HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

Yi-Ming Lau and Choon-Leong Lou
STAr Technologies, Inc.

TestConX中国 China

Shanghai ▪ October 29, 2019

Contents

- Background
- Industrial Requirements
- Objectives
- Experimental Setup & Conditions
- Key Parameters & Considerations
- Experimental Data & Results
- Conclusions
- Acknowledgements

Background

- Traditional HAST or THB
  - Stress devices in chamber at high voltage, high temperature & high humidity
  - At predetermined stress time, devices are powered down and cooled back to ambient temperature
  - Devices are tested outside chamber using an external electrical test system for low level current at precision biased voltage
  - After measurement, devices are put back to the chamber and powered back again to HAST or THB conditions to continue to the next cycle
- Disadvantages
  - Quality issue and human error due to transportation of burn-in board
  - Time consuming, high operational overhead and high cost
  - Lack of real-time test results on the functionality and performance of devices during stress resulting in wastage of stress-hours on damaged devices

Industrial Requirements

- Industrial Requirements
  - More devices require low-level pico-ampere current tests such as off-state current at wide varying voltages (V ~ KV)
  - Real time electrical data is required to understand the device performance during the long stress cycle
  - Enabling experiments to be stopped as and when devices failed, not until the end of the required stress setup.
- Problem Faced
  - There are no sockets, DUT boards & cable assemblies capable of supporting tests at low level pico-ampere current measurements within high temperature and high humidity chamber
  - Requirement of long lifetime sockets, DUT boards & cable assemblies enabling lower cost of burn-in tests

Objectives

- Objectives
  - Qualified set of DUT Board, socket & cable assemblies fully capable to work under high temperature & high humidity
  - Provide low leakage electrical measurements with leakage current down to 10pA/V level under high temperature and high humidity burn-in stress tests
  - Demonstrate in-situ electrical measurements during HAST /THB data with the DUT Board, socket & cable assemblies in high temperature and high humidity chamber
  - Minimal degradation and/or recoverable DUT boards, sockets & cable assemblies

TestConX中国 China

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

5

Experimental Setup & Conditions

- Experiment Setup
  - DUT Board with Sockets and Cable Assemblies
  - Half the channels are in controlled conditions and the other half are under normal (exposed) conditions
  - Environment Conditions: 85°C/85% RH
- Measurements / Read points
  - Sweep measurements from -20V to +20V (1V step)
  - Leakage = Last Point Current / +20V
  - Read Intervals: 0.5hr
- Experiment to Simulate In-Situ & External Data Correlation
  - Oven was POWER DOWN at ~29th hour
  - Oven is POWER ON again at ~34th hour

TestConX中国 China

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

6

Experimental Setup & Conditions

Test & Measurement System
- Source-measurement unit (SMU) with current measurements at resolution down to fA level

Shielded Coaxial Cables connected to shielded ceramic DUT board with traces to DUT Sockets for measurements down-to pico-Ampere levels

High-temperature & high humidity burn-in chamber

TestConX中国 China 2019

23 October 2019

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

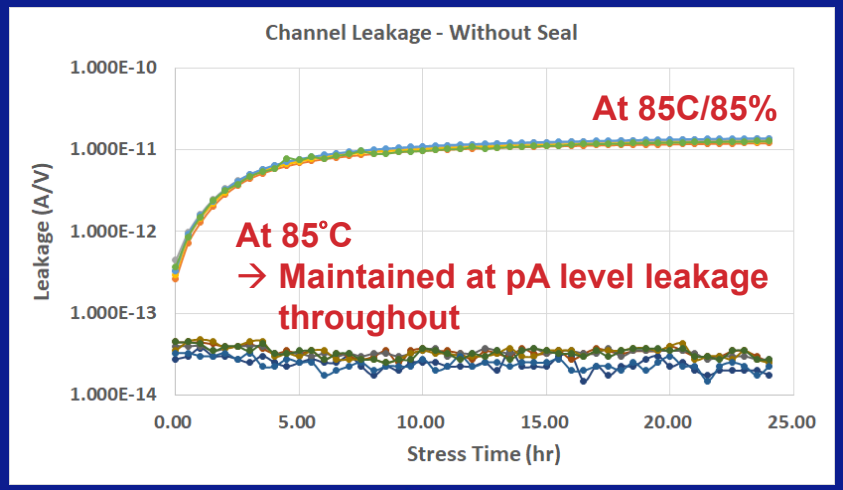
7

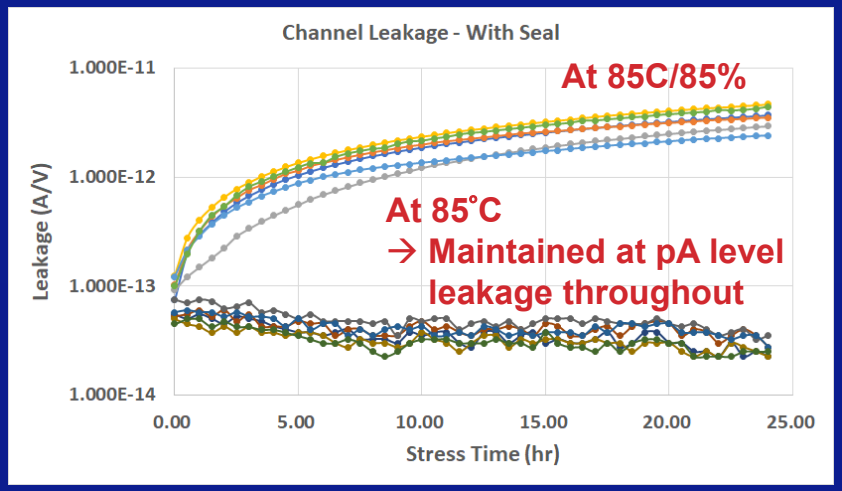
Key Parameters & Considerations

Key Parameters:
- Channel leakage is well-controlled at <1pA/V at 85˚C over 24hrs
- But Channel leakage will increase over time under 85˚C/85% RH condition
- Key Parameter for HAST/THB: HUMIDITY

Key Considerations:
- Channel leakage to stabilize over time
- Leak to be maintained at pA level over time

→ In-situ pA level current measurements over long hours is possible





TestConX中国 China

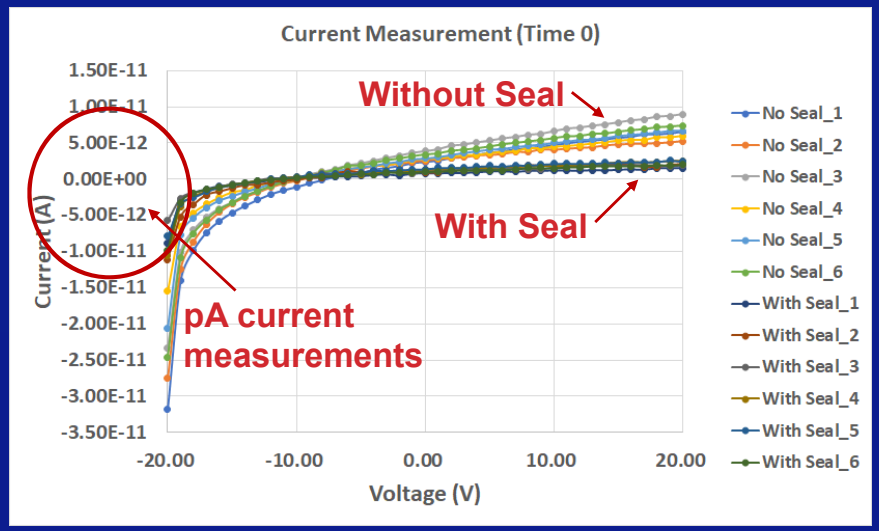
HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

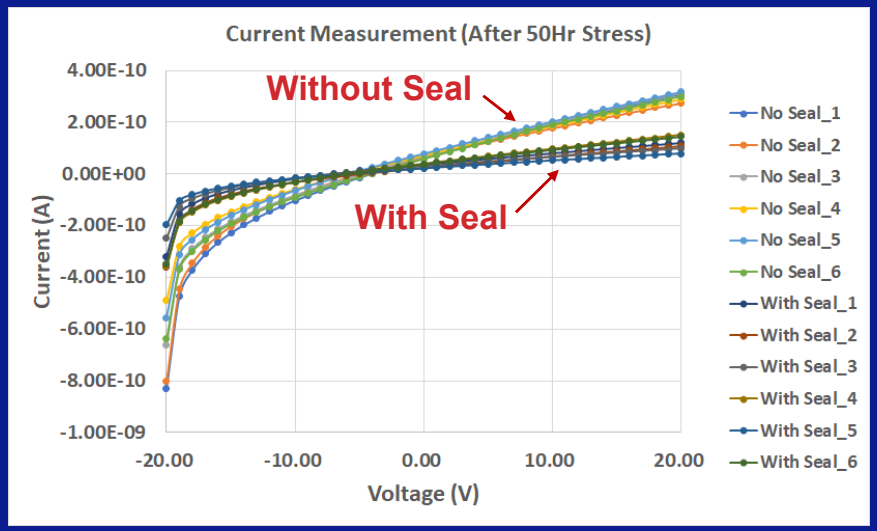
2019

8

Pico-Ampere Current Measurements

- IV data showing pA current measurements for each channel at Time 0hr & 50Hr
- Test & Measurement System exhibit the capability of pA current measurements during stress at 85˚C and 85%RH





TestConX中国 China

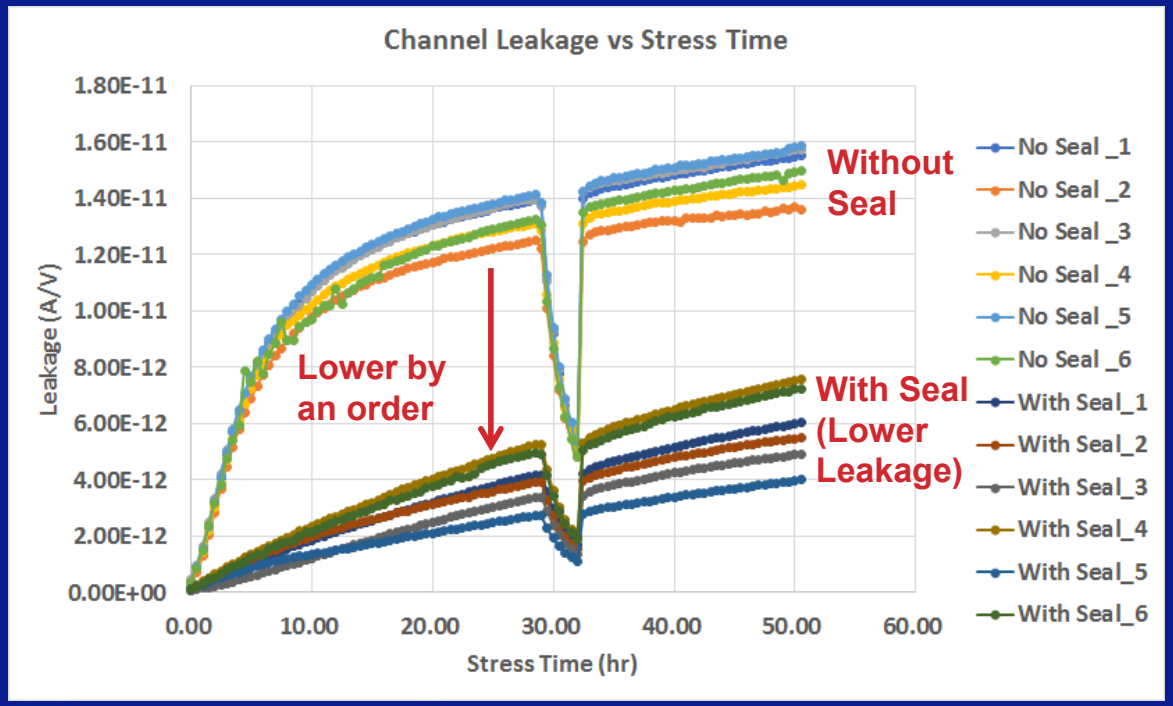
HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

9

TestConX China 2019

Low Leakage During 85°C/85% RH



Channel Leakage at 85°C/85%RH
(a) Leakage (w/o Seal): ~16pA/V
(b) Leakage (w Seal): ~0.8pA/V

- pA leakage level is achievable at 85C/85% RH conditions using the DUT Board, Socket & Cable Assembly
- Sealing can effectively reduce the leakage down to pA level

TestConX中国 China

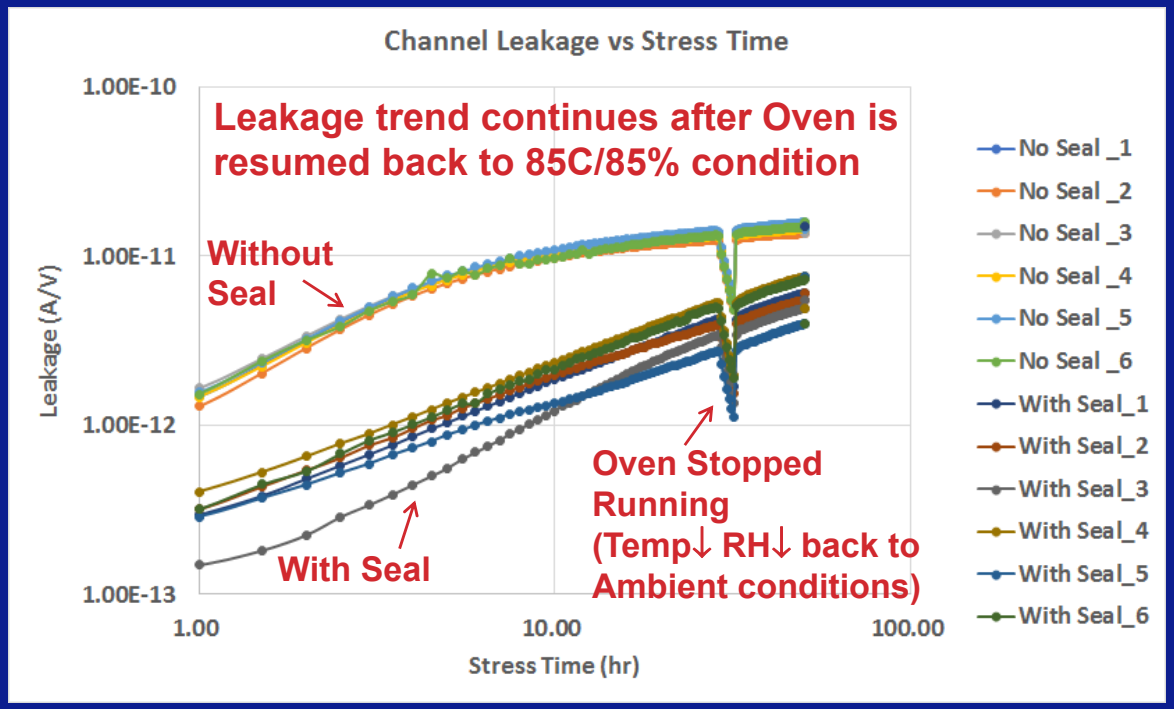
HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

10

TestConX China 2019

In-Situ Electrical Measurements



Oven is deliberately powered down at 29th hour
- Current measurement continues throughout, with the DUT Board Setup in the Oven throughout
- Temp & RH dropped down to ambient conditions
- Channel leakages decreases with Temp↓ RH↓

Oven is re-powered on again at 34th hour
- Channel leakage starts to increase as the environment conditions goes back to 85°C/85%RH

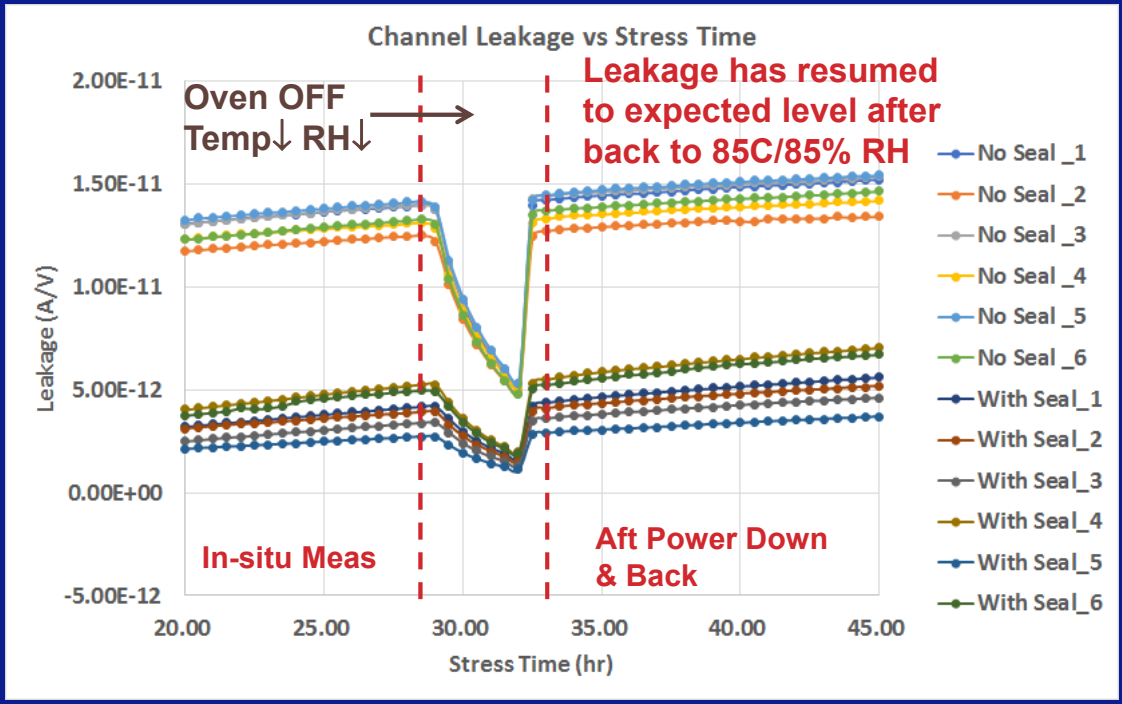
TestConX中国 China

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

11

In-Situ Electrical Measurements



Channel leakage level goes back to the expected level for the Stress Time at the 85˚C/85% RH test environment

This shows that:

(a) In-situ measurements data can be well correlated with electrical data after power off

(b) Real-time electrical analysis throughout HAST/THB Tests can be demonstrated

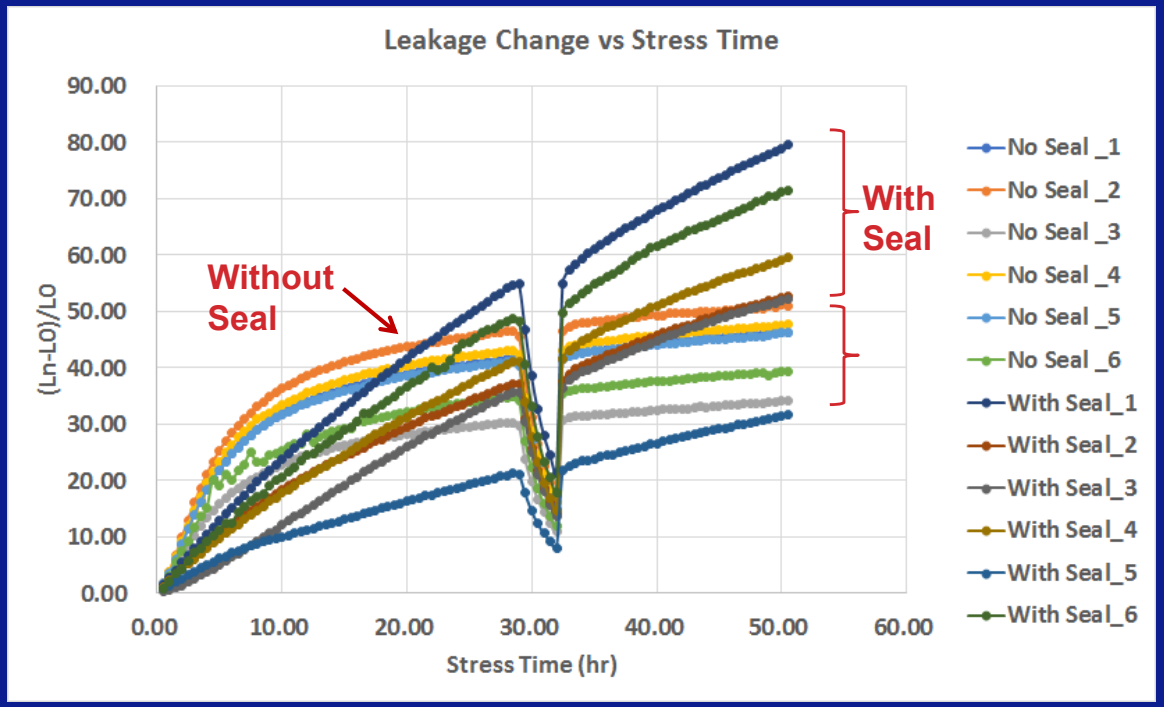
TestConX中国 China

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

12

Will Leakage Increase with Stress Time ?



HAST/THB Tests are usually at high voltages, high temp with high humidity over long hours → Key: Will Channel Leakage increase with Stress Time at 85°C/85%RH?

Based on the data & results Channel Leakage
(a) w/o Seal: Saturates 20hr
(b) w Seal: Increasing trend but will saturate over time

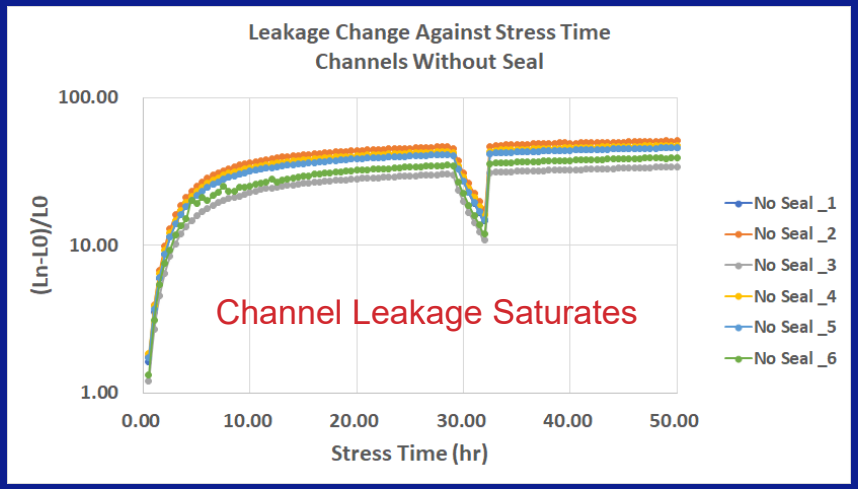
TestConX中国 China

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

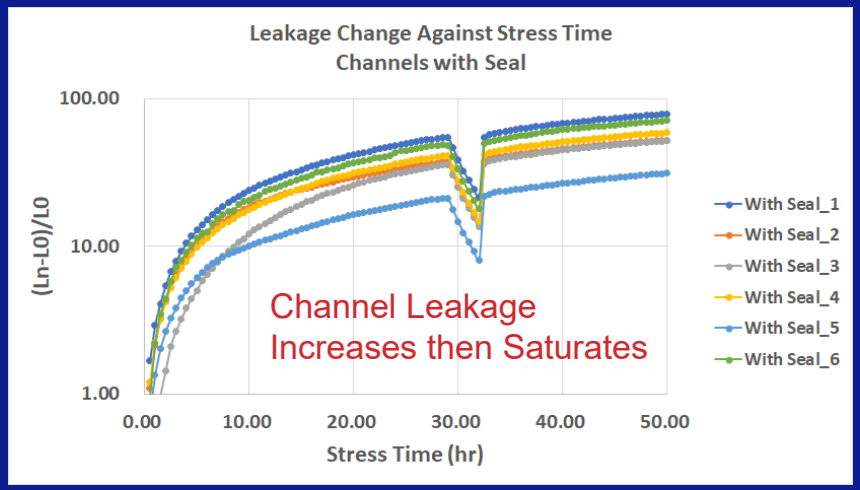
13

Will Leakage Increase with Stress Time ?



← Without Sealing
- Channel Leakage will saturate over Stress Time
- Based on data, saturation point at 85˚C/85% RH is around 20hrs

→ With Sealing
- Channel Leakage will increase then starts to saturate over Stress Time
- Based on data, saturation at 85˚C/85% RH is beyond 50hrs (but will eventually saturate)

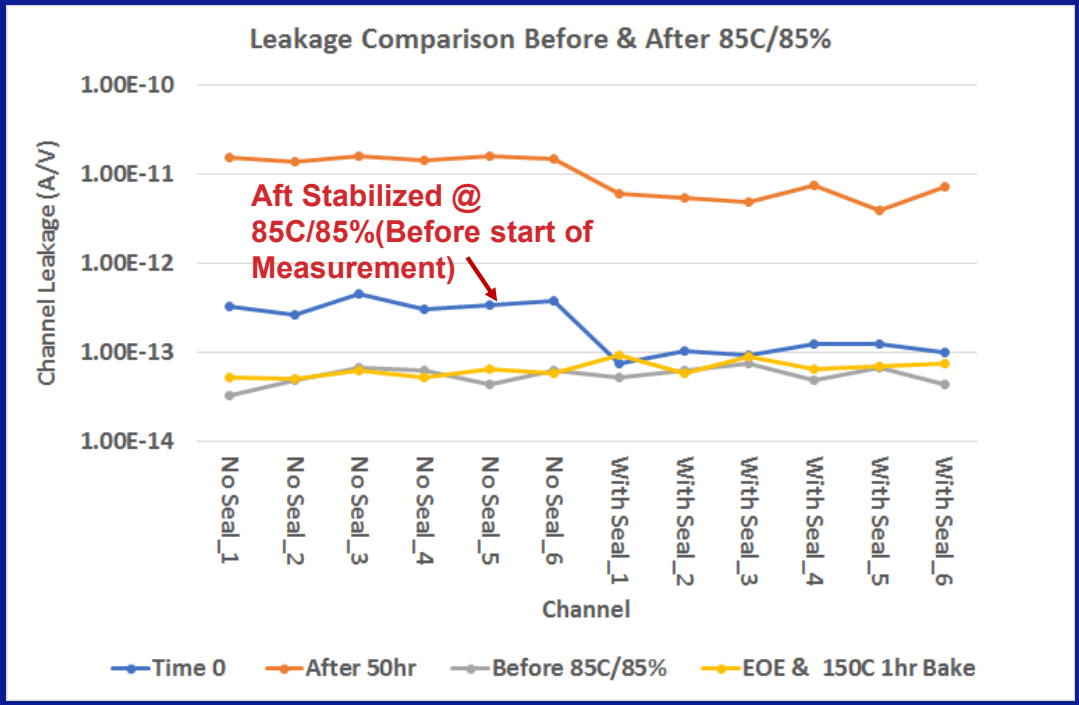


TestConX China 2019

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

14

No Degradation Observed on the DUT Board



Humidity is the key parameter causing the increase in leakage throughout the 85˚C/85% RH Test

Results shows

- **Channel leakage of the board before and after the 85˚C/85% RH Test remains good**

→ There is no damage / degradation to the DUT Board Setup throughout the 85C/85% RH Test

→ The increase in Channel Leakage over time is environment driven and not DUT Board Setup materials driven

TestConX中国 China

HAST In-Situ Electrical Tests Down-to Pico-Ampere Range

2019

15

Results

- Channel Leakage Level
  - pico-Ampere current measurements have been achieved with the DUT board, Socket & cable assembly setup
  - Channel leakage can be reduced down to sub pA level with Sealing
- Channel leakage current recovers to expected level after Power Off & On
  - In-situ measurement data can correlate with traditional method of power off and doing electrical measurements using an external system
- Channel Leakage will saturate over Stress Time
  - Without Seal: Increase & saturates after approx. 20hrs
  - With Seal: Increases & saturates after approx. 50hrs
- There is minimal degradation on the DUT board after 85°C/85% RH Test

Conclusions

- Qualified set of DUT Board, Socket & Cable Assembly has ben demonstrated to be capable of providing low level current measurements
- Consistent pA level electrical measurements have been demonstrated over prolonged burn-in stress tests
- Real time in-situ electrical measurements at low-level pico-A current through HAST/THB Test has been demonstrated to be achievable

Acknowledgements

- The authors would like to acknowledge the support and help rendered by MFG for the production & fabrication of the fixtures used in the experiments