DELAMINATION IN PLASTIC PACKAGE - DIPP –

OSIP PROJECT 2022

ESCCON 2023 – 08/03/2023

D.DACLIN

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DIPP- INTRODUCTION

The future belongs to industrial components (such as Automotive-quality and commercial-quality components) that

- Are already used for launcher-type or short duration satellite missions.
- Revealed specific defects ➔delamination between the chip and the encapsulation resin.

Delamination is more likely to evolve during long term thermal cycling

- Increase of their length
- Reach out to the external sides of the packages → potential corrosion of bondings and dice.

Delamination has generally been accepted for short-term missions

(They "have not enough time'' to worsen due to the short duration of the mission)

But, what's going on for long-term missions

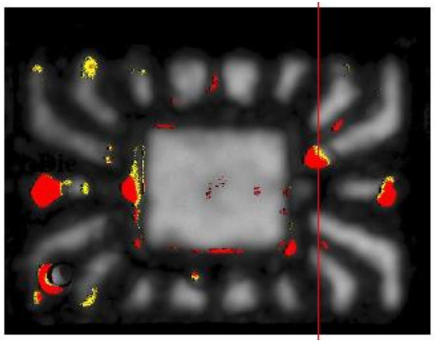
where equipments are exposed to thermal stresses due to repeated thermal cycles and ON-OFF switching

?

SCOPE: STUDY’S OBJECTIVES

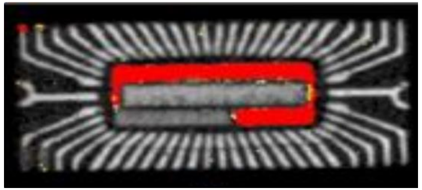
This study has been performed in the frame the **Open Space Innovation Platform campaign (OSIP)** organised by ESA.

Today, we do not have enough experience to estimate what is the level of degradation of industrial plastic packaged parts (COTS) at the end of long term space mission.



PURPOSES OF THIS STUDY

- **To study how these delaminations evolve** over time and the thermomechanical stresses imposed by the equipment/satellite qualification sequences and the space environment.
- **To determine what are the most critical stresses** for such type of plastic body components in the space environment.
- **To establish a basis of criteria** to be used to characterize these delaminations and their level of acceptance.



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OVERALL ASSESSMENT

WP progress and Status:

The project is divided in 5 work packages.

Duration: 12 months

T0 : september 2021

But 5 months delayed (end scheduled end of March 2023)

DELAMINATIONS IN PLASTIC PACKAGE

WP0 – *Management*

WP1 – *Bibliography*

WP2 – *Preparation of the HAST testing*

WP3 – *HAST test sequence*

WP4 – *Analysis of the results*

Work done, WP closed.

WP started, Work in progress.

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WP1: BIBLIOGRAPHY

Objectives

To compile technical and normative documentation (from IEEE, conference, etc…) about delaminations and voids in plastic packages components.

We are looking for information dedicated to :

- ✓ The description of types and localization of delaminations in the parts
- ✓ The most appropriate methods and tools for delaminations and voids detection , i.e the SAM (scan acoustic microscopy)
- ✓ Standards (ESA, MIL, …), for tests methodology and defect descriptions.

Task

For each paper that will be selected for reading, we will put them in a list, with paper title, name of the paper origin, list of the authors and the organization they come from, with a quotation related to the interest of the paper in relation with the subject of the study , and a paper summary.

For the standards, small extract of the points interesting for the study will be put in a document, together with the pertinent tables or figures.

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WP1: BIBLIOGRAPHY

WP1 conclusion

This bibliography is divided in two parts :

- Part 1 dedicated to a review of papers (mainly found in IEEE) related to plastic packages commonly reported defects; these papers are mainly focused:
  - ✓ on delamination
  - ✓ testing sequences developed to create these defects in order to study them
  - ✓ methods used to investigate these defects (such as Scanning Acoustic Microscopy).
- Part 2 is dedicated to a collection of methods and norms dealing with
  - ✓ the test selection,
  - ✓ the conditioning of plastic packages components for use in severe applications

This WP makes us learn that :

✓ the CSAM is the most relevant inspection method for delamination observation.

✓ the HAST sequence is the most appropriated way to age the plastic parts.

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WP2: PREPARATION OF THE HAST TESTING

Objectives

In order to simulate the stresses imposed on the components throughout the space mission lifetime, we target to:

- ✓ select a large panel of different plastic packages that will be representatives of the packages already used or ready to be used in space missions
- ✓ submit them to the constrains of manufacturing operation (vapor phase assembly of packages on PCB)
- ✓ define a test plan in order to simulate the thermomechanical and electrical constraints applied on packages.

HAST sequence (Highly Accelerated Stress Test) or THB (Temperature Humidity Bias Test) are different methods that can match with the simulation of long duration space missions. We will study these methods, and use the most appropriate one.

Task

Selection and procurement of the COTS components:

- ✓ Packages of different sizes, for discrete, integrated circuits (simple and more complex) and power components and from different manufacturers.

Design/procurement of the test PCB : technology similar to the one used for internal assembly qualification of new SMT packages:

- ✓ The test vehicle will be a multilayer PCB with a technology and quality similar to the one used for internal assembly qualification of new SMT packages. The design/routing of the test vehicle and the test set up will be performed.

Definition of the test sequence (HAST / THB)

- ✓ Definition of a test plan in accordance with the norms and with space environment conditions.

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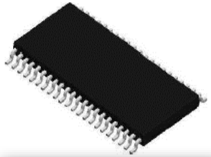
WP2: PREPARATION OF THE HAST TESTING

Packages selection

Package PLCC20

Package DPAK-3

Package TSSOP16

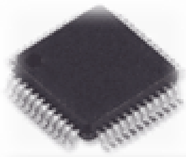


Package TSSOP48

Package MSOP10

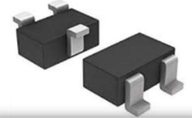
Selection of the type of packages that will be studied.

10 parts of each type will be used

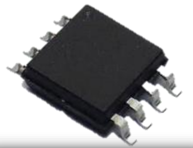


Package PQFP-48

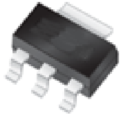
Package SOT23-5



Package SOT323



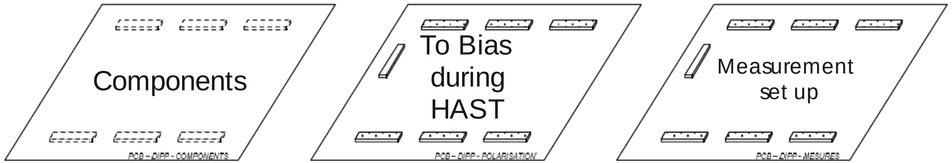
Package SOIC8



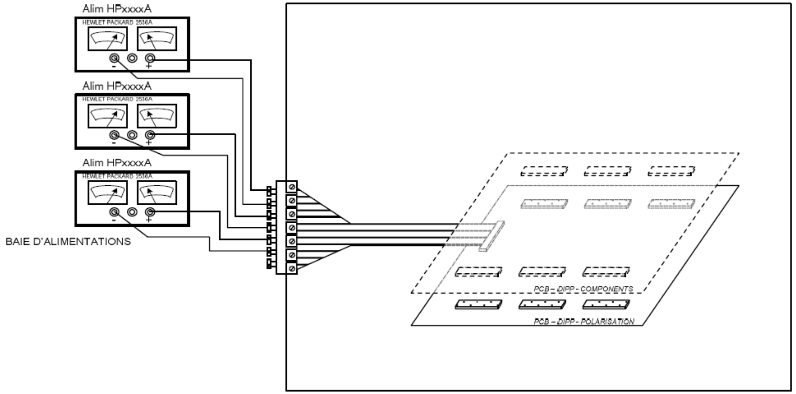
Package SOT-223

WP2: DESIGN OF THE TEST PCB

TEST VEHICLE TESTING PHILISOPHY



HAST Wiring



Initially, we imagined the HAST set up composed of 3 boards:

- ✓ 1 board populated with the components (test vehicle)
- ✓ 1 board to bias the components during the HAST.
- ✓ 1 board needed to perform the measurement.

100% of the components will be biased.

Depending on the complexity of the part, between 60% and 100% of the parts will be electrical tested.

But this configuration required too many connections,

And the number of connections are limited by the HAST device/chamber (30 channels / lines in the I/V matrix)

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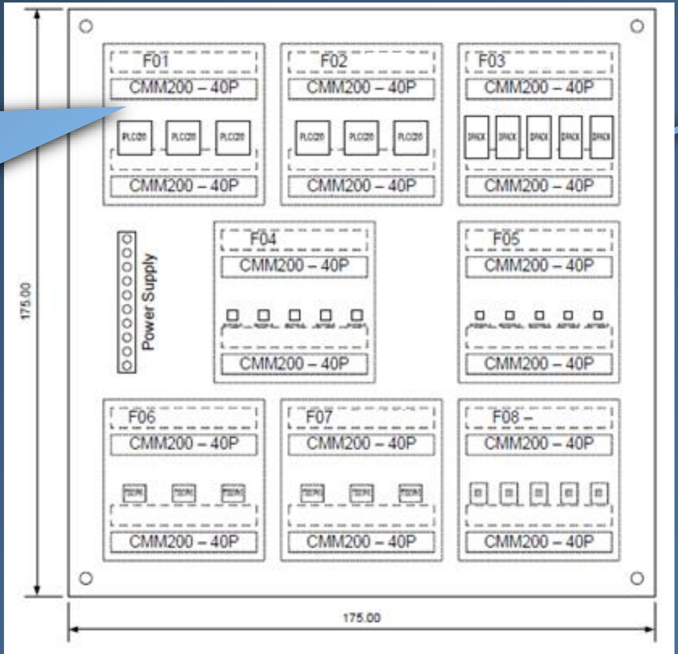
WP2: PREPARATION OF THE HAST TESTING

TEST VEHICLE DEFINITION

''Daughter boards'' dedicated to each type of components.

- ✓ *dimensions 48mmx48mm*
- ✓ *Boards with 2 connectors (40 channels each) on each side to be biased.*
- ✓ *PBA populated on both sides.*

The test vehicle is composed of 1 ''mother board'' connected to ''daughter boards'' dedicated to each type of components, on both sides.



1 ''mother board''

- ✓ Dimensions 175 mm x 175
- ✓ Populated with 16 ''daughter board'' (8 on each side)

100% of the components will be biased.

Depending on the complexity of the part, between 60% and 100% of the parts will be electrical tested.

WP2: PREPARATION OF THE HAST TESTING

TEST PLAN DEFINITION

2 X

Parts preparation
- (kitting, serialization …)

CSAM inspection

Parts assembly on PCB

CSAM inspection

Electrical test @ Tamb

HAST
- *board biased 264h @ 110°C and 85% humidity-*

CSAM inspection

Electrical test @ Tamb

Electrical test:

The aim is to detect leakage current variation, or bonding lifting/breaking due to delamination.

➔I/V plots : Measurement of voltage with regards to a step by step increasing of the current

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WP3: HAST TEST SEQUENCE

Objectives

- ✓ To manufacture the test vehicle
- ✓ To run HAST or THB with parts biased ON, in order to be realistic.
- ✓ To perform non destructive inspections with the SAM in order to detect the initial presence and evolution of delaminations during the stress sequence.
- ✓ To measure the evolution of the (identified) defects along the test sequence, and make a classification of these defects :
  - localization of the delaminations and voids
  - size
  - Criticity
- ✓ To compare this situation with the initial one, and try to establish a list of criteria for acceptance/rejection.

Task

Test vehicle manufacturing

- ✓ The selected parts will be assembled on PCB using the methods and machines (vapor phase reflow) used for standard space PCB production

Operation and monitoring of the test sequence

- ✓ To implement the set up defined in WP2
- ✓ to run the test sequence (HAST or THB).

To perform SAM inspections

- ✓ SAM inspection of the parts before and after each step of the test sequence, in order to record the defects (size, location,...)

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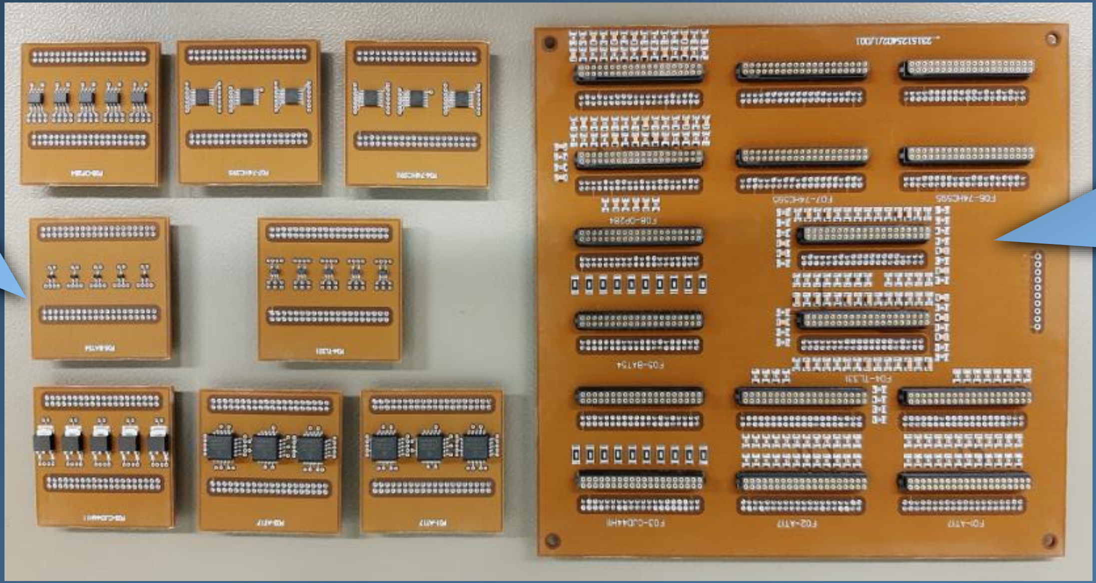
WP3: HAST TEST SEQUENCE
TEST VEHICLE MANUFACTURING

Manufaturing of the ''mother board'' connected to ''daughter boards'' dedicated to each type of components, on both sides.

''Daughter boards'' dedicated to each type of components.

- ✓ *dimensions 48mmx48mm*
- ✓ *Boards with 2 connectors (40 channels each) on each side to be biased.*
- ✓ *PBA populated on both sides.*



1 ''mother board''
- ✓ Dimensions 175 mm x 175
- ✓ Populated with 16 ''daughter board'' (8 on each side)

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WP3: HAST TEST SEQUENCE 1/2

CSAM INSPECTION @ EACH STEP--- SUMMARY

A Trend of Delamination apparition or evolution between T0 – HAST run1 or HAST run 1 – HAST run 2

No new delam or no evolution→ stable; poor impact of HAST

New delam or evolution → low impact of HAST : delam, not critical

New delam or evolution in critical location→ high impact of HAST /delam, critical

No Delam. | Delam. Not critical | Delam. critical




	At T0			After assembly			After HAST1			After HAST2		
	Delamination observed on:											
	Header	Lead	Die	Header	Lead	Die	Header	Lead	Die	Header	Lead	Die
1 PLCC20	No	No	No	No	Yes on bonding area 100%	No	No	Y on bonding area 100%	No	No	Ye on bonding area 100%	No
2 DPAK-3	Yes until 100%	Yes on bonding area until 80%	No	Yes until 100%	Yes on bonding area until 80%	Yes	Yes until 100%	Yes on bonding area until 80%	Yes	Yes until 100%	Yes on bonding area until 80%	Yes
	No	Yes on bonding area until 70%	No	No	Yes on bonding area until 70%	No	No	Y on bonding area until 70%	No	No	Ye on bonding area until 70%	No
3 SOT23-5	No	No	No	No**	No**	**	No**	Yes until 50% **	**	No**	Yes until 50% **	**
4 SOT323	Yes until 100%	Yes until 20%	No	No**	No**	**	No**	No**	**	No**	No**	**
	No	No	No	No**	No**	**	No**	No**	**	No**	No**	**

** Die was in backside. So, the die assembly side could not be inspected on parts after assembly.

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WP3: HAST TEST SEQUENCE

CSAM INSPECTION @ EACH STEP--- SUMMARY

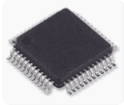
No Delam.	Delam. Not critical	Delam. critical

Trend of Delam. Apparition or evolution between T0 -- HAST1 or HAST1 -- HAST2

- No new delam or no evolution→ stable; poor impact of HAST
- New delam or evolution → low impact of HAST : delam, not critical
- New delam or evolution in critical location→ high impact of HAST /delam, critical





	At T0			After assembly			After HAST1			After HAST2		
	Delamination observed on:											
	Header	Lead	Die	Header	Lead	Die	Header	Lead	Die	Header	Lead	Die
TSSOP16 5	No	No	No	No	No	No	No	No	No	No	No	No
SOIC-8 6	No	No	No	Yes until 10%	No	No	Yes until 75%	No	No	Yes until 10%	No	No
7 TSSOP-48	Yes until 30%	No	No	Yes until 100%	Yes on bonding area until 20%	No	Yes until 80%	Yes on bonding area until 20%	No	Yes until 80%	Yes on bonding area until 20%	No
8 SOT-223	No	Yes on bonding area until 50%	No	No	Yes on bonding area until 50%	No	No	Yes until 20%	No	No	Yes until 20%	No
MSOP10 9	No	No	No	No	No	No	No	No	No	No	No	No
10 PQFP-48	No	Yes on bonding area 100%	No	No	Yes on bonding area 100%	No	No	Yes on bonding area 100%	No	No	Yes on bonding area 100%	No

** Die was in backside. So, the die assembly side could not be inspected on parts after assembly.

WP3: HAST TEST SEQUENCE
CSAM INSPECTION

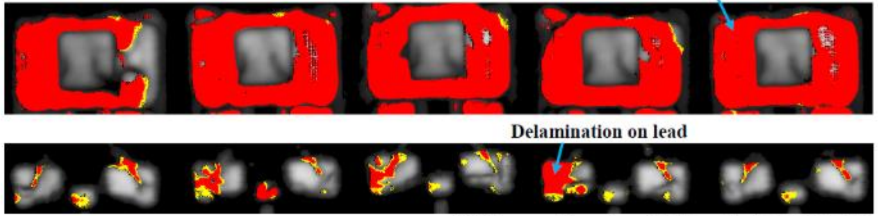
LET'S FOCUS ON DPAK-3

Top scanning - 15MHz

CSAM image @ T0

Delamination on header

V0301 V0302 V0303 V0304 V0305

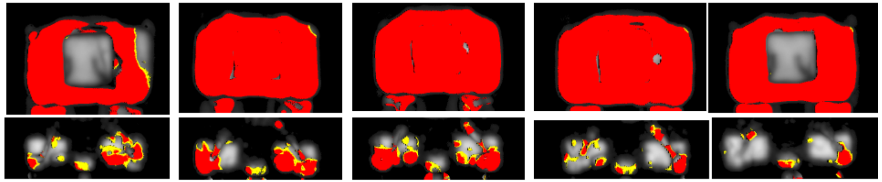


Delamination on lead

T0 (images taken from SAM analysis 21-5861-100)

CSAM image after assembly

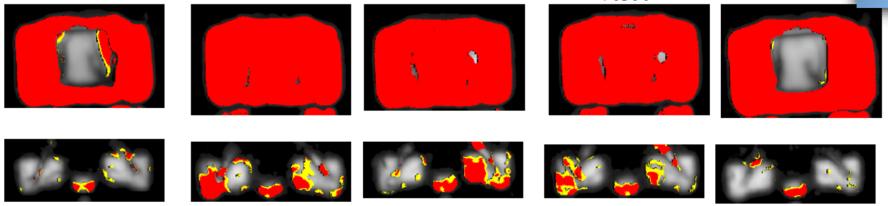
V0301 V0302 V0303 V0304 V0305



After part assembly on board (images taken from SAM analysis 21-5861-200)

CSAM image after HAST -Run 1

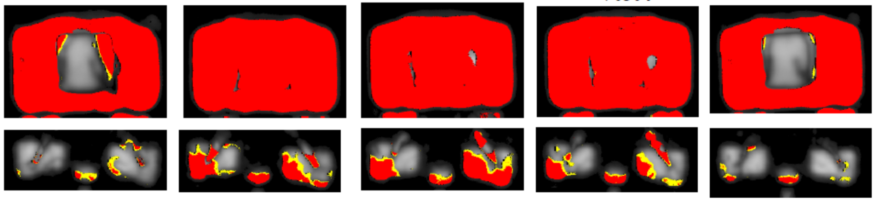
V0301 V0302 V0303 V0304 V0305



After HAST1 (images taken from SAM analysis 21-5861-400)

CSAM image after HAST -Run 2

V0301 V0302 V0303 V0304 V0305



After HAST2

Delamination occurs till the beginning (T0) and increase after assembly.

HAST seems to have a low impact in the creation or evolution of delamination

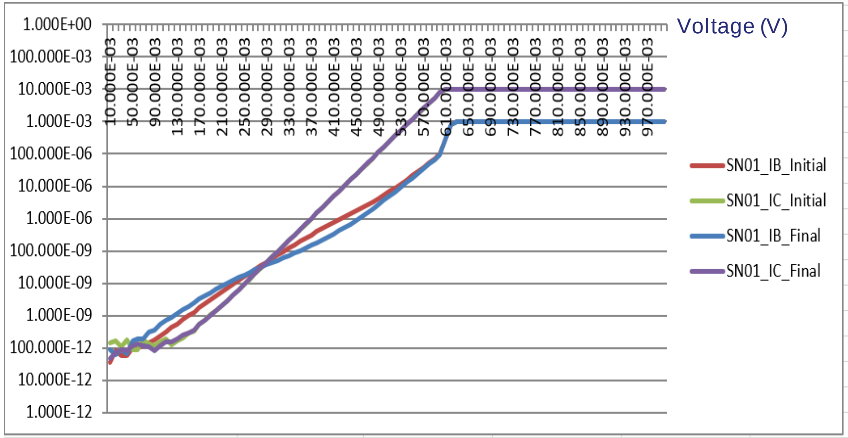
WP3: HAST TEST SEQUENCE

FOCUS ON CJD44H11 *(Extract from xls file)*

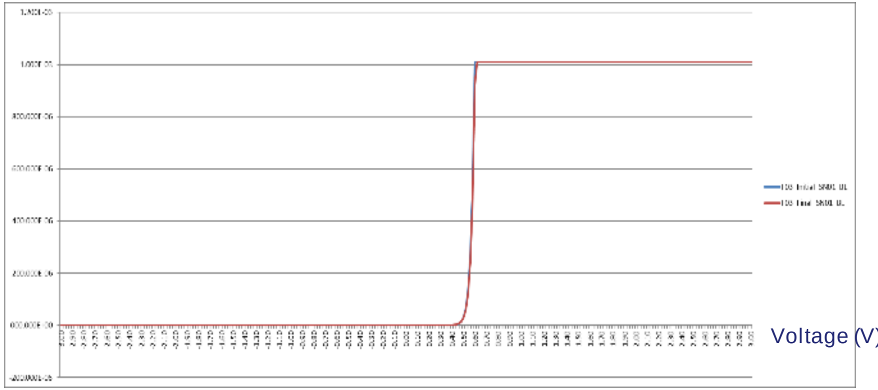
WP3: Electrical test @ each step

Example SN 01 after HAST Run #1.

Current (I)



Current (I)



Voltage (V)

The parameters are similar before and after HAST run #1. The curves are superimposed.

The junction characteristics is similar before and after HAST run #1. The curves are superimposed.

Even if the parts in DPAK-3 show dramatic delamination, we do not show nor failure nor variation in the electrical parameters measured after HAST Run #1.

WP3: HAST TEST SEQUENCE

WP3: Electrical test @ each step

Electrical Test

- ✓ A specific test plan has been defined for each component but the parameters are different.

Electrical Test has been performed before and after the HAST runs.

The parameters have been measured and compared between:

- ✓ T0 and HAST Run 1
- ✓ HAST Run1 and HAST Run 2

Measure

- ✓ The I/V plots have been created for each part, for each parameter.

Conclusion:

- ✓ No failure has been observed (no short circuit or open circuit) after the 2 runs of HAST,
- ✓ Even parts with dramatic delamination (such as the one in DPAK-3) do not show any electrical parameters variations.
- ✓ Data from electrical test of HAST Run #2 are still in analysis.

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WP4: ANALYSIS OF THE RESULTS - FINAL REPORT

Objectives

- ✓ To perform a classification of the defects (types, severity, evolution)
- ✓ To make a proposition of criteria for the acceptation of delaminations at T0

Task

To perform a mapping of the defects wrt to type of packages

To analyze the evolution of the defects

✓To make a description of the different type of defects found

✓To make a correlation between the evolution of the defect size and the test sequence step

✓To make an evaluation of the defect criticity

CONCLUSION

- Delamination occurs:
  - ✓ since the beginning (T0) or after assembly
  - ✓ not after HAST (1 run or 2 runs).
  - ✓ HAST seems to have a low impact in the creation or evolution of delamination.

- Electrical testing did not reveal major discrepancies or failure ➔ no short circuit or open circuit have been detected.

- Data from HAST run #2 are in analysis.

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Thank you for your attention !

Any questions ?

For further information, you can contact Déborah DACLIN : deborah.daclin@thalesaleniaspace.com