SOLAR CELL PRODUCTION REQUIRES EFFECTIVE METROLOGY

Recent IR Thermography Developments Can Help
Agenda:

• **Infrared Cameras for Solar Cell Inspection**

• Survey of current solar cell test methods

• New solutions for solar cell installation and maintenance
Solar Cell Inspection:

Solar Cell Product Cycle

R&D  Production  Installation  Maintenance
Advantages of IR:

- Early stages of development or production
  - Electrical: I-V, C-V, Carrier Characteristics
  - Typically requires wafer probing
  - May also require thickness gauging and special sample prep, depending on measurements

- Conventional IR thermography alternative
  - Can reveal shunt and series resistance, cracks, breaks in screen-printed parts, etc.
  - No special prep work required
  - Detection through glass is poor
  - Has relatively low spatial resolution due to thermal diffusion
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- **Survey of current solar cell test methods**
- New solutions for solar cell installation and maintenance
• Shunt Detection or Reverse Bias testing
  – Simply wire it backwards
  – Diode / check valve discussion

• Sensitivity & Optical FoV are key

• Easiest of the “R&D” grade thermal test methods

• Careful - may damage the cell.

• Thermal diffusion is the downfall
Electroluminescent Testing

- Apply a forward voltage & current to the PV Cell.

- Electrons in -> Photons Out

- Requires a Near IR camera

- Works in steady state or lock-in.
Lock In Thermography

- Filter removes almost all noise
- InSb works best
- $\varepsilon \alpha$ don’t matter, NEdT/100!
- Small current, minimizes possibility of damage
- Best Solution available!
Gross Defect Detection

- Simple inspection with low cost uncooled IR camera, typically a handheld.
- Requires minimal training
- Every installer should be performing this test
- Easy Reporting software available
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Detailed defect detection

- Need to see detailed IR image for defects in preshipping & installed panels

- The challenge:
  - Glass attenuates energy in the spectral region where IR detectors are most sensitive
  - If you can overcome the glass absorption problem, a sensitive detector (~20mK) may see the defect
  - Glasses selected for solar panels typically have high transmittance in the 0.4 – 1.1µm range
  - However, transmittance remains relatively high up to about 4µm
Seeing IR Radiation Through Glass

3.8 - 4.05um
Defect detection in solar panel roof assemblies with protective glass covers. Left: standard InSb IR camera. Right: same camera with 3.80-4.05µm spectral filter. Defects are bright spots.
• IR thermography can spot shunt and series resistance defects, cracks, and other anomalies
• Filtered InSb cameras allow effective inspections of most types of solar panel assemblies
• This makes them suitable for both R&D and production applications
• A major advantage is the short time required to complete a set of measurements
• Another is no elaborate sample preparation
• In most cases, data can be acquired in seconds, compared to minutes or hours with other methodologies