

Wafer-level Integrated Micro-scale Concentrating Photovoltaics

TECHNOLOGY

Novel low-cost micro-CPV approach seamlessly integrates high-efficiency micro-PV cells with an innovative multi-functional Si platform.

Hybrid micro-scale photovoltaic

- Direct sunlight: High-efficiency, high-concentration multijunction micro-cell arrays
- Diffuse sunlight: Low-concentration Si cell

Micro-scale Optical concentration

- Anisotropically-etched reflective cavities into Si wafer as efficient non-imaging micro-optical concentrators.

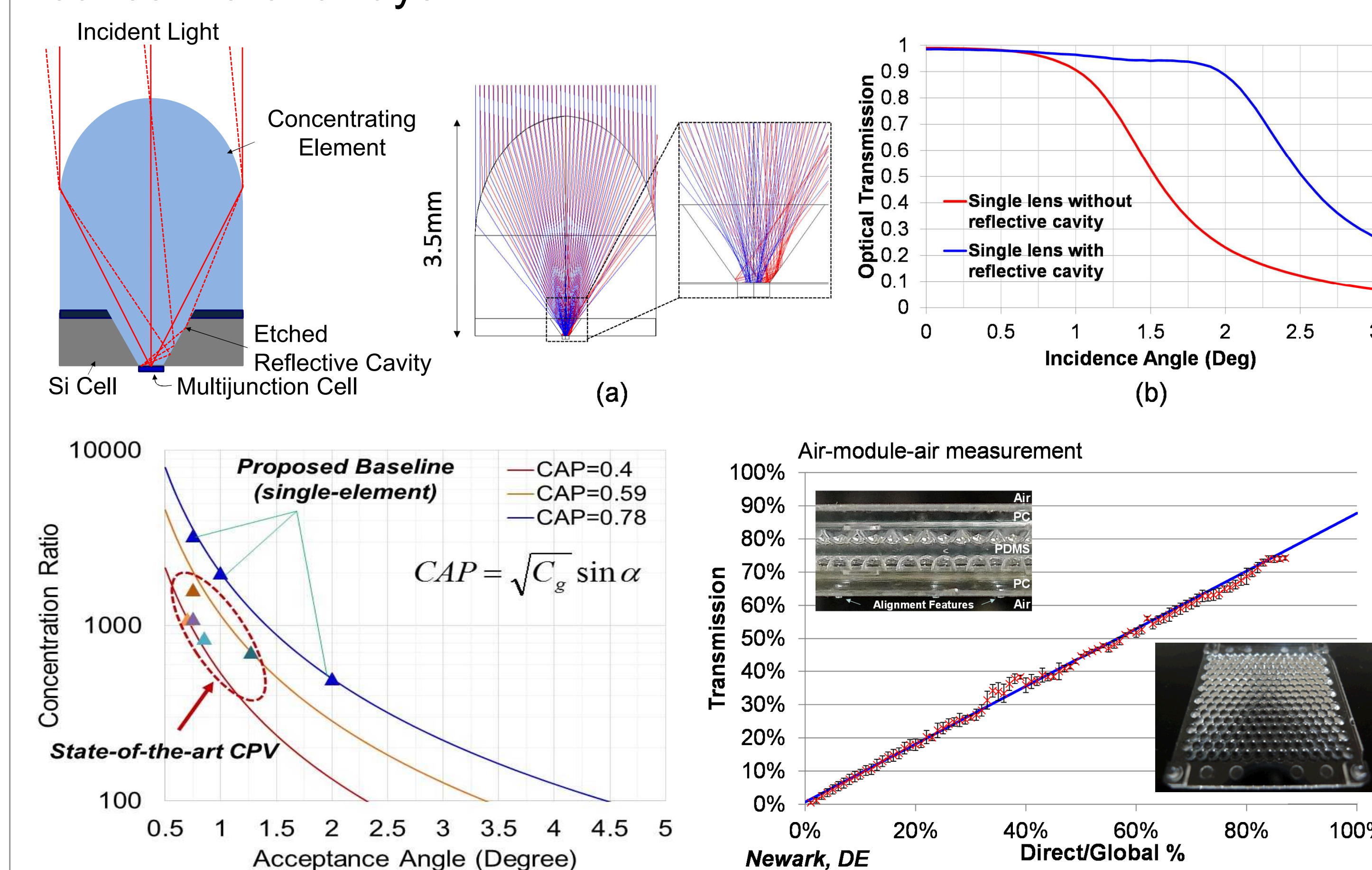
Mechanical micro-assembly

- Etched Si pit facilitates component integration

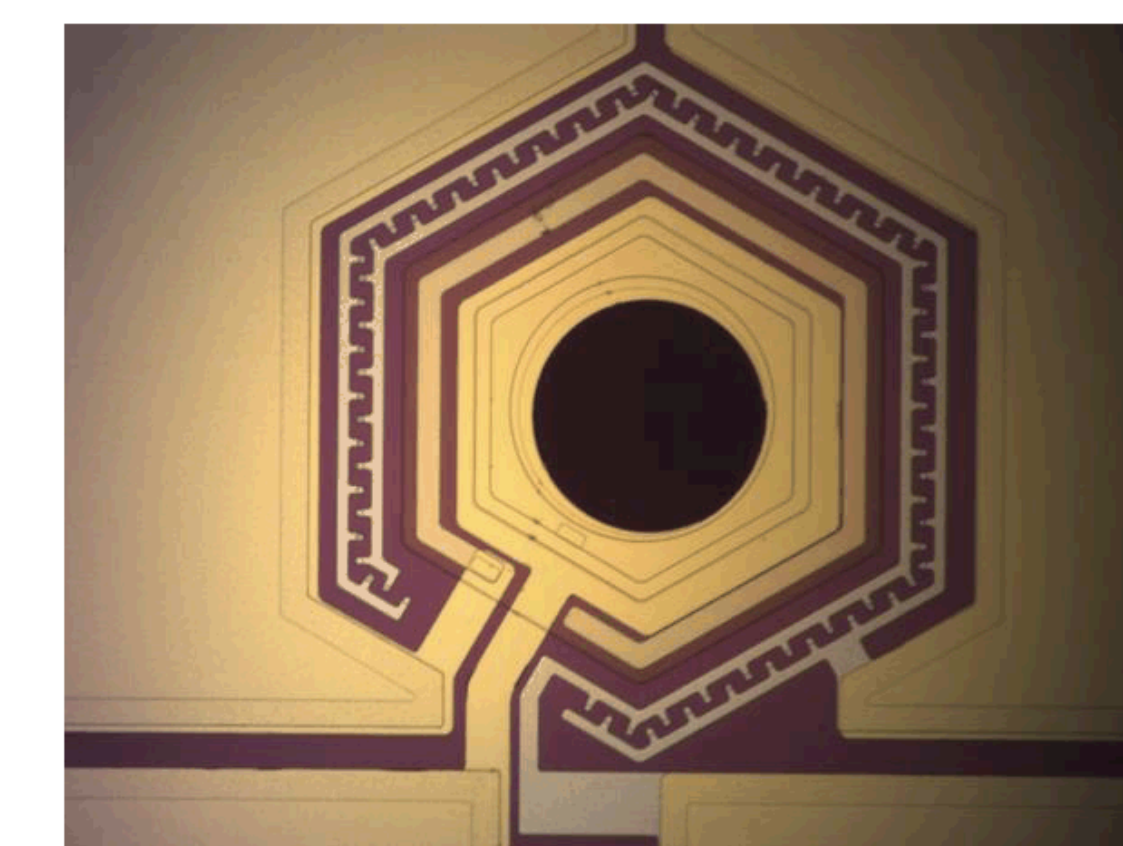
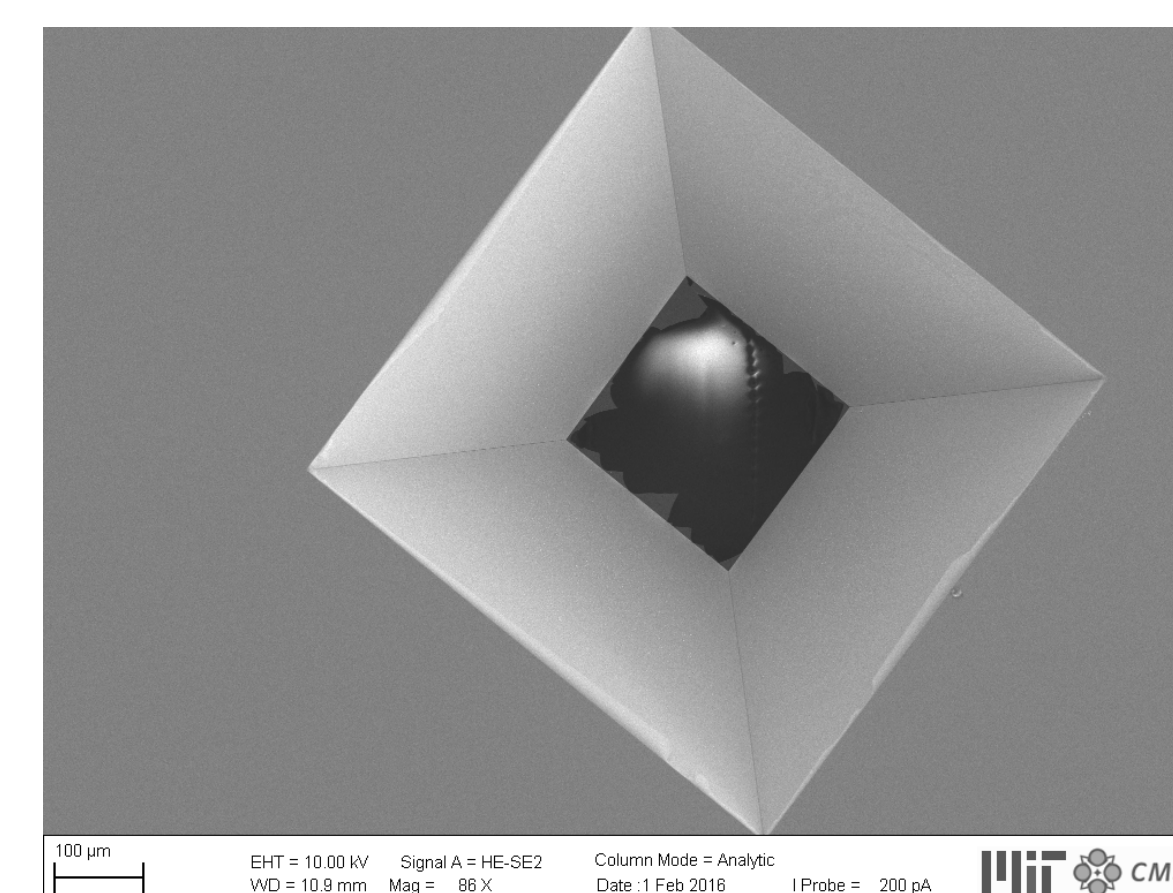
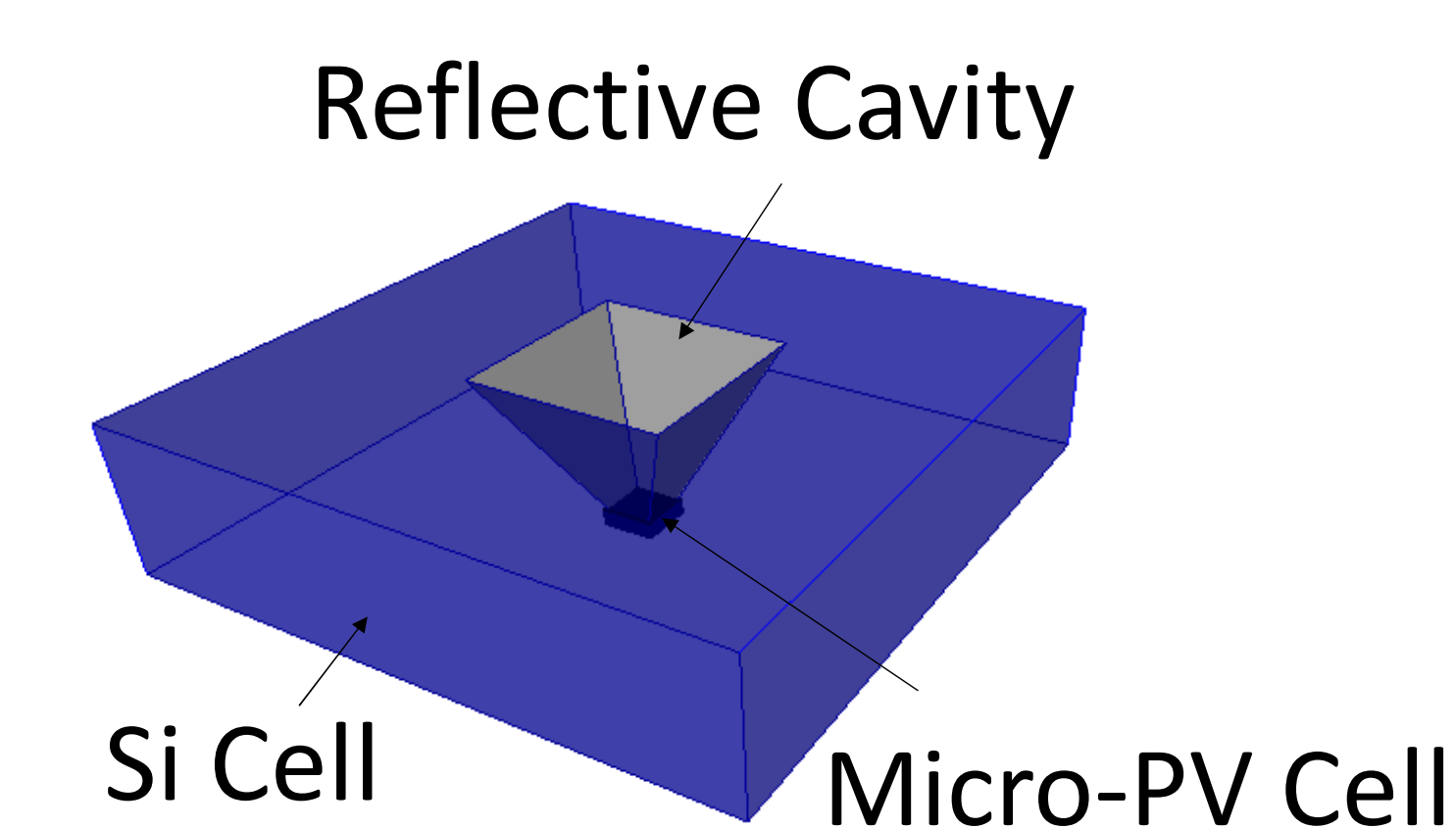
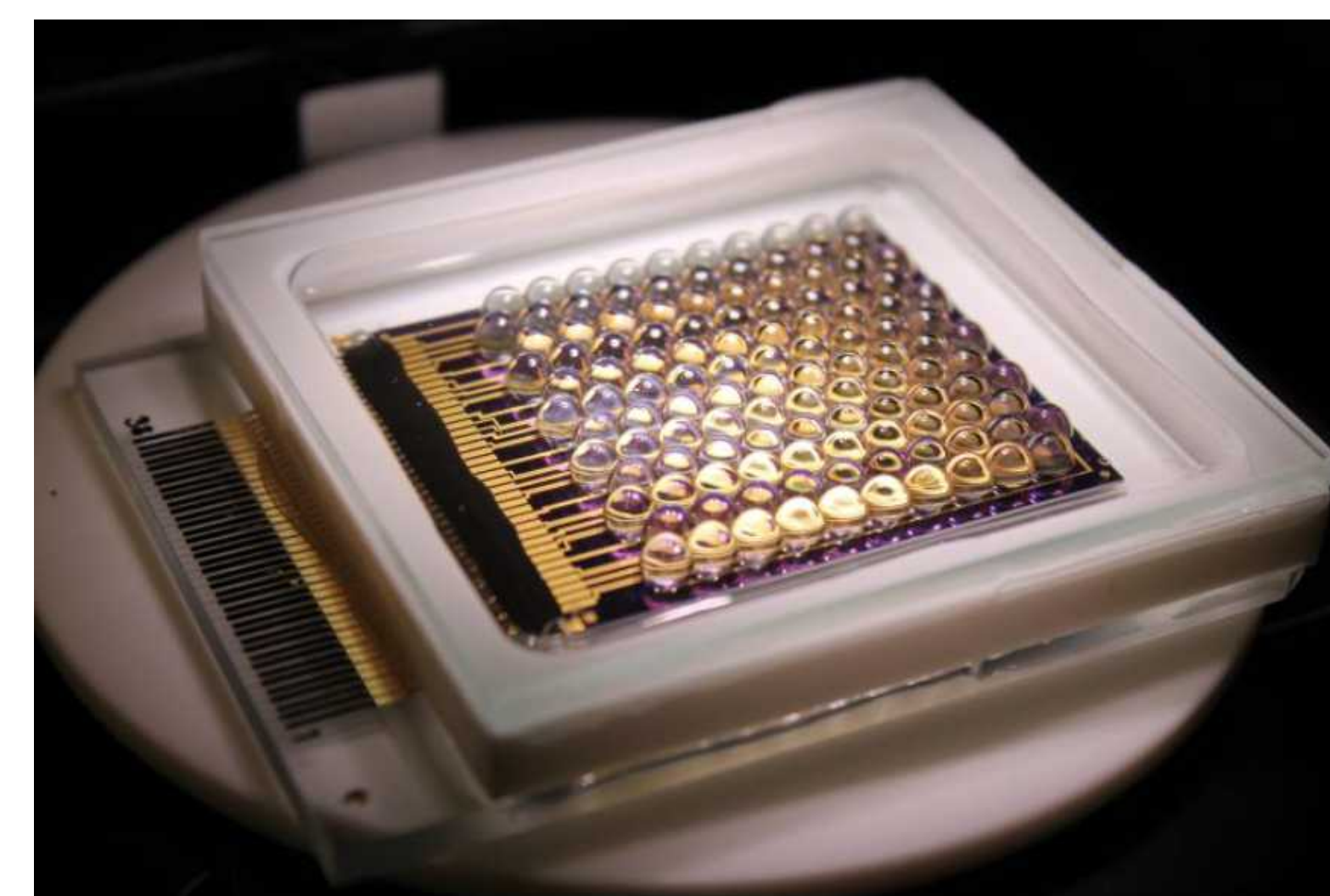
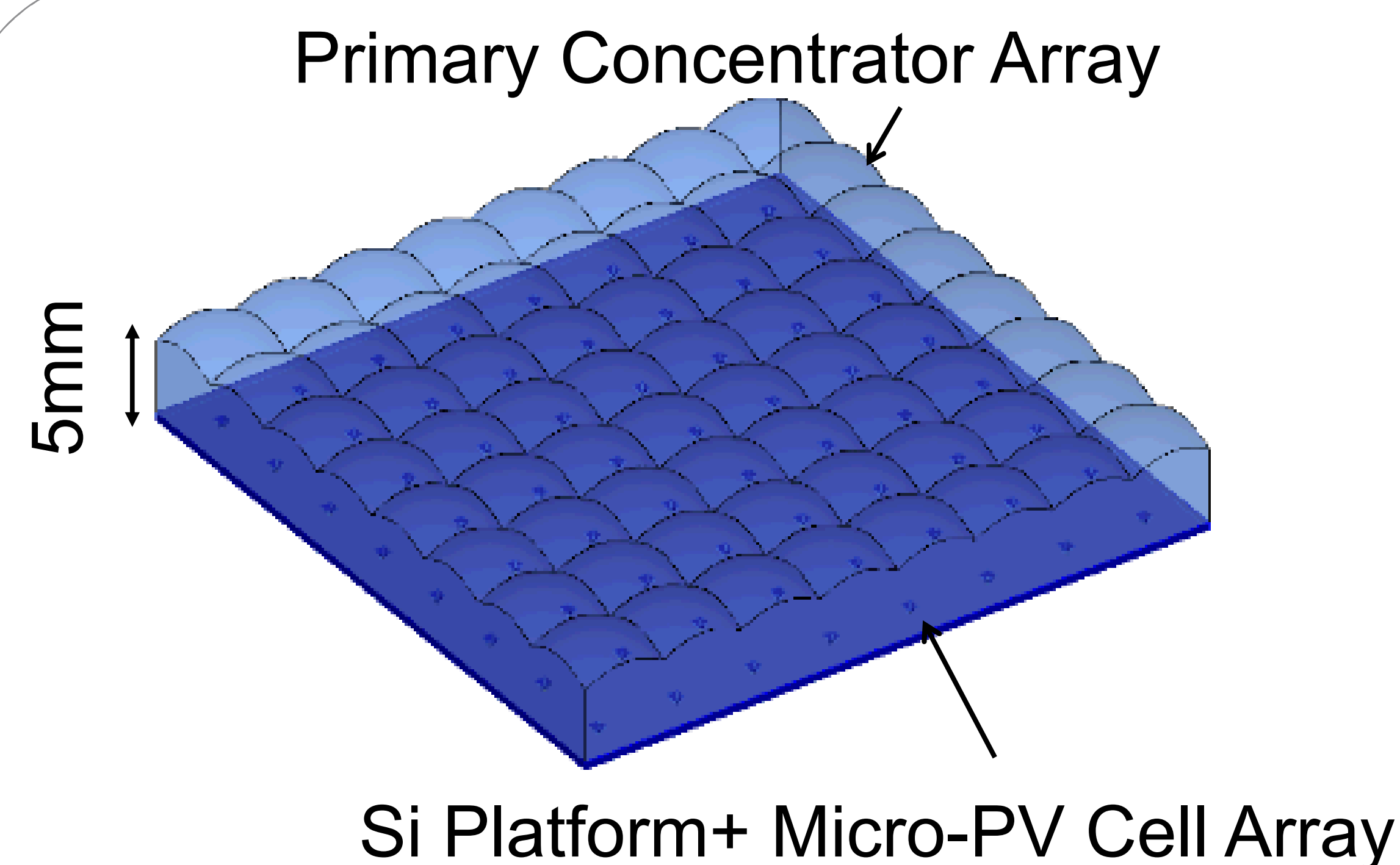
Low-cost fabrication and assembly

Micro-scale Optical Concentration

- ❖ Naturally-formed non-imaging optical concentrator arrays in Si
- ❖ Simple, low-cost, molded primary concentrator sheets
- ❖ High concentration (1000X-2000X) dramatically reduces costs of high-efficiency semiconductor materials
- ❖ Large acceptance angle allows use of low-cost coarse trackers
- ❖ Compact form-factor: thickness < 5mm
- ❖ Low-cost manufacturing and assembly of PV cell and concentrator arrays

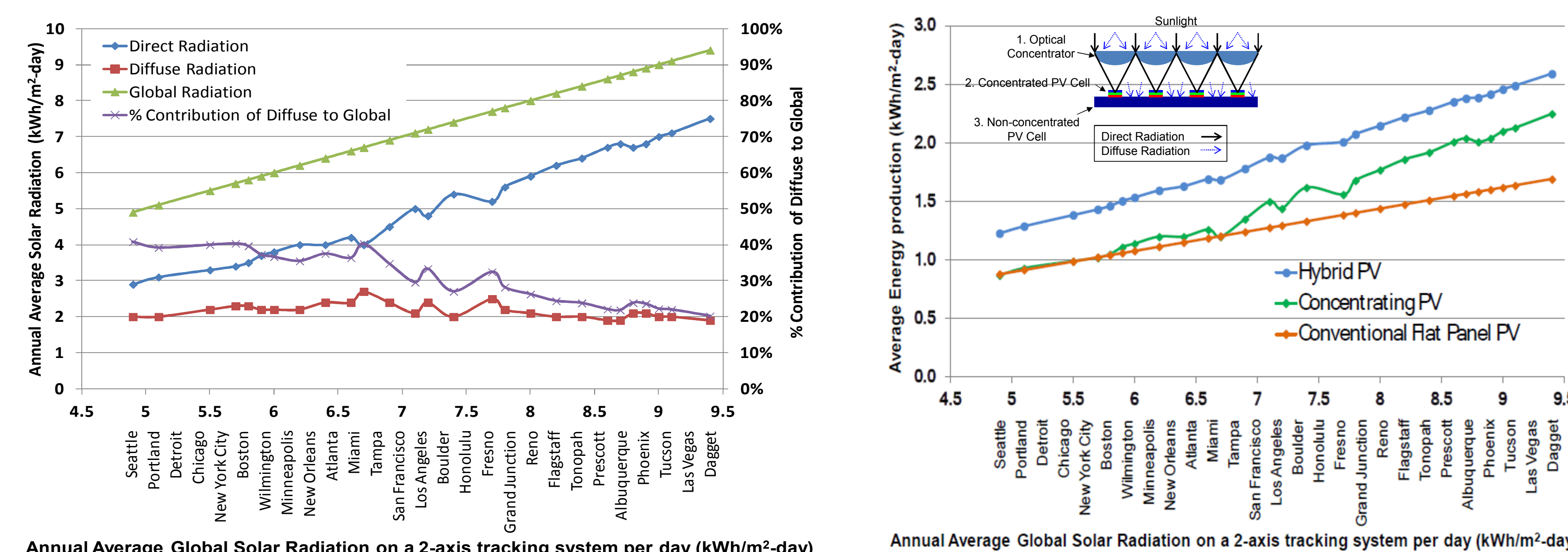


Simple, high-efficiency micro-optical concentrators embedded in a novel multi-functional Si platform minimize multi-junction cell usage: >50% reduction.



Micro-concentrating PV module integrating arrays of micro-cells and micro-optics closely within a compact module offers the high performance of CPV and the flat physical profile and balance-of-system advantages of Si flat panel PV.

Hybrid Photovoltaic Architecture

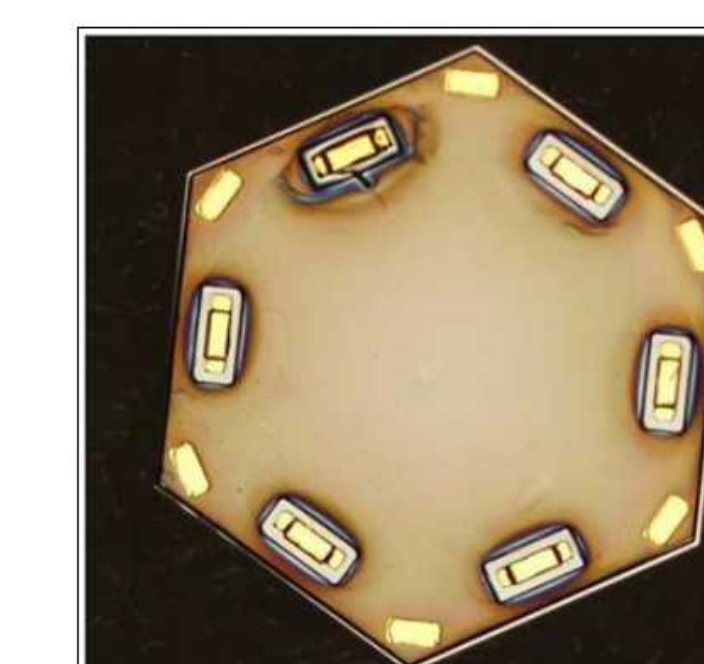
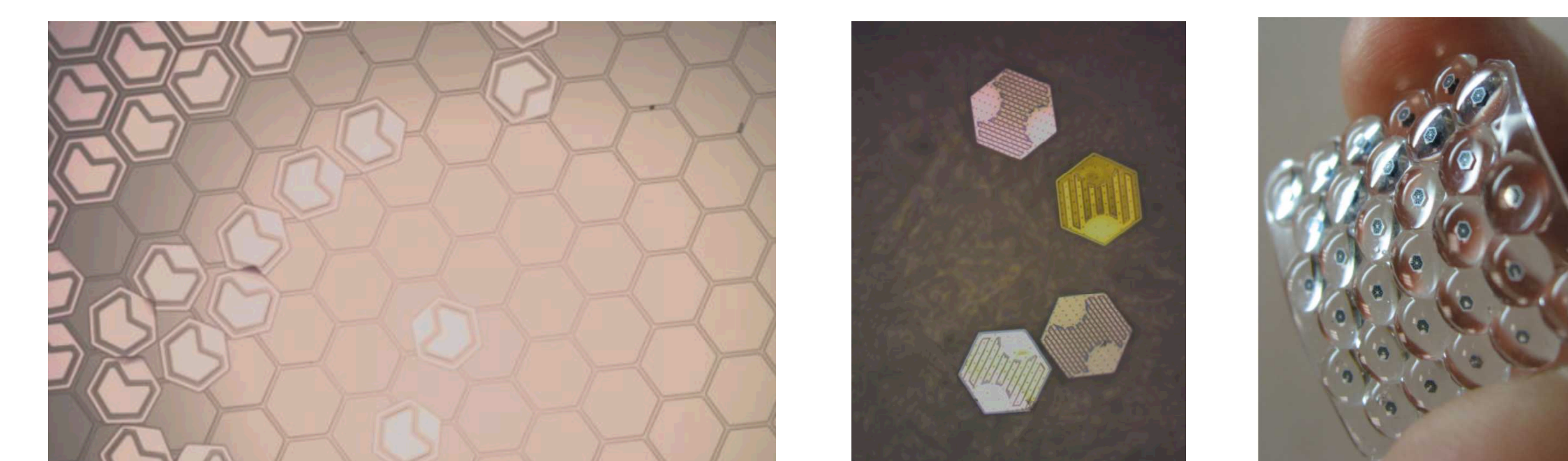


Technologies	Direct Eff.	Diffuse Eff.	Module Efficiency (DNI/Diffuse)		Module Cost	Module Thickness
			80/20	60/40		
Proposed Approach	41.4%	13.4%	35.8%	30.2%	< \$150/m ²	<5mm
Tandem CPV	36.7%	0%	29.4%	22%	~ \$235/m ²	> 8cm
Si Flat Panel	22.4%	19%	21.7%	21%	~ \$140/m ²	~ 3cm

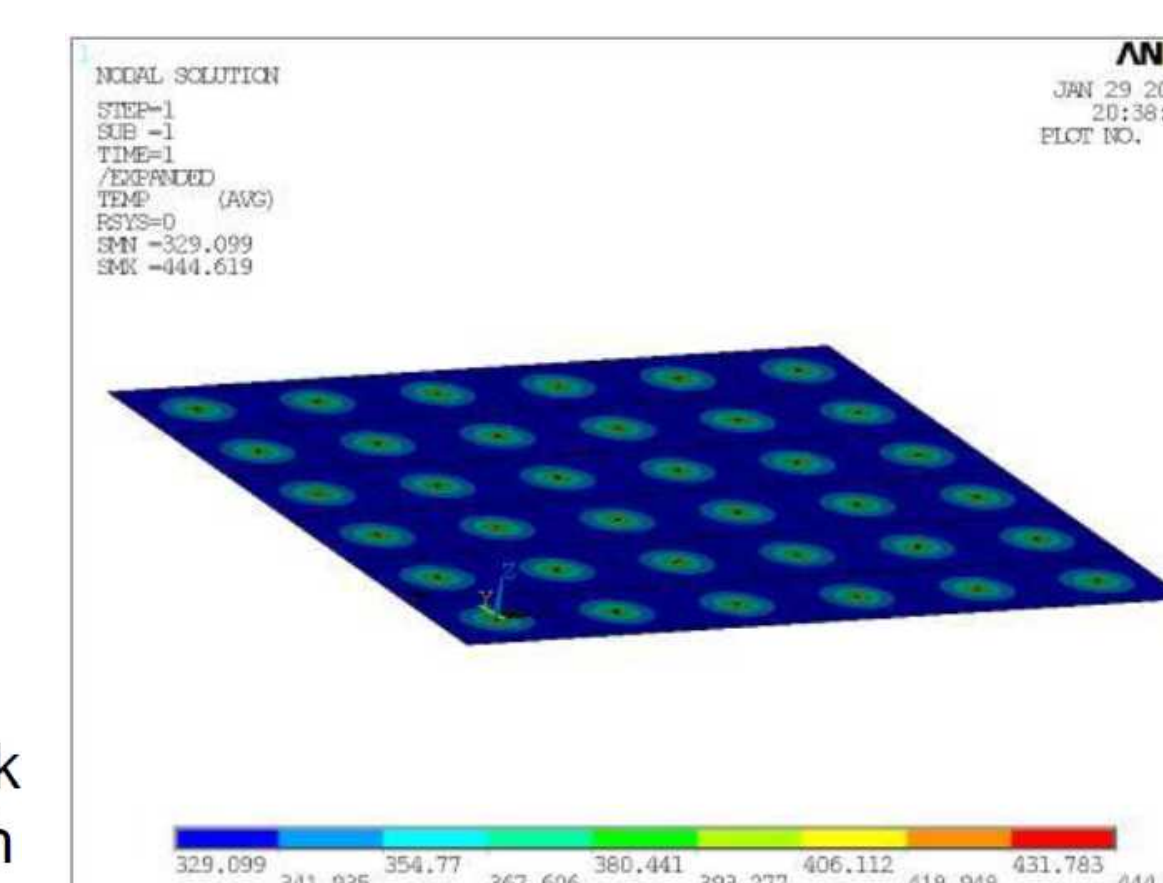
Under all weather conditions across the USA, proposed hybrid approach will produce 40-60% and 20-40% more energy per unit area than Si flat panel PV and CPV, respectively, while offering the same module cost as Si PV.

Micro-scale Photovoltaic Solar Cells

- ❖ Micro-scale PV cells 100's μm in diameter
- ❖ Enhanced cell performance
- ❖ Reduced semiconductor cost
- ❖ Improved thermal management
- ❖ Interconnection flexibility



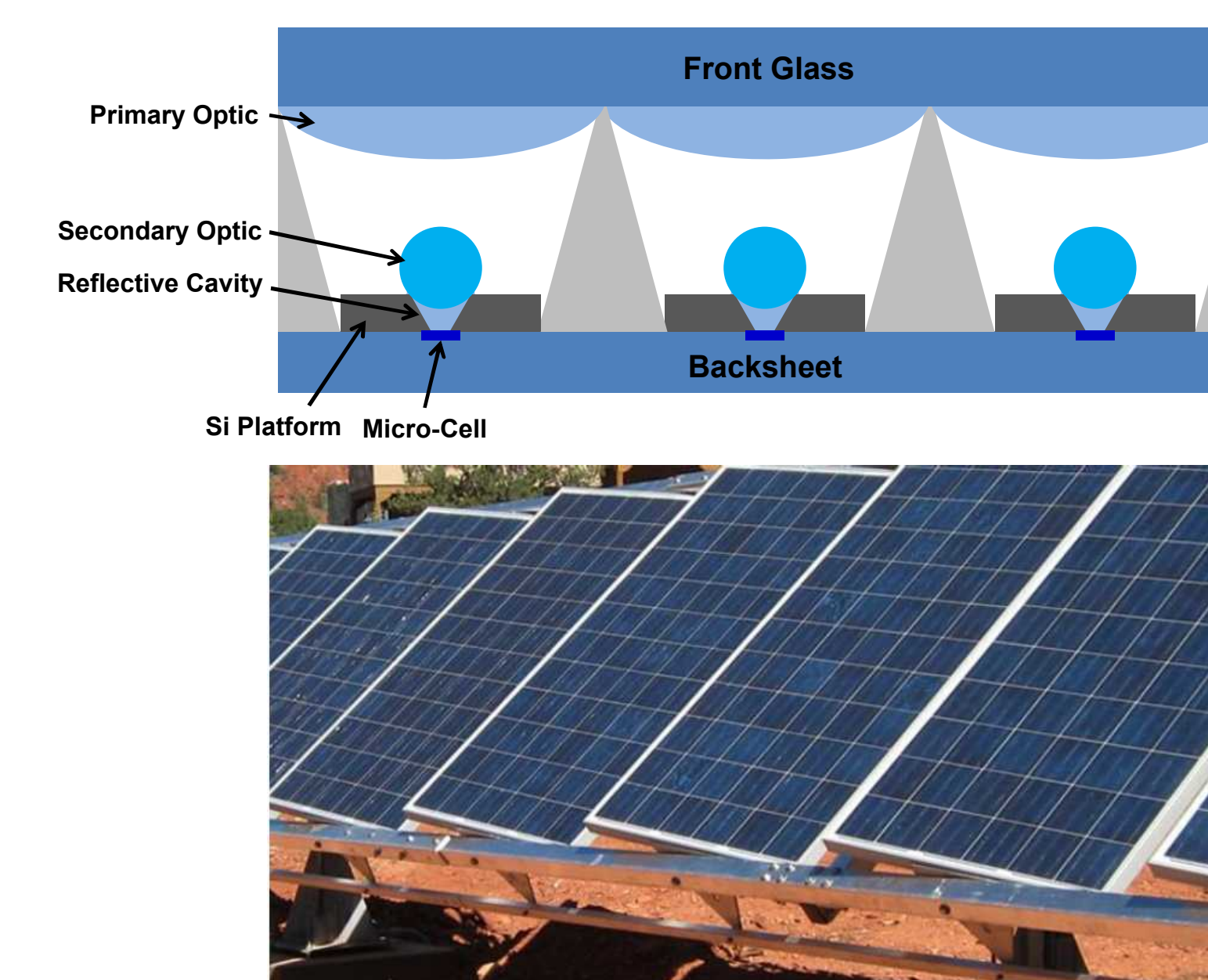
Fully back contacted 6 micron thick InGaP/GaAs dual junction cell with leveled back contacts



Dimension down-scaling of solar cells below mm's allows substantial performance improvement and cost reduction at the device-, module-, and system-levels.

Scalability

- ❖ Micro-concentrating Si platform amenable to advanced module designs that further improve concentration and tolerance



Wafer-level integrated micro-CPV are scalable to large-area solar power panels and are fully compatible to existing Si-based infrastructures.

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