Hotspot Detection for Cell Production Lines
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Abstract
Since the 1970’s manufacturers of both thin-film and conventional c-Si modules have known of the reliability problems associated with hotspot defects. The recent multi-GW ramp of PV manufacturing has occurred without industry-standardized inline hotspot tests, and some fraction of today’s field failures may be attributed to this class of defect. We describe several of the root causes and outline a measurement technique that has been developed and deployed for use in both R&D labs and manufacturing lines.

Background
Hotspots are, in general, most noticeable when a cell is placed in reverse bias. As an example, consider the c-Si module shown below.

Assume that one cell (outlined in red) is shaded while all other cells are fully illuminated.

Causes of shading might include:
- Bird or Leaf
- Building Shadow... etc.

A shaded cell with minor defects will readily withstand the high reverse bias (~10-12Volts, typical) that persists until the shadow is removed, but a cell with significant shunts will leak reverse current and exhibit extremely localized heating at each defect.

The temperature rise near a defect can vary from mild (1-80°C) to extreme (>200°C), but equilibrium is reached within 10’s of seconds.

Hotspots: Common Causes
x-Si
- Incomplete edge isolation
- Crystalline defects intersecting junction
- Metal-decorated cracks
- Overfiring: pn junction “punchthrough”

Modules
- High resistance or “cold” solder points

Thin Film
- Scribeline shunts- incomplete removal or redeposition

Back Contact & Emitter Wrap-through
- Metal particles & bridges on backside
- Print alignment errors

Typical Damage (x-Si)
Mild (<80°C rise)
- Low damage probability

Moderate (~80-200°C rise)
- Backsheet bubbles
- Coverglass cracking
- loss of quasi-hermetic seal

Extreme (>200°C rise)
- Cell damage

Moisture Intrusion
- Corrosion & Power Loss
- Warranty failure.

Manufacturing Requirement
- Reduce Warranty Exposure by removing hotspot cells prior to lamination with high speed (~100-400ms), high reliability (>99.9% accurate) inspection.

Measurement Method
Method: Time-resolved Thermography
Camera: LWIR (8-12 micron)
Speed: a) Inline: 30-400ms / cell
b) R&D: 30ms- 5 min.
Simultaneous capture of time-resolved I-V
- a) breakdown events
- b) busted shunts

Individual pixel Analysis
Peak Temp @ 20s
Severity @ 400ms
Time-resolved I-V

Inline Inspection Points
Cell Line- Hotspot Detection
Module Line- Hotspot Detection

Summary
Field failures caused by hotspots may be addressed with modern cell or module-level hotspot inspection machines capable of >3000 WPH.