Outermost Technology

www.outermost-tech.com

Technical Services for LED Industry

We support your LED and micro-LED effort from development to commercialization

Reliability Testing

To limit the risks of product failure in the field

- Environmental testing: HTOL, TC, HTS, ...
- Functional testing: luminous flux, forward voltage, ...
- Time-zero compatible service

Failure Analysis

To understand products failure

- High leakage failure (melt)
- Open failure (wire fusing)
- Resistive open failure (epoxy crack)

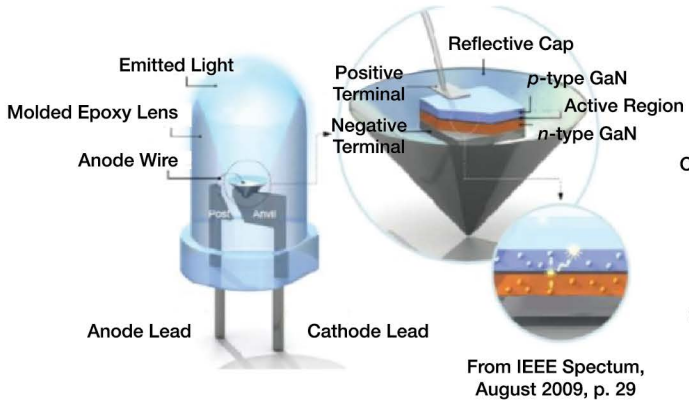
Materials Analysis

To identify failure root causes and characterize materials

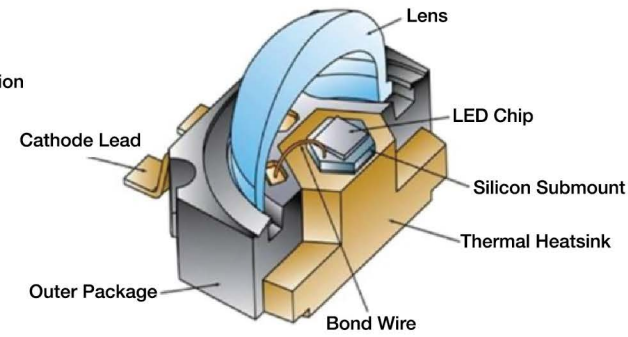
- C_s-TEM to distinguish individual atoms
- PCA-SIMS to analyze organic contaminants
- DBS/PALS to characterize crystal defects

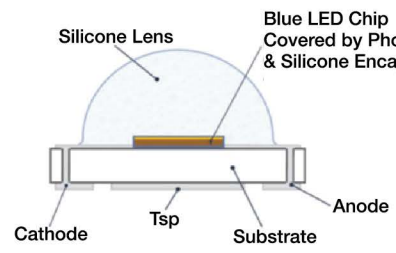
...and much more!

Explore the Insights of your LED with Outermost



From IEEE Spectum, August 2009, p. 29





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Reliability Testing for LED Industry

Why LED Reliability with us?

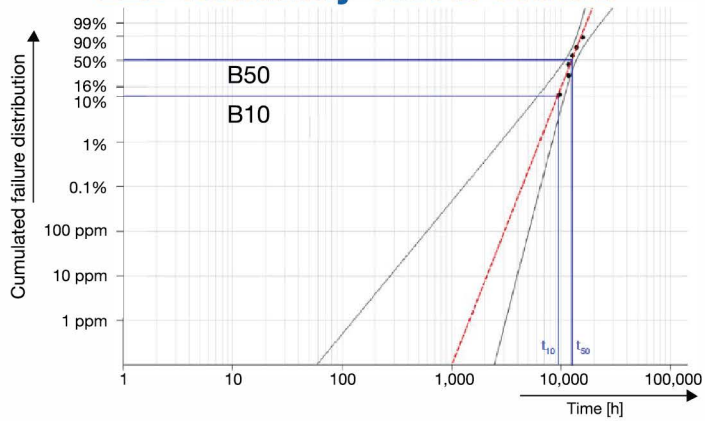
Affordable Price
Up to 40% lower than industry pricing

Time-Zero Service
For optimal and efficient logistic

Free Consultation
Before and after service

Failure Analysis
With highly advanced technologies

LED Reliability Test is Crucial



LED Cumulative Failure Distribution-OSRAM AN006

LED Reliability Test Sequence

Environmental Testing — Environmental Testing

0 h — 504 h — 1,008 h

1st Functional Testing — 2nd Functional Testing — 3rd Functional Testing

This typical LED reliability test sequence with Outermost Technology includes functional tests. Their inclusion in the sequence addresses time-zero requirements as those tests are done at the same location as the environmental tests.

Available Functional Tests
Luminous flux (or lumen maintenance)
Forward voltage
Reverse current
Correlated Color Temperature (CCT)
CIE color coordinates
Color Rendering Index (CRI)

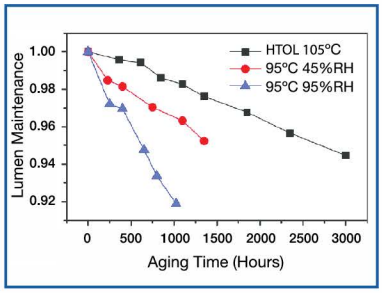
Luminous flux evaluates the decrease in light output of a bulb that occurs over time during the environmental tests.

Reliability Testing: Functional Test Equipment and Examples of Data

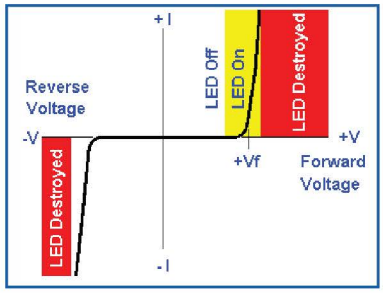
Keithley 2460 Source Meter

Instrument Systems ISP 1000 Integrated Sphere

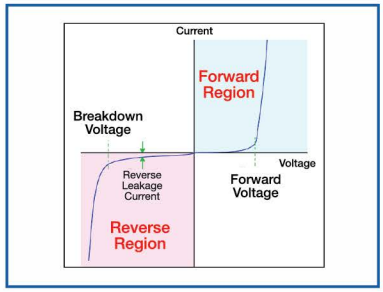
Instrument Systems CAS 140CT Spectrometer



Average lumen degradation of LED packages in different stress conditions – Jianlin Huang



Forward Voltage (V_f)



Reverse Current (I_R)

Test Item	Standard	Test Conditions	Duration
High Temperature Operating Life Test	JESD22-A108	Room or high temp. with bias	1,008 hrs
High Humidity and Heat Life Test	JESD22-A101	85°C, 85% R.H. with bias	1,008 hrs
Low Temperature Life Test	JESD22-A108	-40°C with bias	1,008 hrs
Temperature Cycle (Air)	JESD22-A104	-40°C (15 min.) ⇄ 125°C (15 min.)	1,000 cycles
Thermal Shock (Liquid)	JESD22-A106	-55°C (5 min.) ⇄ 125°C (5 min.)	500 cycles
High Temperature Storage	JESD22-A103	125°C or 150°C	1,000 hrs
High Humidity Heat Storage	JESD22-A101	60°C, 90% R.H.	1,008 hrs
Low Temperature Storage	JESD22-A119	-40°C	1,008 hrs
Solderability	JESD22-B102	T_{sol}=260°C, 10 sec or SMT simulation	-
Resistance to Soldering Heat	JESD22-B102	T_{sol}=260°C, 10 sec or SMT simulation	-

Contact us for questions about the test conditions and to obtain pricing

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Failure Analysis for LED

Why LED Failure Analysis with us?

Affordable Price
Up to 40% lower than industry pricing

Fast Turnaround Time
Typically 4-7 business days

Free Consultation
Before and after service

Advanced Technologies
From Materials Analysis

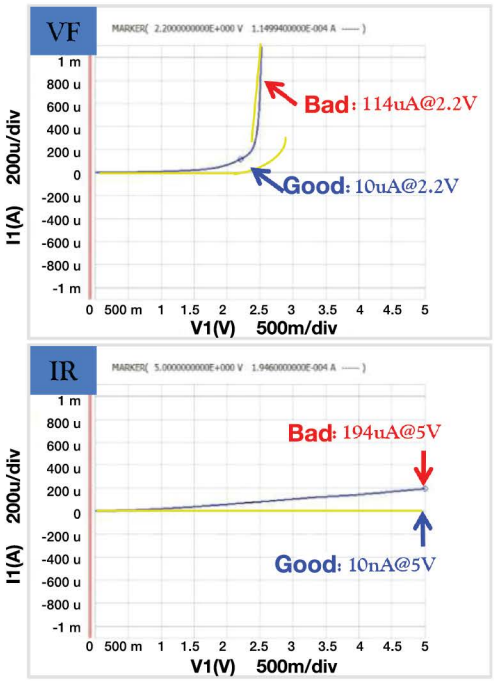
Services for Failure Analysis	
Non-Destructive	Curve Tracer, X-Ray imaging
Microscopy	3D-CT, C_s-TEM, EMMI, FIB, SCM, SEM, SSRM, TEM
Scattering	DBS, PALS, SIMS
Chemical Analysis	EELS, XPS

High Leakage Failure (Melt)

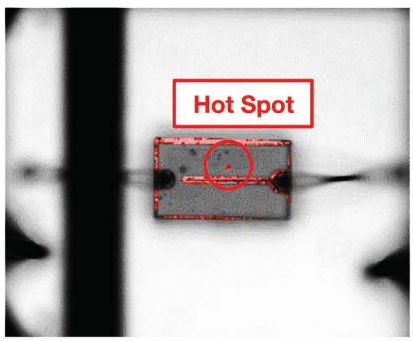
Typical Testing Sequence

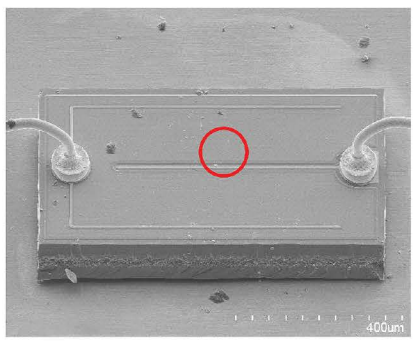
- Curve tracing for leakage check
- EMMI analysis for fault localization
- Decapsulation and delayering
- Scope or SEM inspection

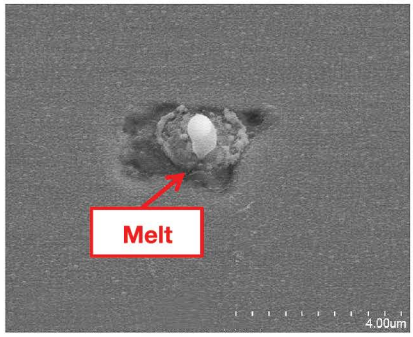
V-I Curve



EMMI (THEMOS) & SEM



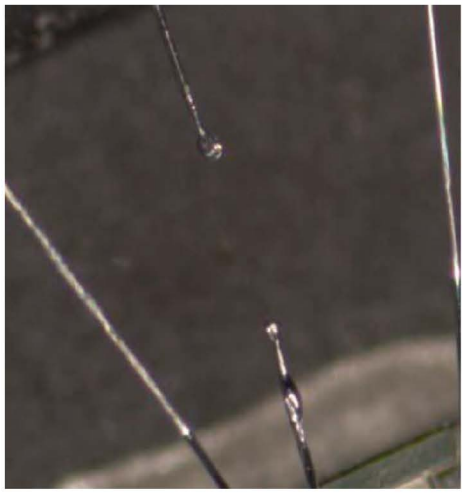


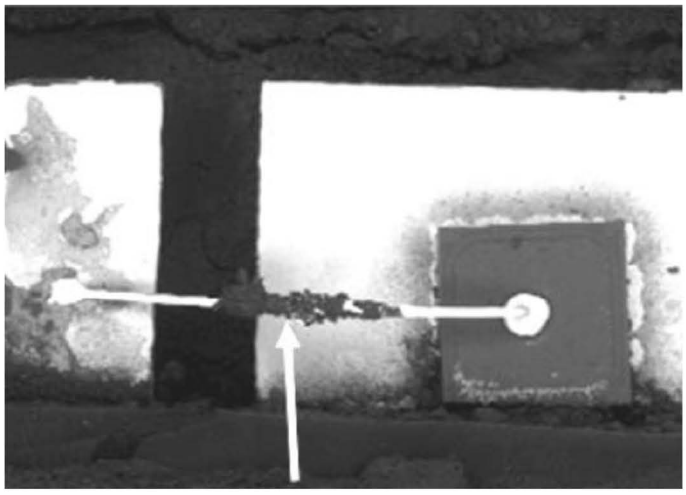


Open Failure

Typical Testing Sequence

- Curve tracing for open check
- X-ray or 3D-CT analysis
- Decapsulation or cross-section
- Scope or SEM inspection

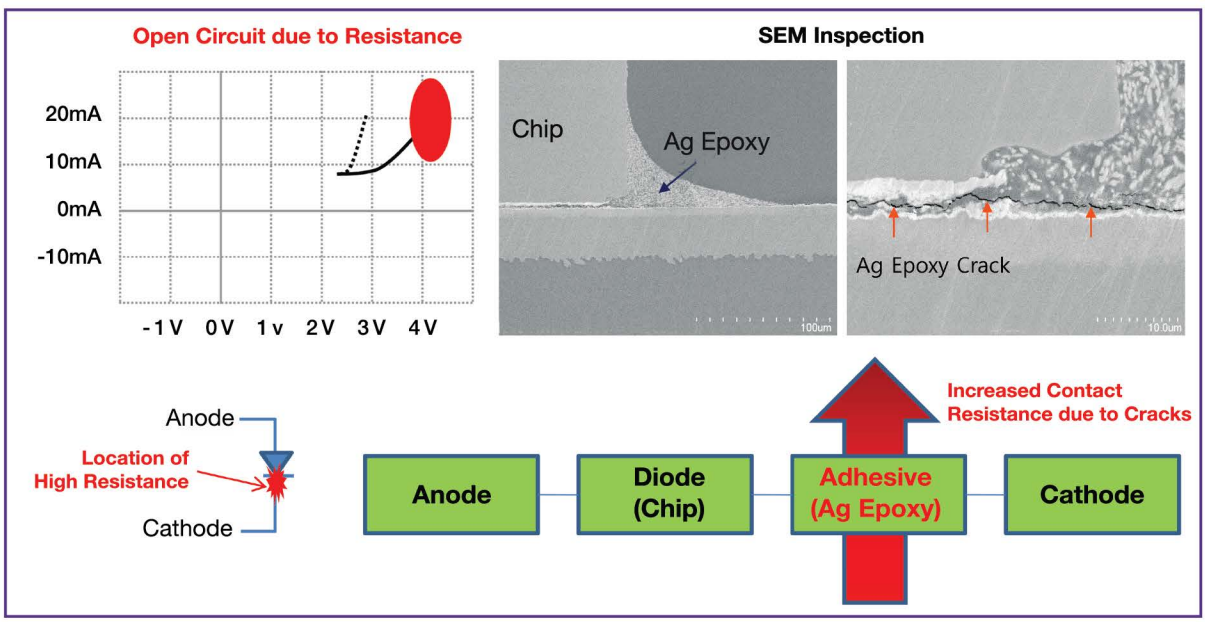




Resistive Open Failure (Epoxy Crack)

Typical Testing Sequence

- Curve tracing for open check
- X-ray or 3D-CT for wire bonding/adhesive area check
- If no defect on wire bonding
  - Cross-section for adhesive
  - Scope or SEM inspection



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LED Characterization Services

Why characterize LED with us ?

Affordable Price
Up to 40% lower than industry pricing

Free Consultation
Before and after service

In-Depth Data Interpretation
As a second opinion to yours

Quality Assurance Program
Free remeasurement if not satisfied

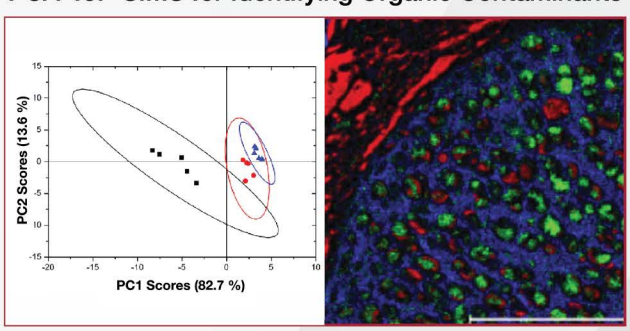
Advanced Applications

Objective	Solution
Distinguish individual atoms	C_s-TEM*/EELS
Identify organic contaminants	PCA-SIMS
Characterize crystal defects	DBS/PALS

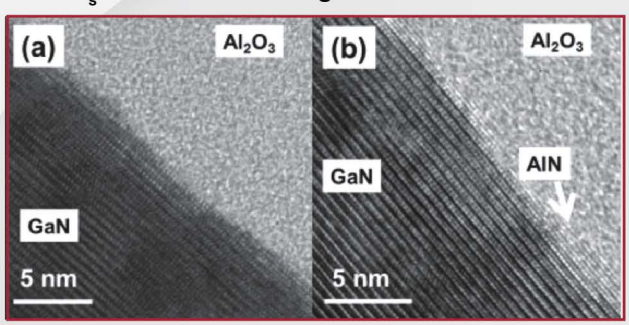
*C_s-TEM: Aberration corrected TEM which has 5x higher resolution than HR-TEM

Spectroscopy and Characterization Highlights

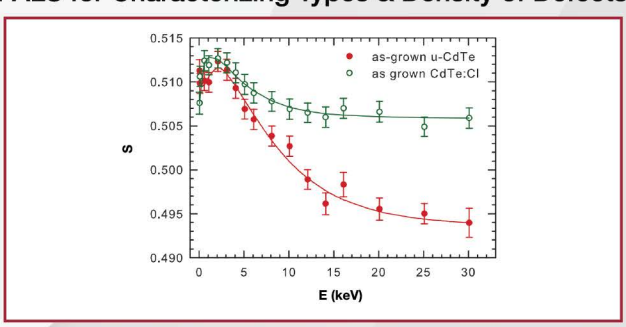
PCA-ToF-SIMS for Identifying Organic Contaminants



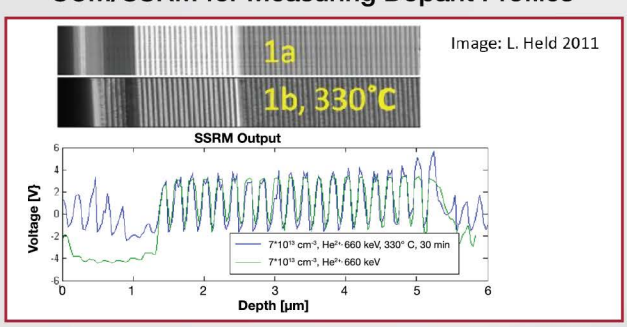
C_s-TEM for Resolving Atomic Interfaces



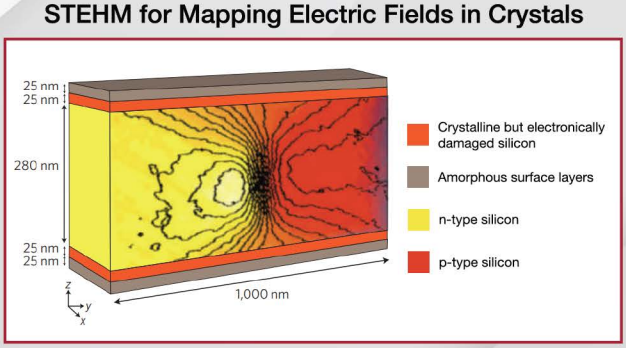
PALS for Characterizing Types & Density of Defects



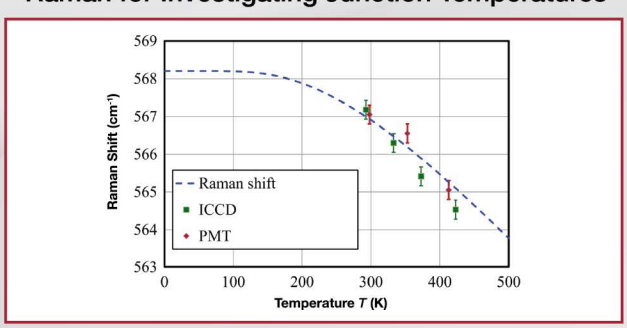
SCM/SSRM for Measuring Dopant Profiles



STEHM for Mapping Electric Fields in Crystals



Raman for Investigating Junction Temperatures



*SIMS image from Nie 2019 and Wu 2019; TEM image from Yatabe 2016; STEHM Image from Midgley et al 2009; Raman image from Horiuchi et al. 2015