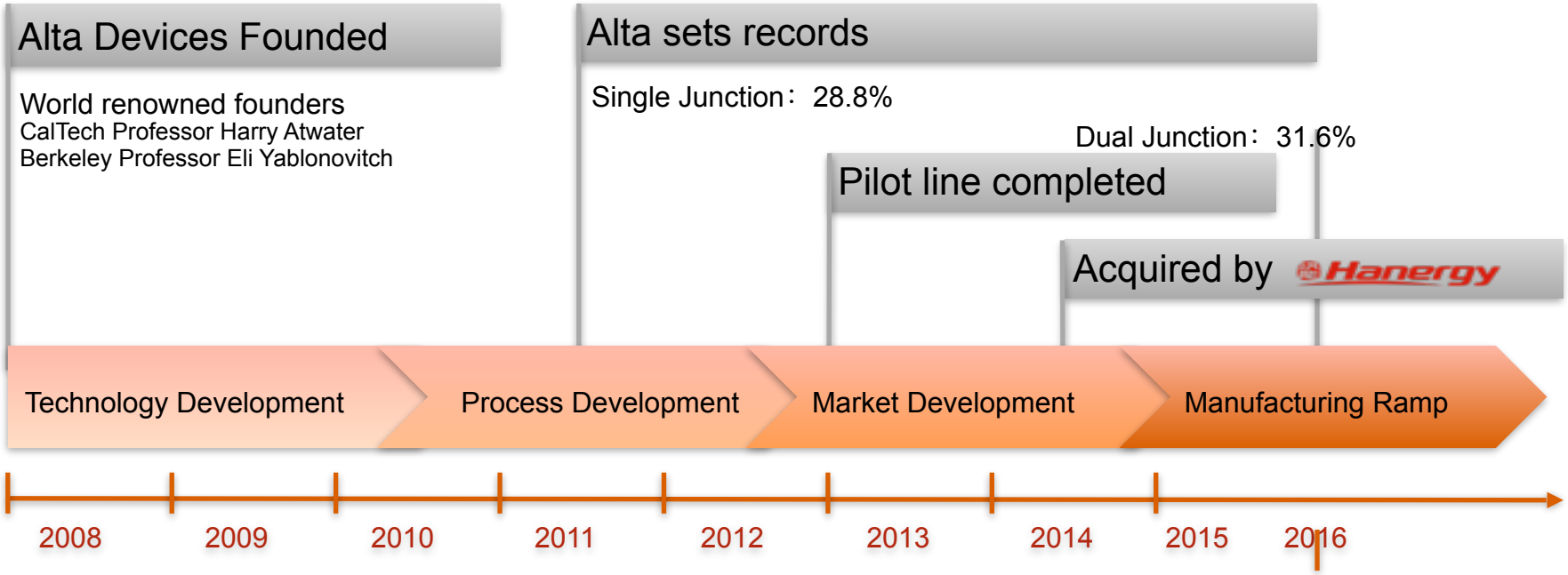
Lightweight, High-Efficiency Solar Cells

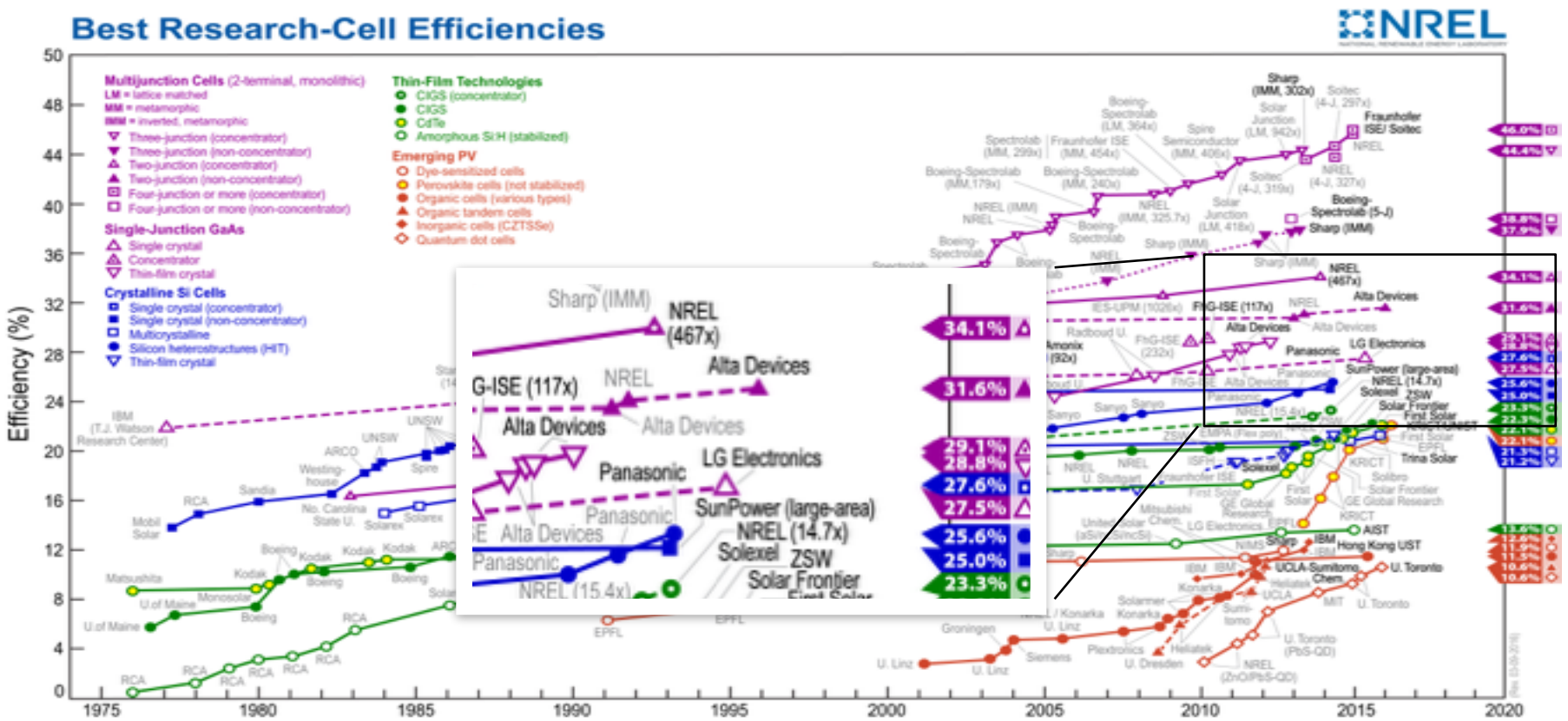
Aarohi Vijh

Company History



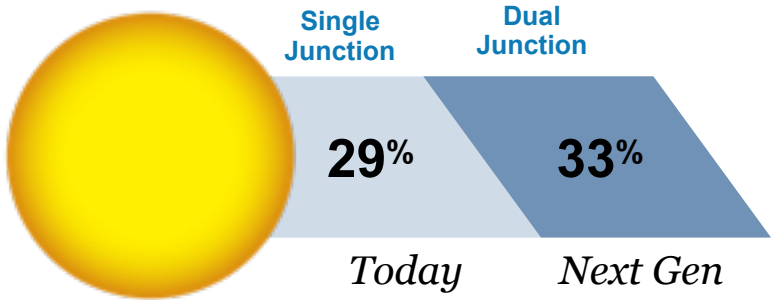
Mission is to bring highest efficiency solar to broad markets

Single and Dual Junction Records



World record for non-concentrator 1-J and 2-J cells

Ultra-High Efficiency



Super-thin solar cell material employing photon recycling enables world record efficiency

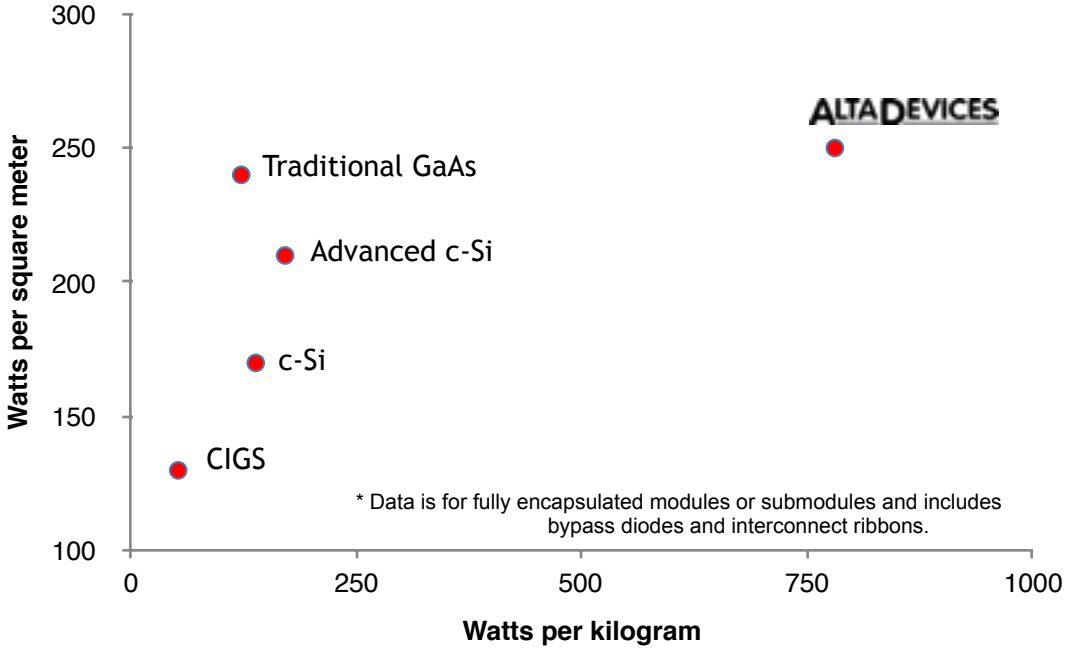
Weight Reduction

Ultra-Light Weight

*Weights shown in g/m²

We are targeting low weight designs to increase our power-to-weight performance, by using advanced materials.

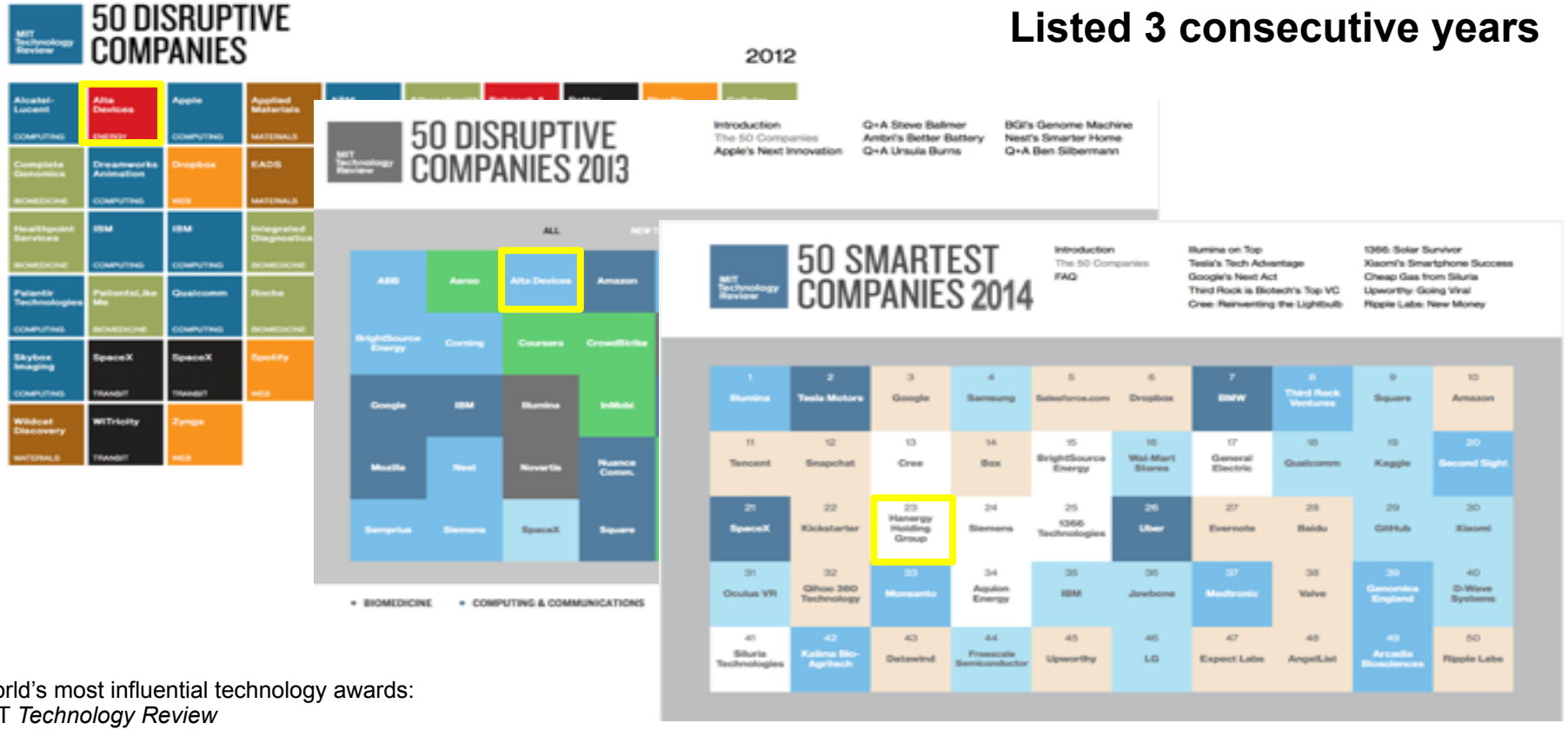
Mass and Area Ratios



>1000 W/kg unencapsulated

>750 W/kg with encapsulation on one side

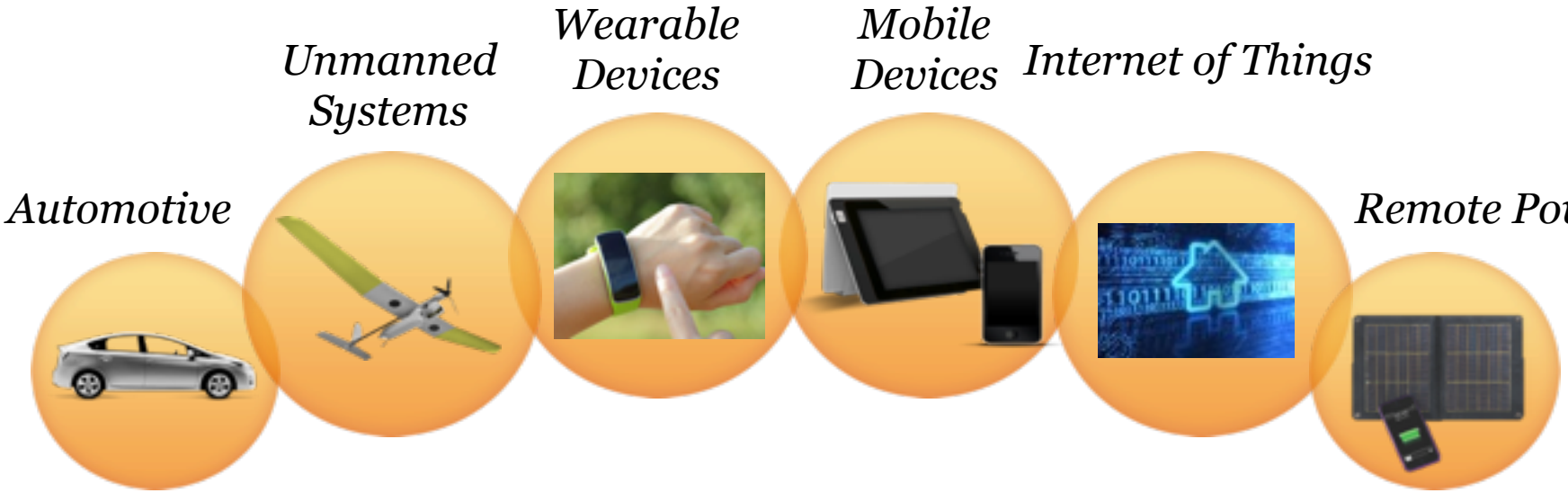
Ranked in World's 50 Disruptive Companies



Listed 3 consecutive years

World's most influential technology awards:
MIT *Technology Review*

Mobile Power Applications



Alta Devices provides power where it simply doesn't exist today: anything that moves, can be carried, or worn

UAV Example

Technology Overview

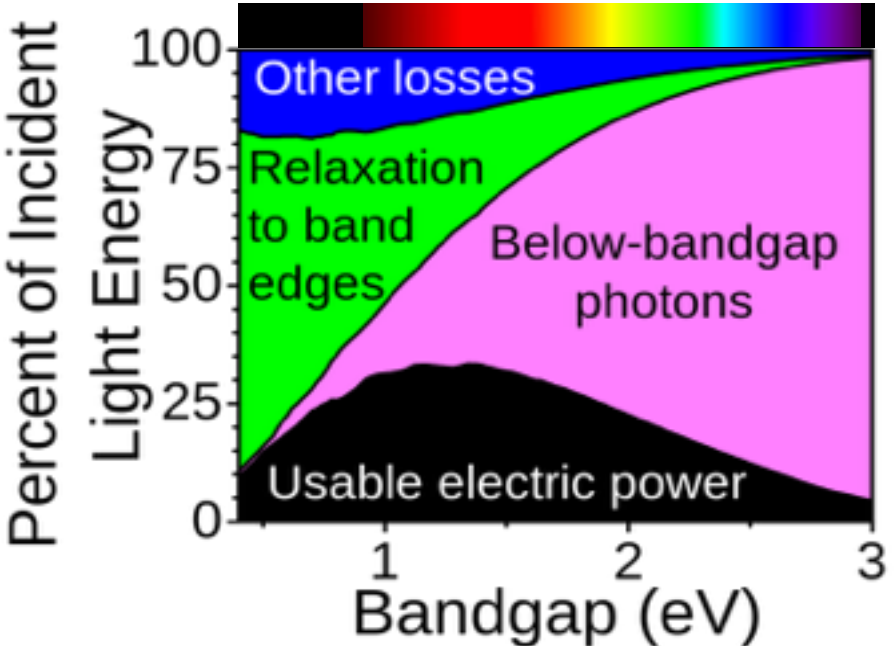
Key Enablers

Mission is to bring highest efficiency solar to broad markets

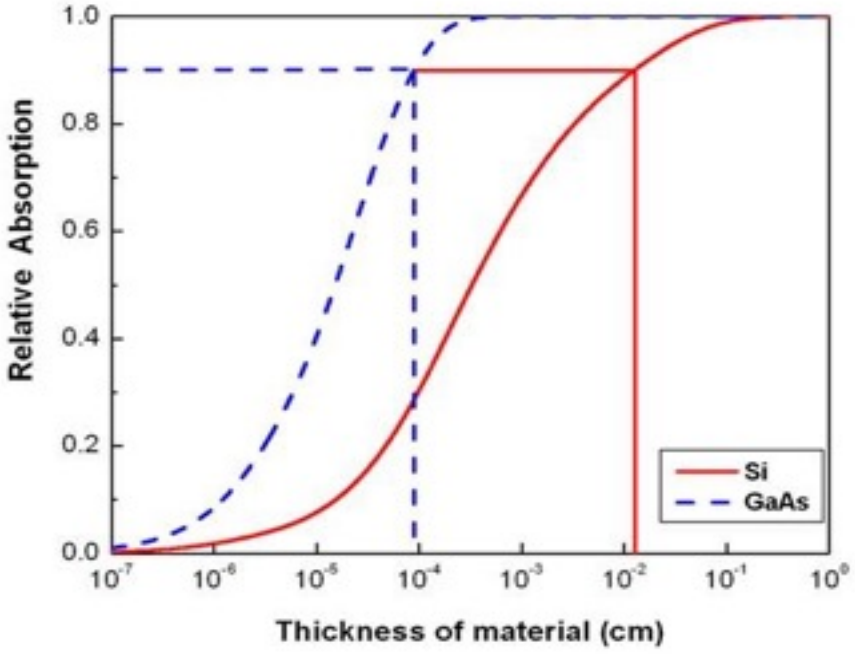
1. Single crystal GaAs
2. Thin film/epitaxial growth and lift off
3. Photon recycling

Optimal Bandgap Cells

- GaAs is close to the ideal bandgap for single junction cells (1.4 eV)
- Lower bandgap wastes energy of “blue” photons
- Higher bandgap cannot absorb “red” photons

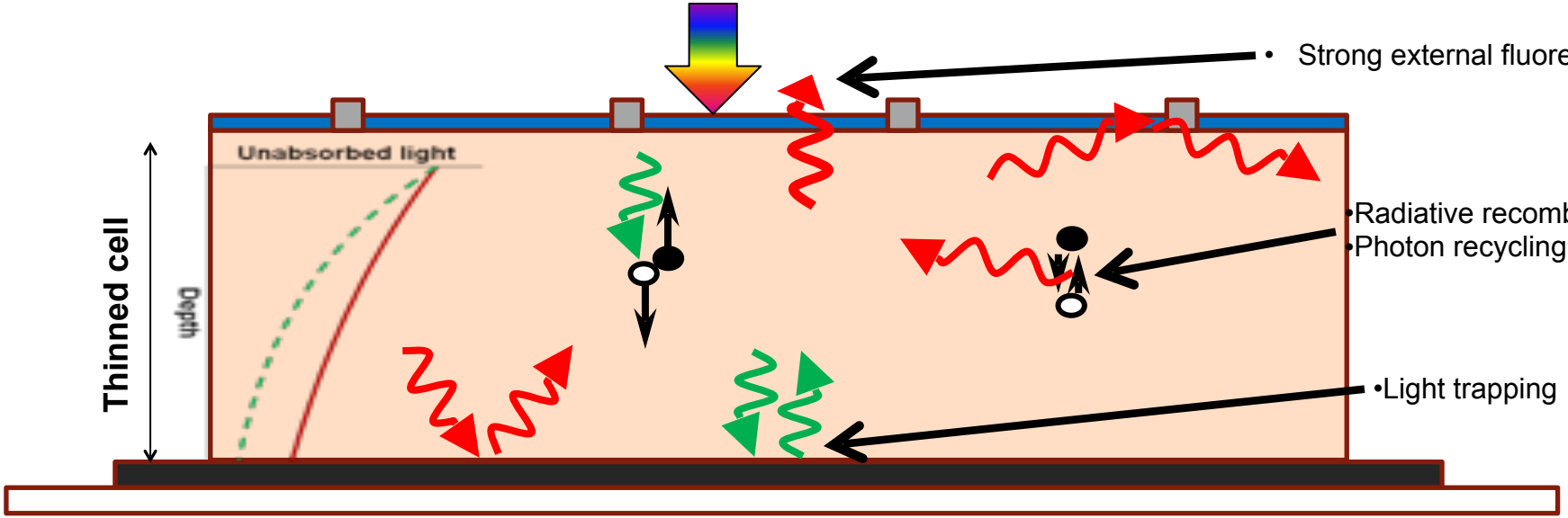


Comparing GaAs vs. Silicon



- Over 100 microns (0.004”) of silicon are needed to absorb 90% of photons
- For GaAs, this number is about 1 micron (0.00004”) of material.
- Silicon layer will need to be a hundred times thicker than GaAs for same absorption
- Because GaAs is a direct bandgap material

Design of Thin-Film, Single-Crystal Cell



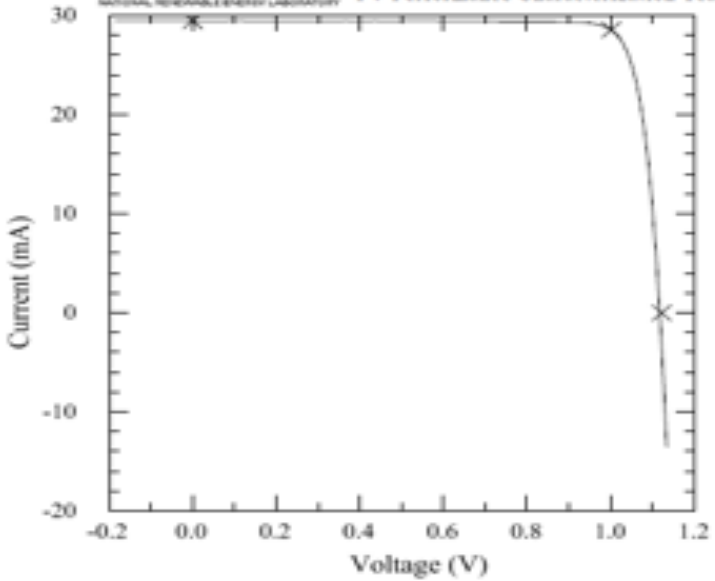
- Single-crystal thin films provide new solar cell design opportunities
- Minimizing optical, as well as electrical, losses key to high performance

Alta Devices' World-Record Cell

Mar 06, 2012 10:57
Spectrum: ASTM G173 global

Device Area: 0.9927 cm^2
Irradiance: 1000.0 W/m^2

NREL
X25 IV System
PV Performance Characterization Team



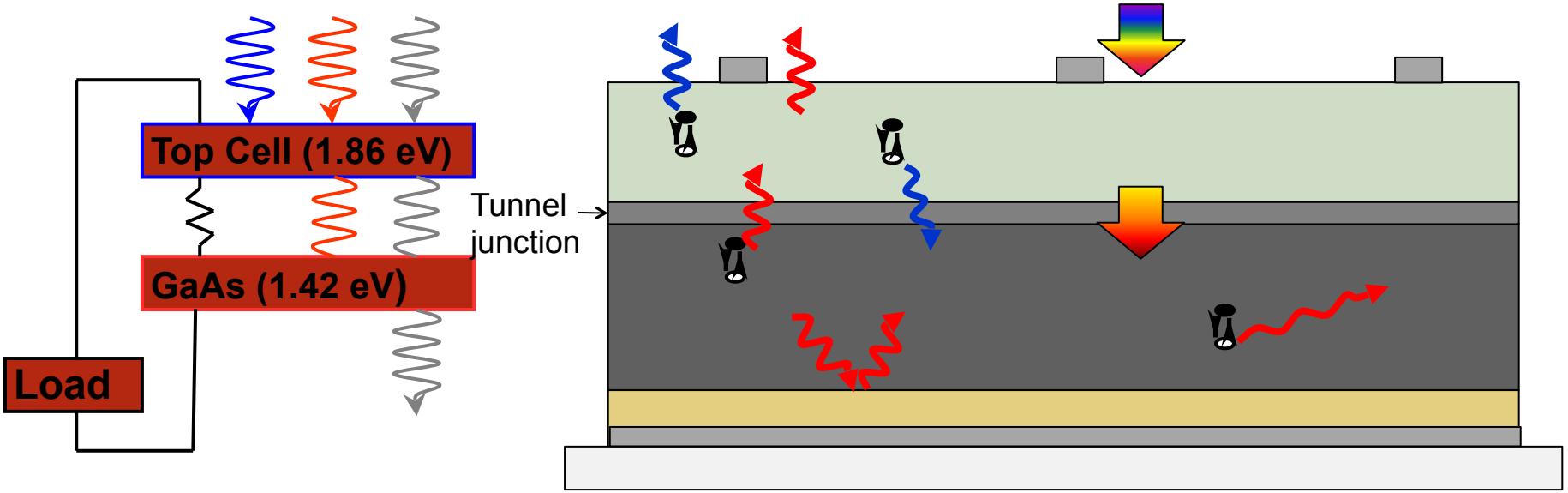
V_{oc} = 1.1220 V
I_{sc} = 29.461 mA
J_{sc} = 29.677 mA/cm^2
Fill Factor = 86.50 %

I_{max} = 28.557 mA
V_{max} = 1.0013 V
P_{max} = 28.593 mW
Efficiency = 28.80 %

ALTADEVICES

B. M. Kayes et al., *37th IEEE Photovoltaic Specialists Conference*, 2011

Dual Junction Solar Cells



Voltage adds in series

Both junctions designed to have the same current

Efficiency increases because top cell better utilizes high-energy photons

NREL-Certified 31.6% Cell Efficiency

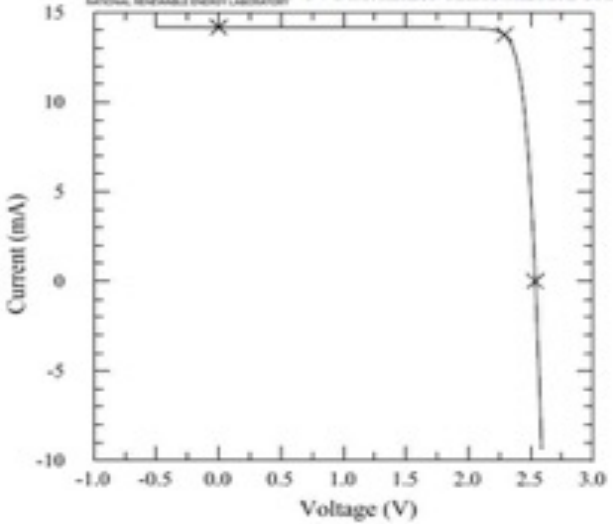
Alta Devices

GaInP/GaAs Tandem Cell

Device ID: AD33551-I-3
5:14 PM 1/5/2016
Spectrum: ASTM G173 global

Device temperature: 25.0 ± 1.0 °C
Device area: 0.999 cm^2
Irradiance: 1000.0 W/m^2

NREL
OSMSS IV System Confidential
PV Performance Characterization Team

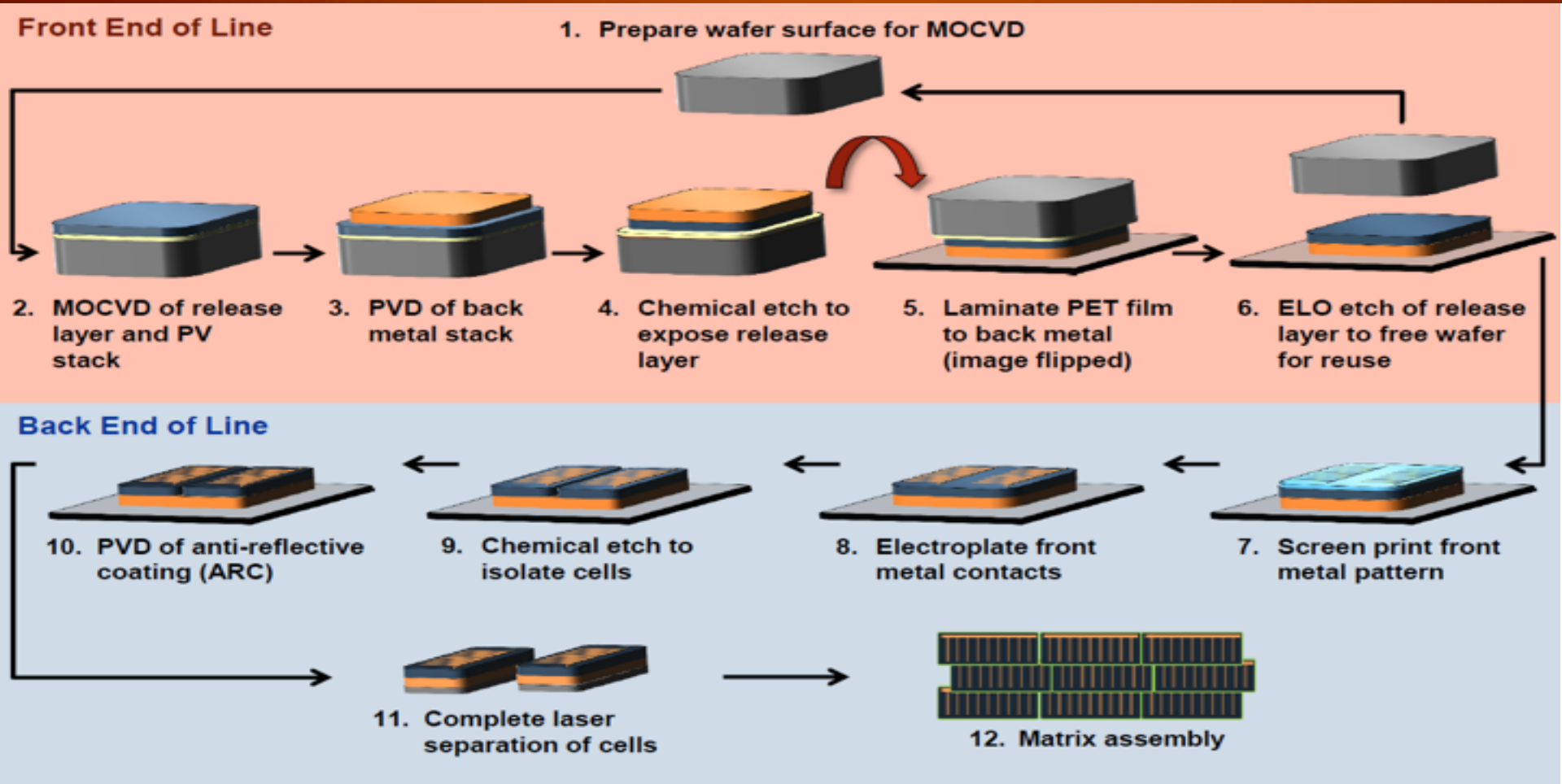


V_{oc} = 2.5381 V
I_{sc} = 14.164 mA
J_{sc} = 14.184 mA/cm^2
Fill Factor = 87.7 %

I_{max} = 13.754 mA
V_{max} = 2.2906 V
P_{max} = 31.505 mW
Efficiency = 31.55 %

Process Overview

Summary of Alta's Process Flow

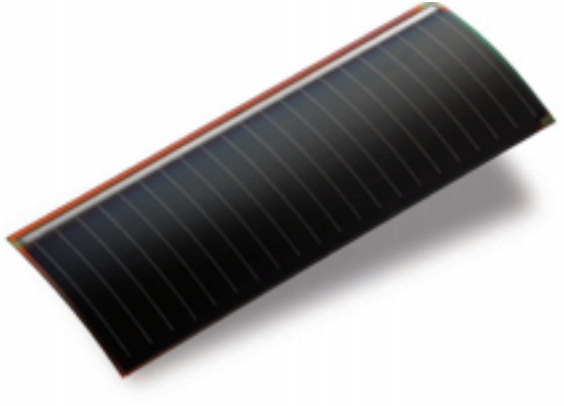


Application

Performance of Production Cells

Alta Devices produces the highest performance single junction solar cells available on the market.

- The gallium arsenide based cells are thin, flexible, and lightweight, enabling a broad range of mobile power applications
- World-record cell and module efficiencies
- Low temperature coefficients and high sensitivity to low light generate unsurpassed real world performance



Mechanical Data and Design

Format	[mm]	50 x 19.6 ± 0.5
Thickness	[µm]	110 ± 10
Weight	[mg]	180
Front	[-]	1.0 mm bus bar, AR coating
Back	[+]	Polymer carrier film, vias for electrical contact

Temperature Coefficients

Voltage	[%/ °C]	-0.187
Current	[%/ °C]	+0.084
Power	[%/ °C]	-0.095

- ~214 mW (AM1.5)
- ~1 volt per cell
- Temperature coefficient -0.1%/C over a wide temperature range

Series/Parallel Connections

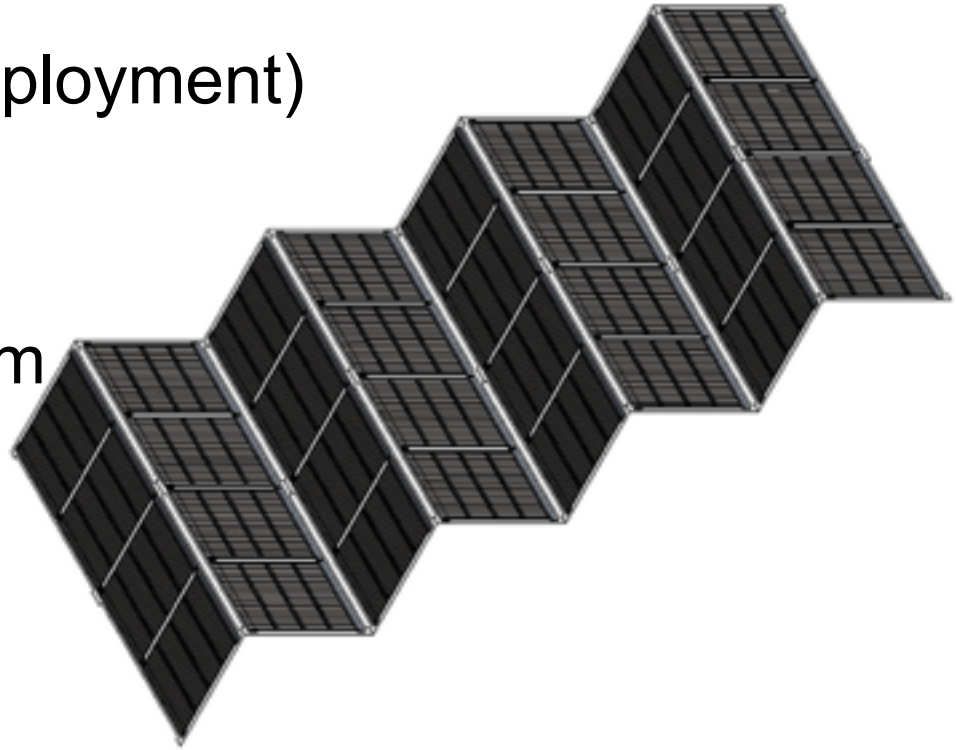
Example ~3U Layout

- 6 watts
- 10 grams of added weight including diodes, adhesives and encapsulation

- Cells are thin (~0.1mm) and can be overlapped for high packing factors

Example ~2U folding subarray

- 29W
- Weight 60 grams (plus deployment) including encapsulation
- 310x700mm
- Thickness per fold <0.5mm
- Can also be rolled



Is weight important?

- Initial launch costs per kg are coming down
- Weight is still important
  - For higher orbits, moon missions
  - Station keeping and reorientation maneuvers
  - Raising and lowering orbits

>>> Particularly interesting for electric propulsion

Summary

- Thin GaAs solar provides high W/kg, W/m^2 and W/m^3
- Alta Devices (Sunnyvale, CA) is a world leader in this technology
- Open to working with cubesat teams

- Contact: aarohiv@altadevices.com

Thank You

www.altadevices.com

aarohiv@altadevices.com