

Flexible, Lightweight, High-Performance Photovoltaics

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Devices, Inc.***

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Overview: Flexible III-V PV Technology



❑ MicroLink Devices

- ❑ ISO 9000 III-V materials and device manufacturer
- ❑ Established year 2000

❑ Flexible, High-Efficiency ELO Solar Cells and Sheets

- ❑ Industry-leading high specific power (>2 kW/kg)
- ❑ Enabled by epitaxial lift-off (ELO) process
- ❑ Flexible, lightweight, high efficiency, cost effective
- ❑ HALE IMM product available now, space-qualified version in 2024 / 2025

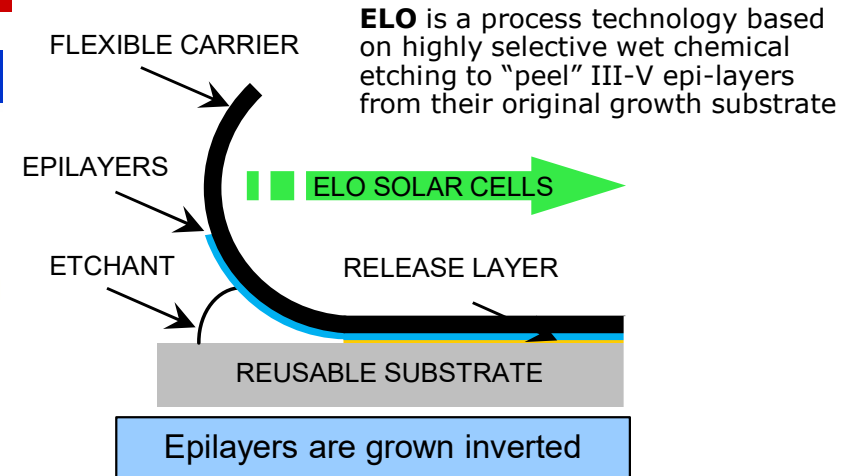
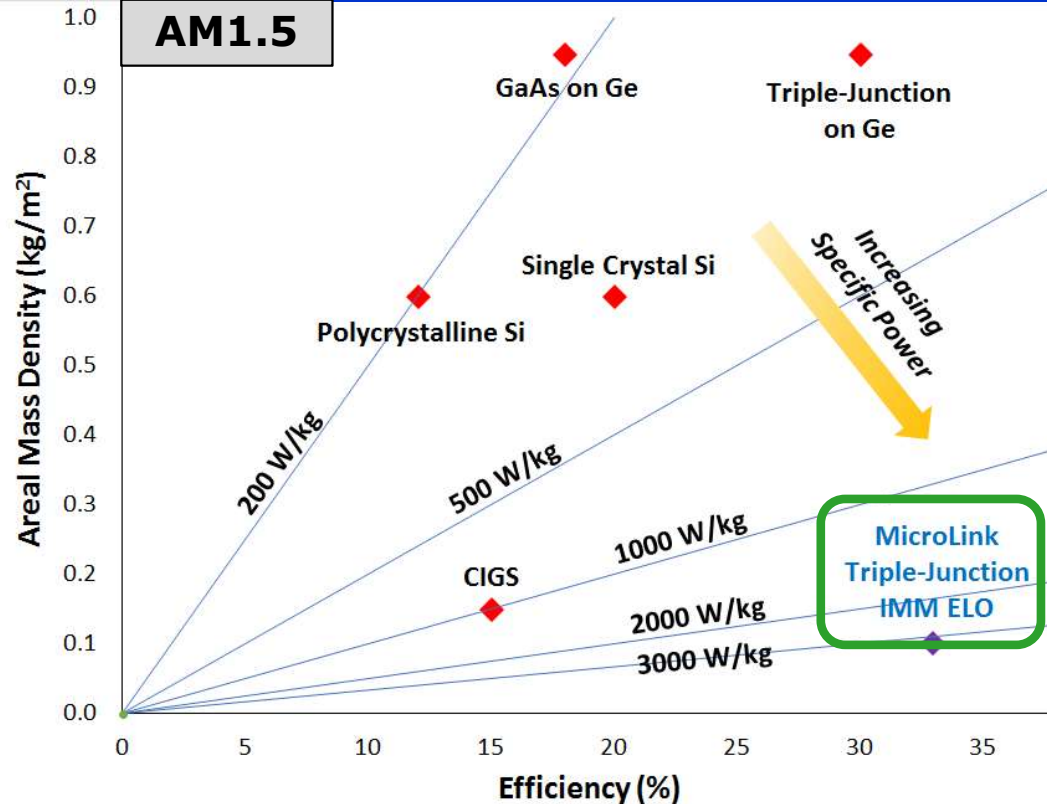
❑ Unique Cells for New System Design Approaches

- ❑ Thin, flexible ELO cells enable novel integration methods: including conforming to curved surfaces, custom cell shapes, form factors and microcells
- ❑ IR-rejecting ELO solar cells can lower operating temperatures and further increase real-world power
- ❑ All topside or backside contacts possible
- ❑ Pathways to improve efficiency, rad tolerance & resilience

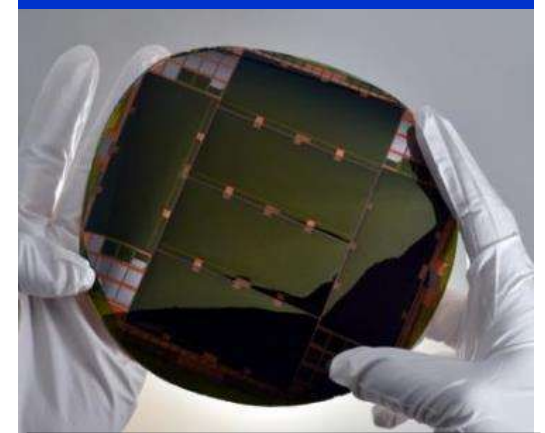


Epitaxial Lift-Off (ELO) Benefits for Photovoltaics

Areal Mass Density and Efficiency of Bare Cells



150 mm diameter ELO foil



Foil is <30 μm thick and flexible

- ❑ Low Areal Mass Density – GaAs substrate is removed
- ❑ Lower Cost – GaAs substrate reuse reduces solar cell BOM
- ❑ High Efficiency – Inverted metamorphic multijunction (IMM) III-V design
- ❑ Flexibility – Cells can be bent without degrading performance

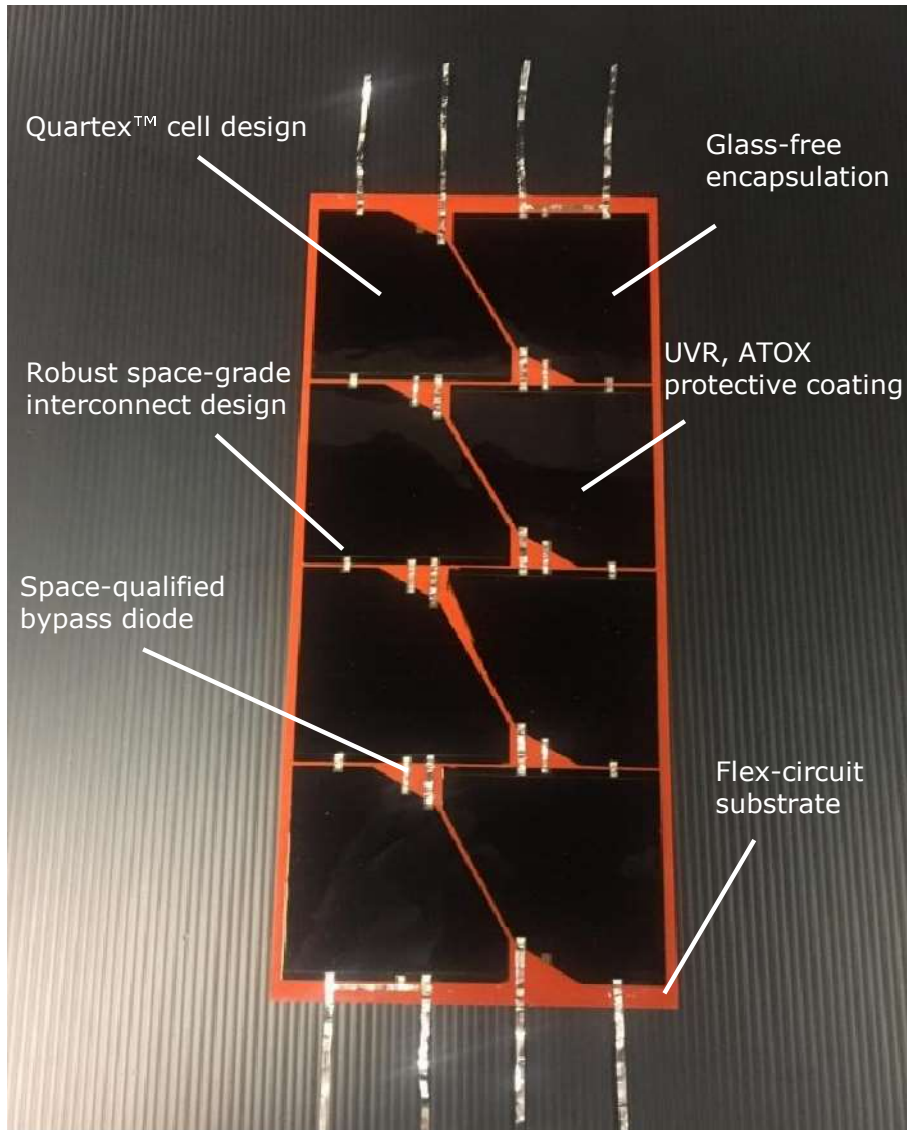
High Altitude Long Endurance (HALE) UAV Applications



- ❑ Lightweight, high-efficiency ($\sim 30\%$) cells conform to curved surfaces



Solar Sheet for Spacecraft



- Preliminary specifications:
 - Two cell designs
 - Low Fluence ($1e14cm^{-2} e^{-}$) – 94%
 - Standard Fluence ($1e15cm^{-2} e^{-}$) – 85%
 - Mass density: 400-700g/m²
 - Orbit lifetime: 7-10 year LEO
- Timeline
 - Development phase: 2022-2024
 - Qualification phase: 2024-2025



Lower Projected Operating Temperature for ELO Solar Cells



DEFENCE AND SPACE

III-V ELO dual vs. triple junction

- ❑ Epitaxial lift-off cells are a game changer for solar arrays in LEO
 - Significant mass and cost reduction

reference: 3J on Ge	3J ELO (GaInP/GaAs/InGaAs)	2J ELO (GaInP/GaAs)
efficiency = 30% (AM0, T_{room})	efficiency = 30% (AM0, T_{room})	efficiency = 27% (AM0, T_{room})
absorptivity 91% $T_{oper.} = 74^{\circ}C$	absorptivity 82% $T_{oper.} = 69^{\circ}C$	absorptivity 65% $T_{oper.} = 55^{\circ}C$
efficiency = 24% (AM0, $T_{oper.}$, EOL)	efficiency = 24% (AM0, $T_{oper.}$, EOL)	efficiency = 23% (AM0, $T_{oper.}$, EOL)

EOL: End of Life, incl. all loss factors in space

Courtesy M. Kroon, Airbus

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- ❑ IR-rejection from ELO cell architecture lowers operating temperature
- ❑ Quantum wells and enhanced BSR can further improve both BOL and EOL

Summary: Flexible, Lightweight, High-Performance III-V PV

- ❑ MicroLink has demonstrated flexible, high-efficiency PV products for the UAV and soldier markets
- ❑ MicroLink is qualifying PV products for the space market
- ❑ Unique properties of ELO cells can enable new approaches to photovoltaic system design

