SEMPRIUS

High performance semiconductors anywhere

Silicone Yellowing Due to Material Interaction in a CPV Application

Steve Seel*, Wolfgang Wagner, and Scott Burroughs

Feb 17th, 2011

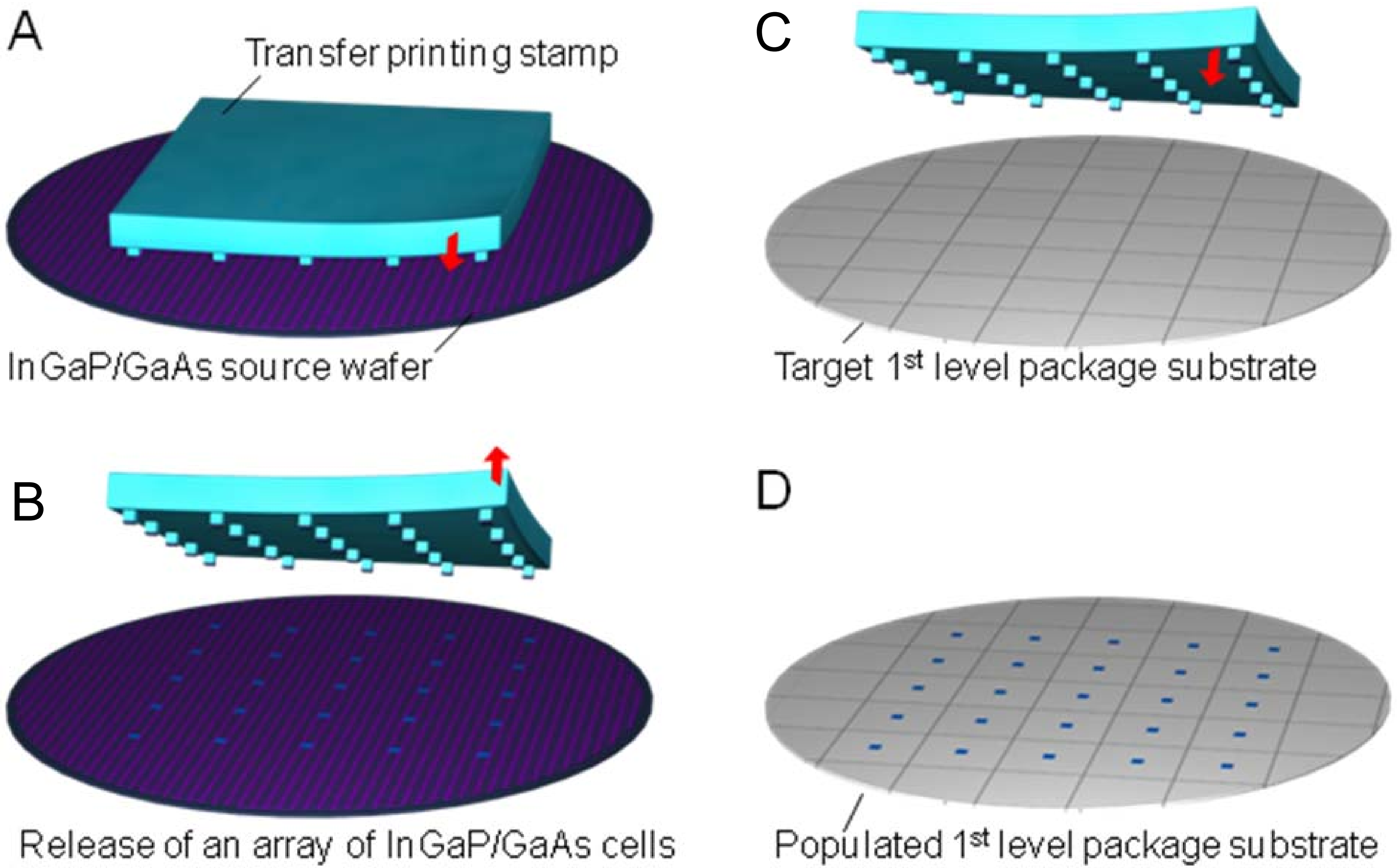
*steven.seel@semprius.com, 919-314-7708

Semprius Background

- Semprius is developing low cost, high performance concentrator photovoltaic (CPV) modules to make solar power generation economically viable in sunny, dry climates. The company's unique micro-transfer printing technology enables CPV modules with high performance, high reliability and low cost with scalability to high-volume production.

- Semprius is also licensing its micro-transfer printing technology for non-solar applications to enable a wide variety of new products requiring large-area, thin, lightweight form factors, unprecedented performance, high reliability and low cost. Applications include flat-panel displays, flexible electronics, large-area sensors, RF devices and other applications requiring heterogeneous integration of high-performance semiconductors.

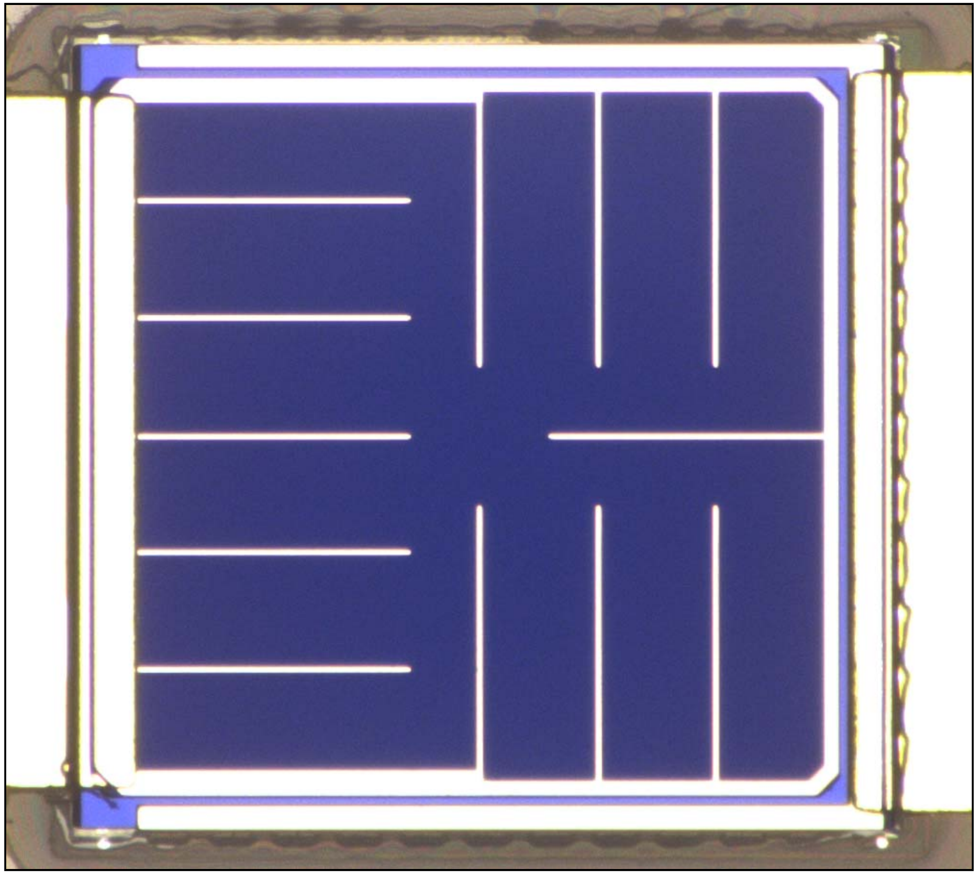
Transfer Printing Process



Transfer printing allows for epi source wafer reuse

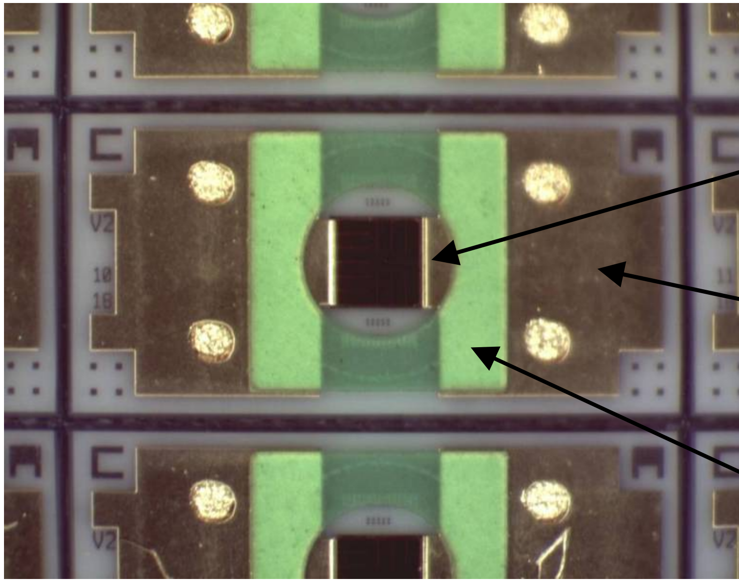
SEMPRIUS
High performance semiconductors anywhere

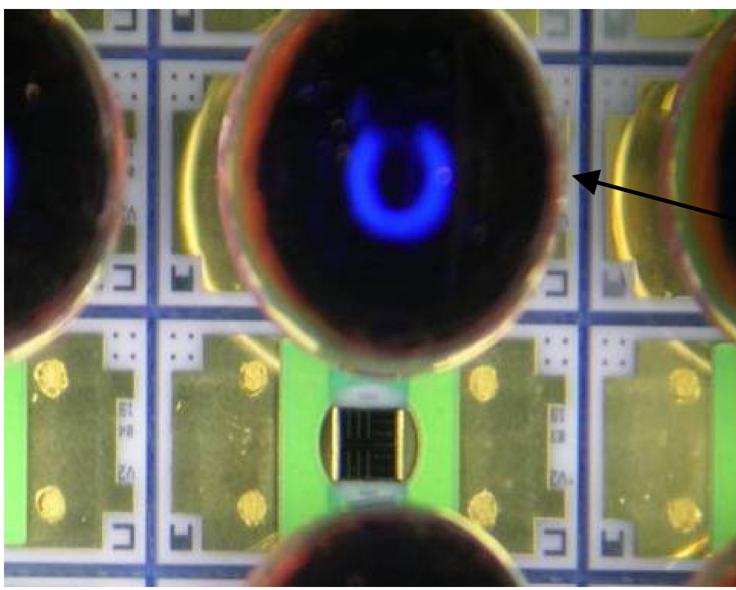
Cell Geometry & Interconnection



- 650um triple-junction unifacial solar cell with +40% efficiency
- Thin film metallization creates anode/cathode interconnection
- Residual heterogeneous anchors from printing process around perimeter of solar cell

Packaging and Secondary Optic





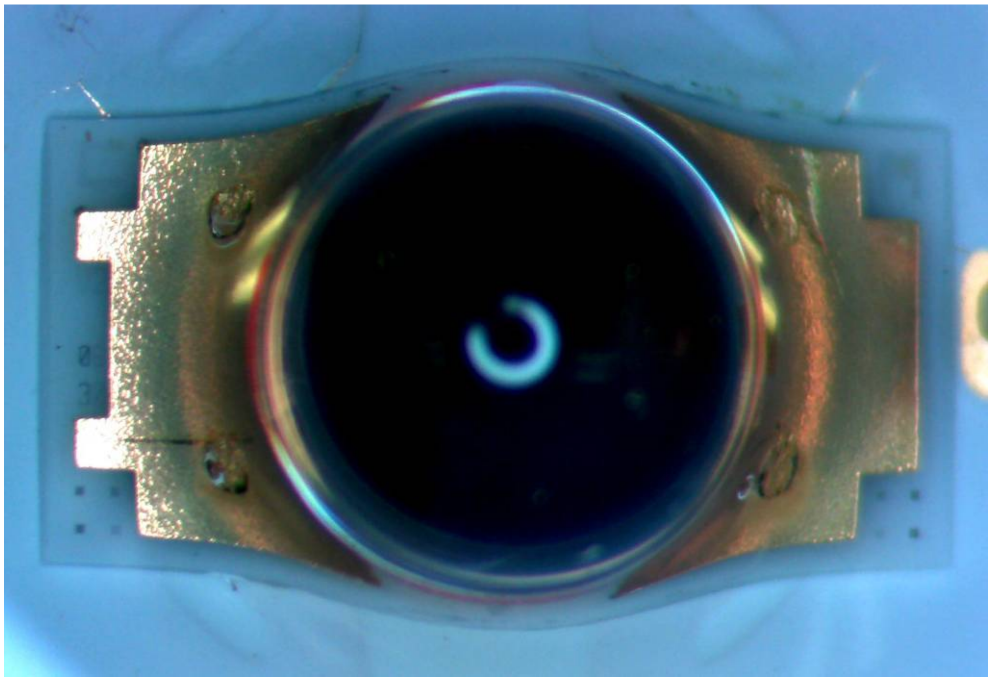
Cell printed onto thin epoxy on ceramic interposer with vias

Evaporated + plated thin film interconnection to solar cell

Photoimageable soldermask used as spacer to control position of glass secondary optic relative to solar cell

Secondary optic provide uniform illumination on cell and 0.9 degree acceptance angle

Silicone Underfill and Overcoat



*Distortion due to refraction by silicone

- Silicone dispensed onto packaged solar cell then ball lens cured in place
- Elimination of air gap between glass ball lens and solar cell reduces Fresnel losses
- Silicone encapsulated solar cell, metallization, and solder joint improves reliability

Failure Mode Discovery

- Long-term damp heat testing was being performed to evaluate effectiveness of silicone encapsulation to protect solar cell

- No secondary optics in place since only darkIV being measured
  – DIV more sensitive to shunts and series resistance changes
  – Easier to measure since no optics involved

- After 1000 hrs at 85C and 85%RH, the silicone encapsulation appeared to be discolored but impossible to measure impact without secondary optics in place

- Lesson Learned: Short cut in testing protocol (no lightIV recorded) means that potential failure mode could have been missed

Silicone-Soldermask Interaction

Exposed to Soldermask

Control Sample

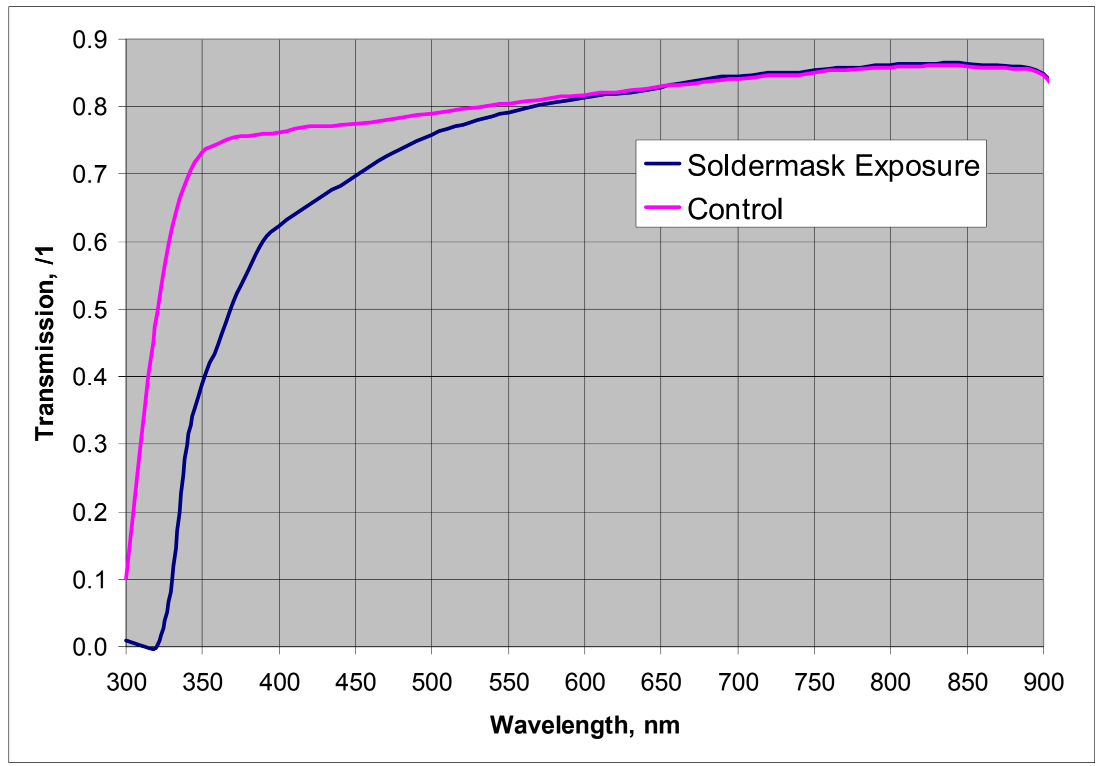
- Sample Coupon Generation

-Cast silicone onto large area of soldermask

-Expose sample to damp heat (85C and 85%RH)

-Peel off silicone from soldermask, attach to glass

-Measure optical transmission of silicone on glass



Root Cause of Failure

- Heat and humidity exposure of silicone alone not root cause since control sample shows no signs of degradation
- Tests at 85C without moisture showed same undesirable silicone-soldermask interaction
- Silicone discoloration likely due to fast diffusion of mobile green dye in soldermask into “porous” silicone at temperature
- Alternative soldermasks with brown dye **did not** show any signs of interaction with silicone through damp heat testing
- Classic case of interactions between reliable components causing problems only observed once full product assembled

Long-Term Module Reliability

Module **without** silicone-soldermask issue