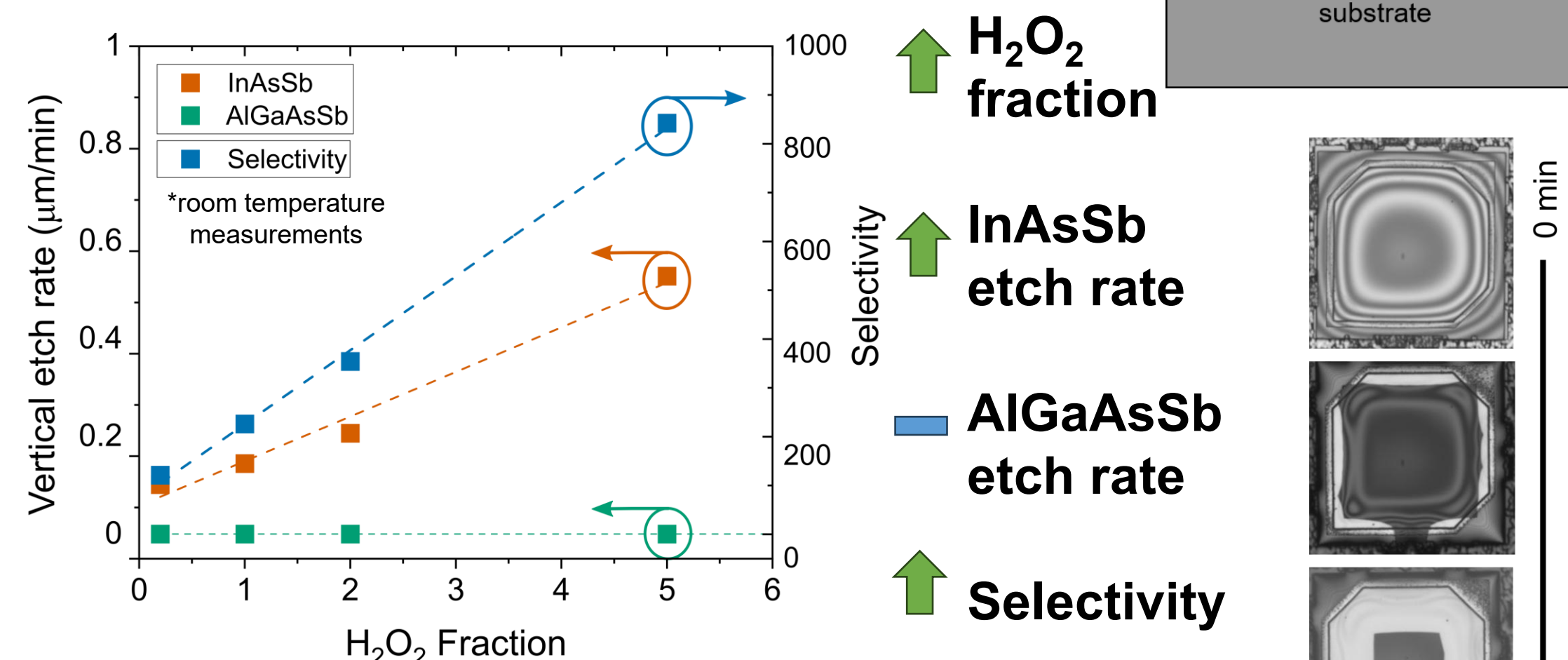


Fabrication flow:



PROCESS DEVELOPMENT

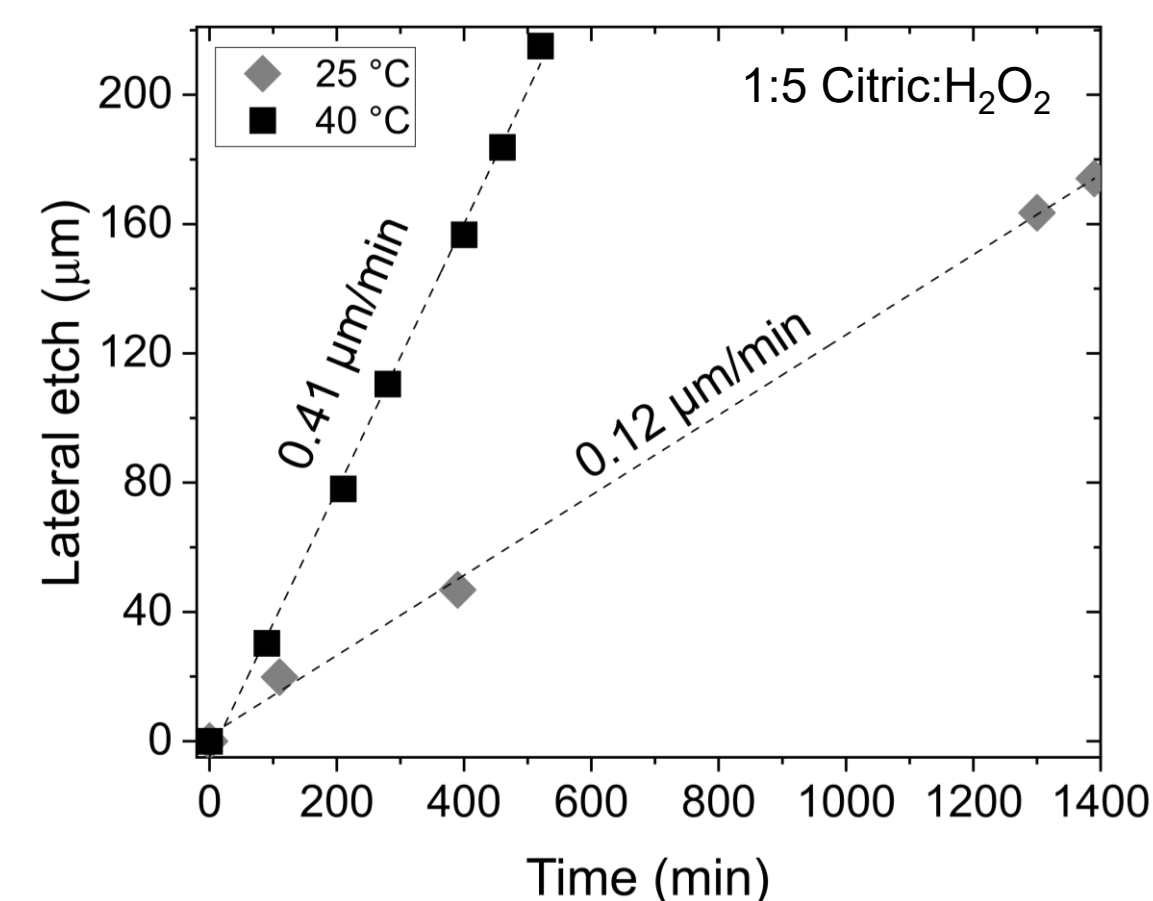
AlGaAsSb membranes were used for process development to enable use of an IR camera for imaging lateral etch.



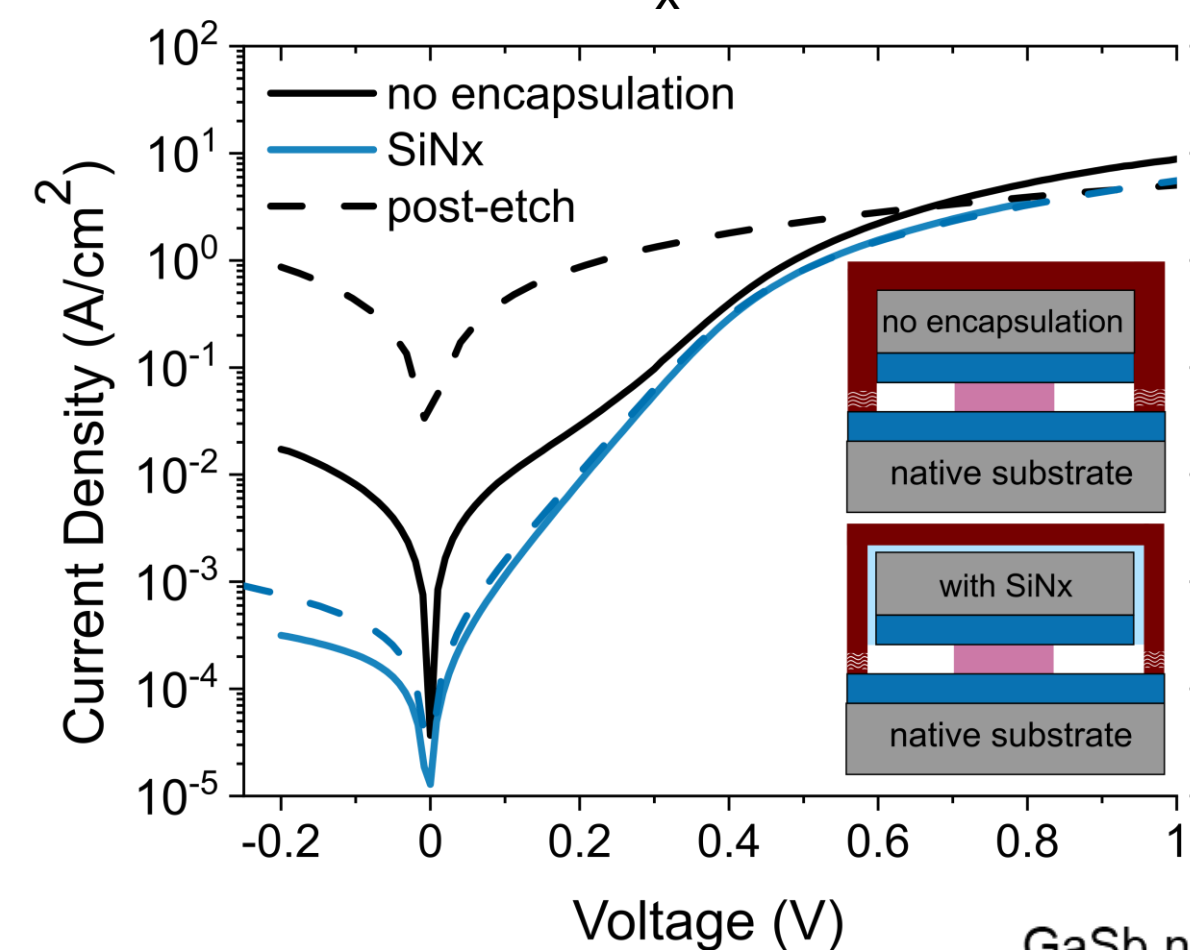
↑ **Temperature**

↑ **InAsSb etch rate**

↑ **Selectivity**



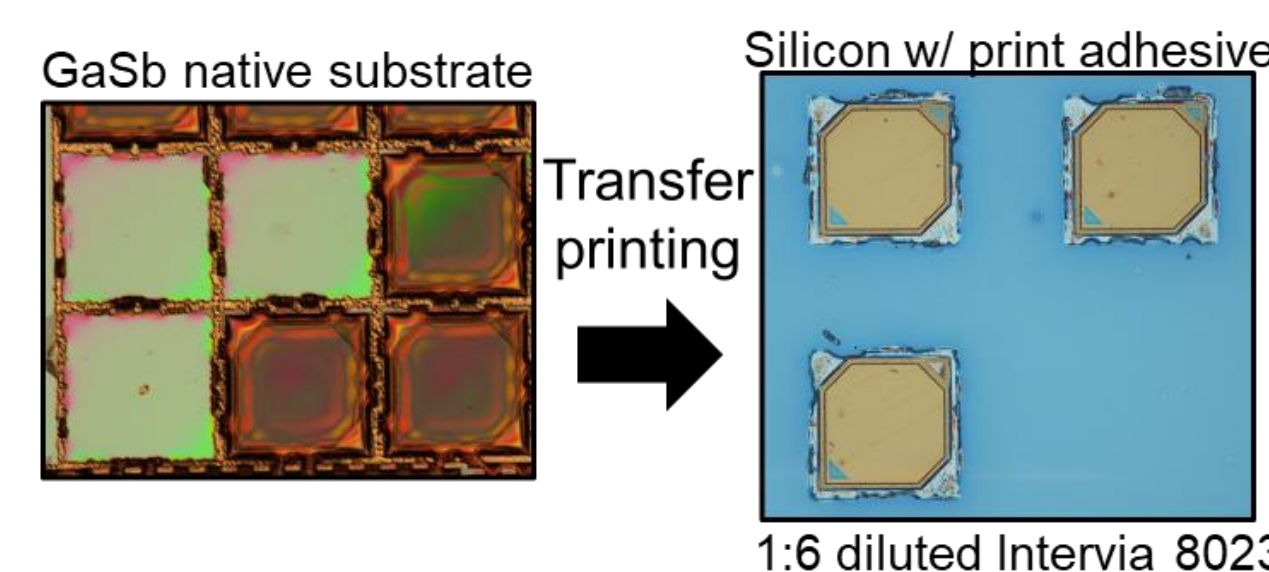
GaSb photovoltaics were exposed to the citric acid-based etch and dark current was compared for bare and encapsulated devices with SiN_x.



SiN_x provides:

- Sidewall passivation
- Protection during wet etching
- Anti-reflection coating

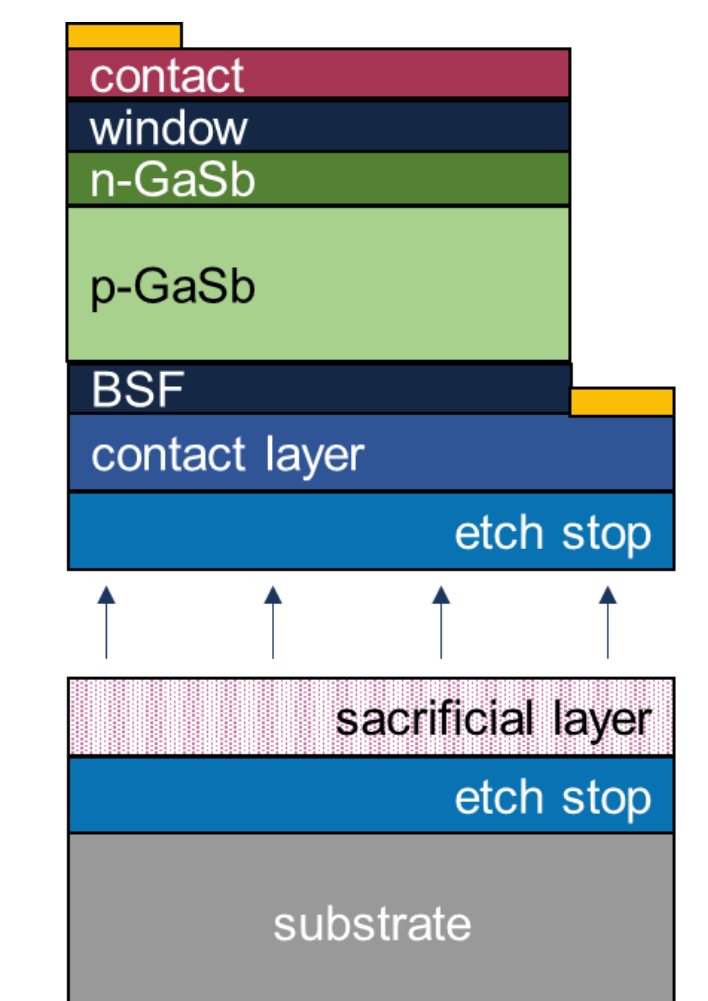
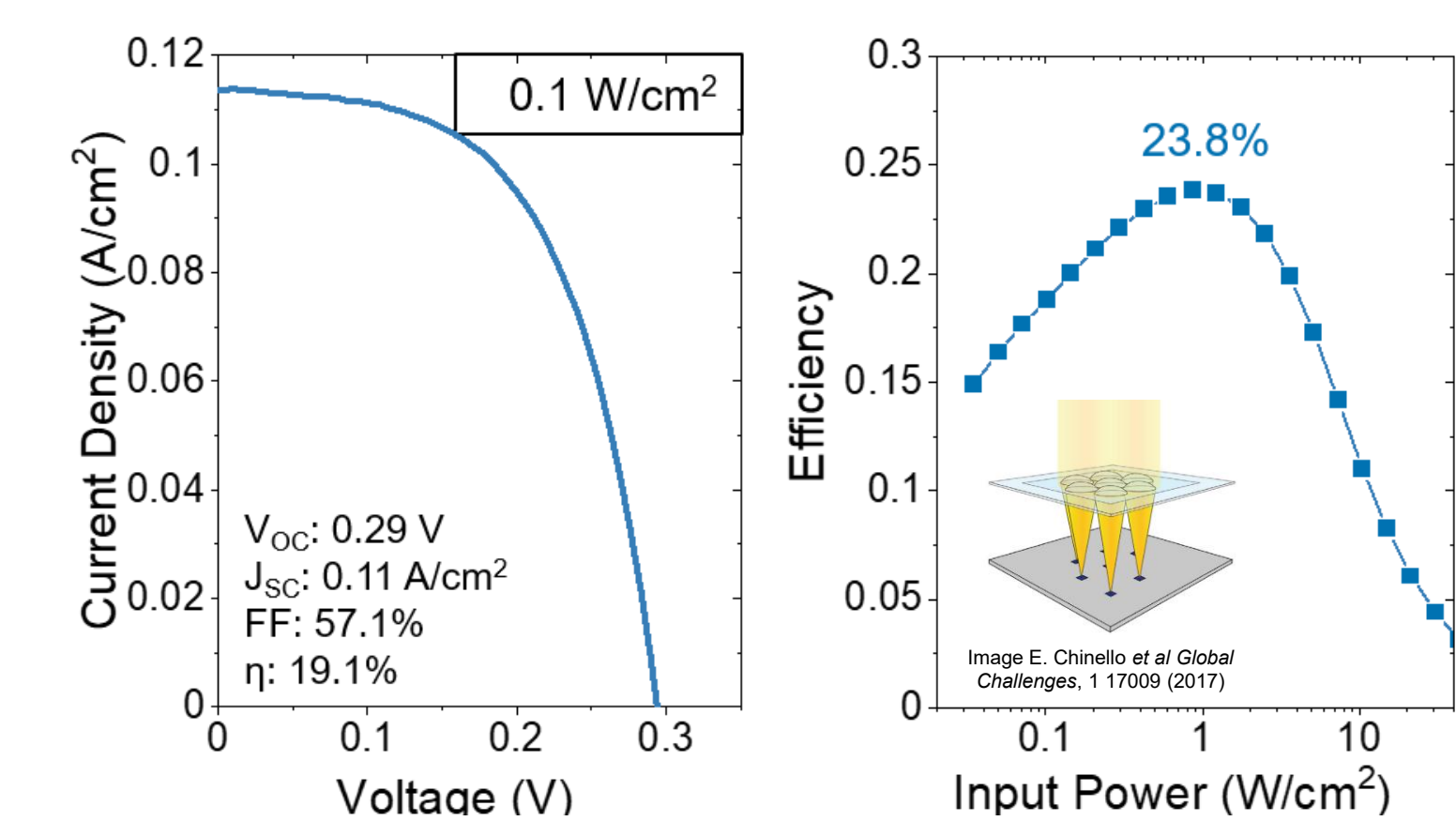
Print adhesives were used to adhere chiplets onto silicon substrates



DEVICE RESULTS

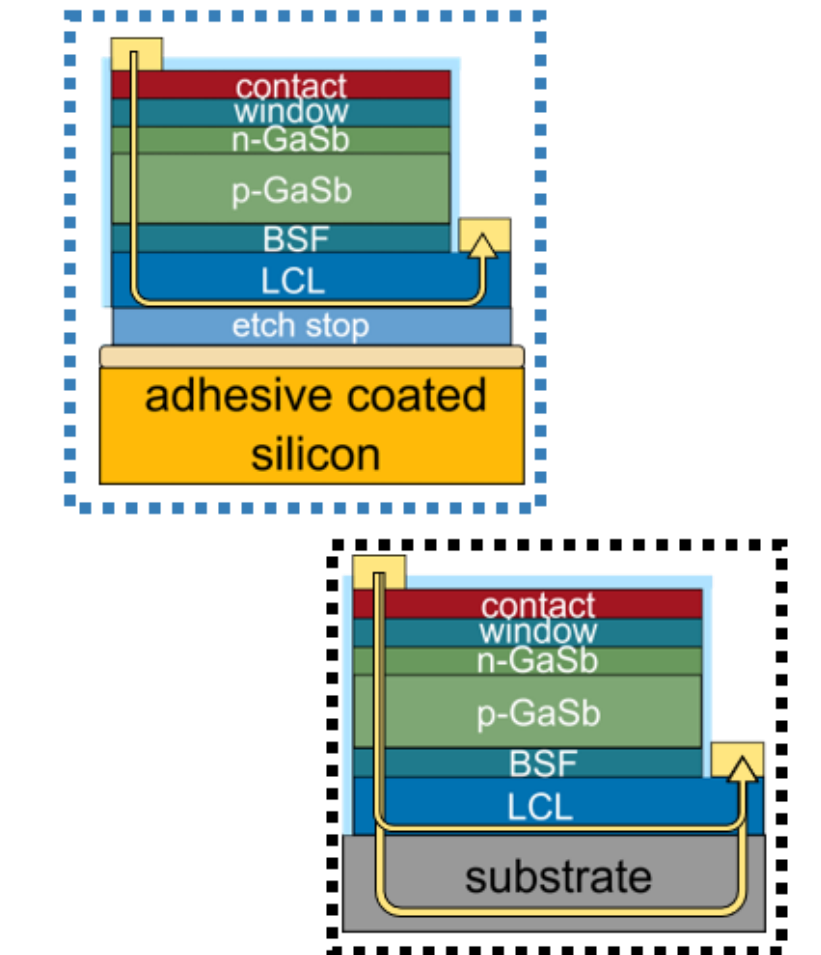
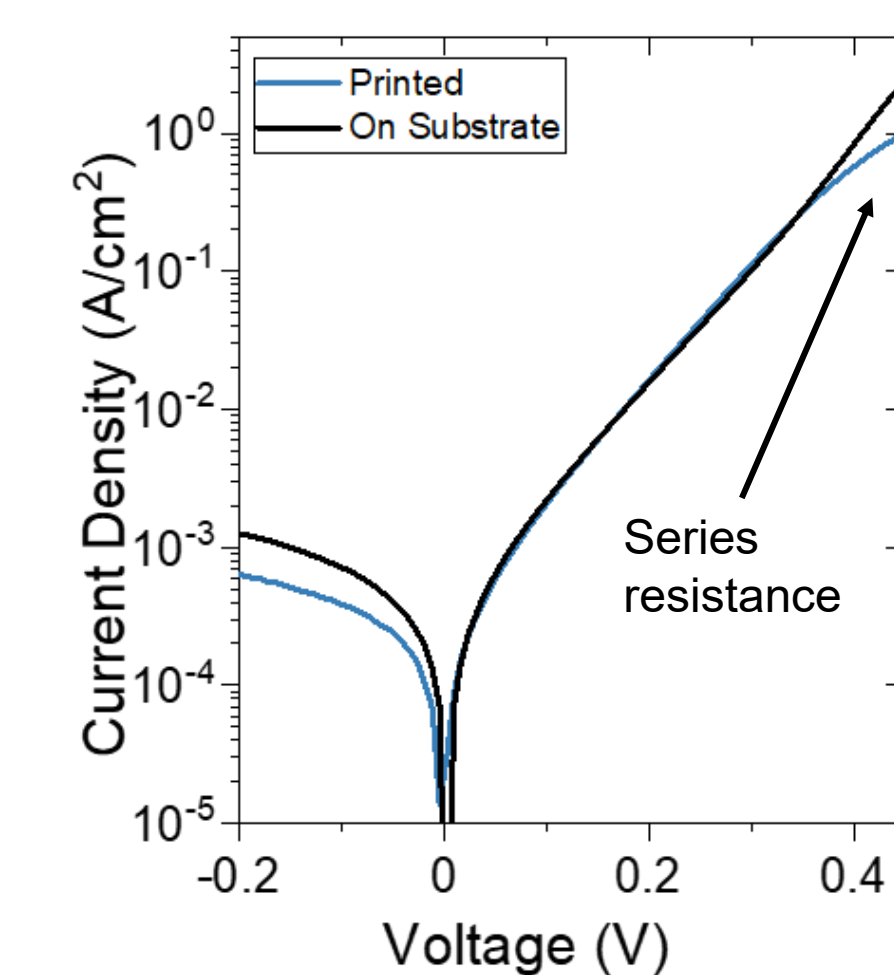
M.A. Stevens *et al.* Appl. Phys. Lett. 127 173906 (2025)

GaSb photovoltaics were printed onto silicon and tested under 1550 nm illumination at 0.03-40 W/cm².



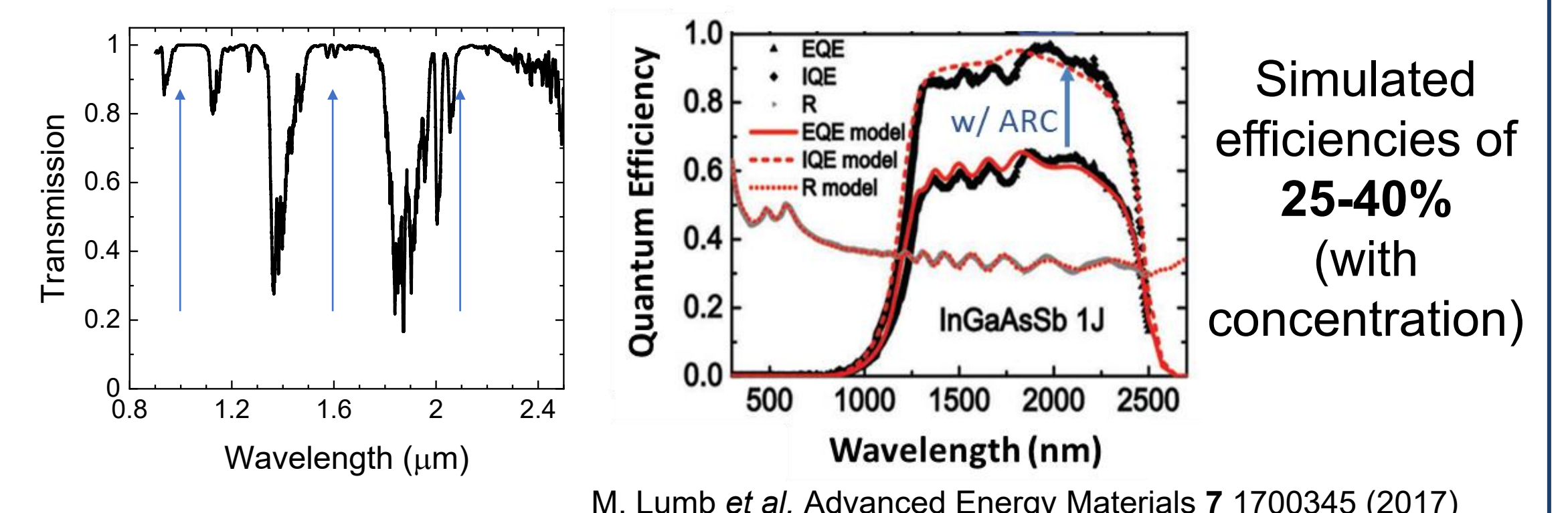
Printed devices **maintain 85%** of their power conversion efficiency when compared to on-substrate devices.

On-substrate devices have the advantage of lateral conduction through the substrate, leading to peak PCE at 6.6 W/cm².



EXTENDING WAVELENGTH

Moving from 1550→2000 nm better matches the availability of high-powered lasers but will require different receiver materials.



SUMMARY

AlGaAsSb membranes and GaSb devices were grown on top of epitaxial release layers and immersed in solutions of C₆H₈O₇:H₂O₂ at 40 °C to laterally etch the InAsSb sacrificial layer.

Lessons Learned

- Vertical etch rates are NOT a good measure of lateral etch rates.
- Dielectric encapsulation is critical
- Tethering depth and full clearing of InAsSb is necessary

Next Steps

- Explore different tethering materials (photoresists vs. dielectrics)
- Optimization of print parameters to reduce need for print adhesive.
- Fabricate InGaAsSb-based photovoltaics for 2 μm lasers.