OSIP: Assessing pseudo-hermeticity on COTS with plastic encapsulated materials

ESA Contract 4000135494/21/NL/GLC/ov

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Assessing pseudo-hermeticity on COTS

Outline

- **Introduction, objective and work packages**
- **Tasks description:**
  - **Task 01: Investigate device plastic packaging construction (WP1000)**
  - **Task 02: Test techniques study (WP1000)**
  - **Task 03: Test technique trade-off (WP1000)**
  - **Task 04: Test sample selection criteria (WP2000)**
  - **Task 05: Test samples manufacturing (WP2000)**
  - **Task 06: Test plan design (WP2000)**
- **Preliminary results**
- **Gathered data summary and future work**

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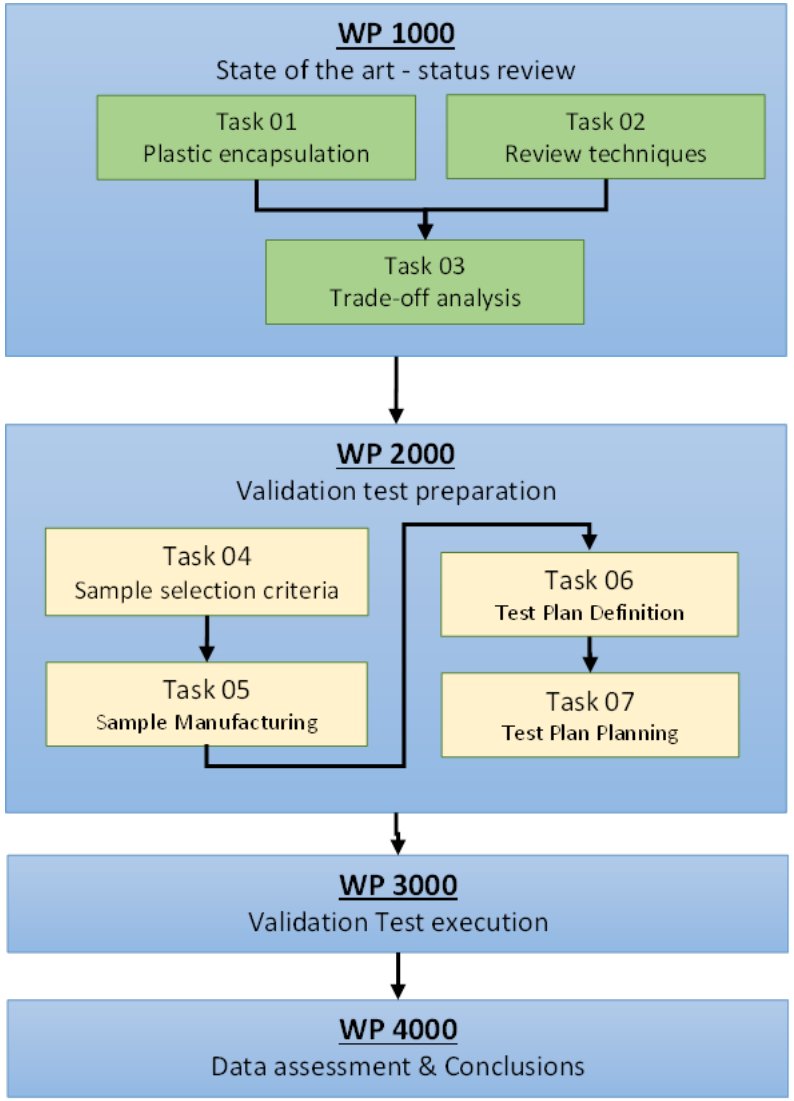
Introduction, objective and work packages

Objective

- ✓ To identify.
- ✓ To validate.

A proper test technique that allows to assess the EEE plastic packages pseudo-hermeticity.

Robustness against moisture ingress.



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Task 01: Investigate device plastic packaging construction

What does influence moisture absorption?

Mould compound

- Key part of the component.
- Curing parameters.

Lead frame structure and materials

- Lead frame materials.
- Determine the presence of delaminations.

Die attach material

- CTE compatibility with other materials used in the PEM construction.
- Curing parameters.

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Task 01: Investigate device plastic packaging construction

- **Optimum materials/process parameters**

Materials	
Mould compound	• Capling GR900C Q1L4E
Lead frame	• Base material: Cu Alloy 194 Full Hard. • Plating: ENEPIG Ni:20-80µ"Pd:0.8-6.0µ"Au:0.12-0.6µ" Selective plating with Cu Enhanced treatment.
Tape	• Nitto6250L Silicon adhesive.

Key Specifications	Unit	Caplinq GR900C Q1L4E
Filler Content	%	86.5
Gel Time@175°C	seconds	39
Tg	°C	120
CTE Below Tg	PPM/°C	11
CTE Above Tg	PPM/°C	37
Ionic Content NA+	PPM	3
Ionic Content CL-	PPM	8
Moisture Absorption 24 Hrs.	%	0.22
Flexural Strength@RT	N/mm²	150
Flexure Modulus@RT	N/mm²	19000

Mould compound transfer parameters	
Clamp force	• 150 kN
Moulding temperature	• 175 °C
Mould pressure	• 9 MPa
Transfer time	• 90 s
Post cure time	• 6 h
Post cure temperature	• 175 °C

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Task 02: Test techniques study

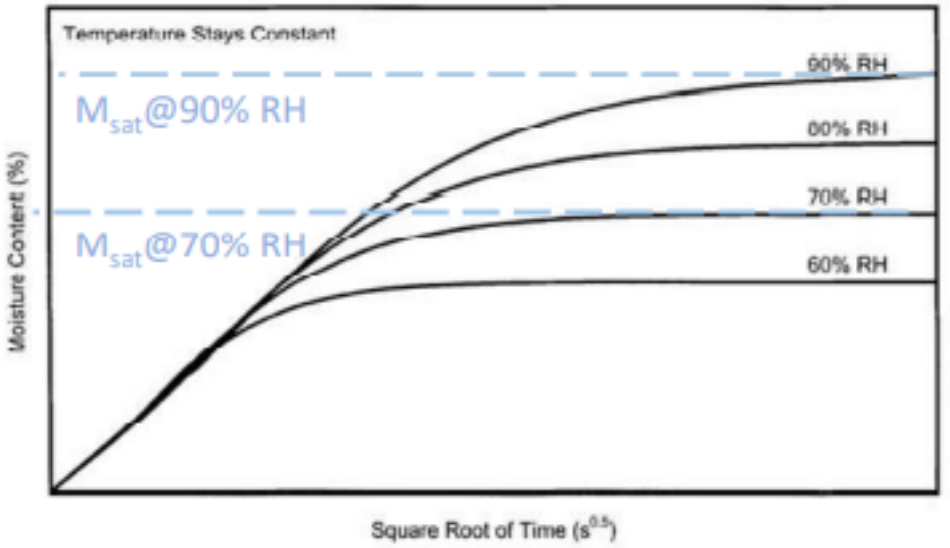
- **Introduction**

✓ **Moisture ingress in plastic materials:** It is a type of absorption process whereby surface-adsorbed water molecules are disolved or permeate into the solid plastic.

✓ **Key parameters related to moisture absorption:**

➢ **Moisture concentration:** $$M_t = \frac{W_t - W_{dry}}{W_{dry}}$$

➢ **Moisture saturation concentration:** M_{sat}



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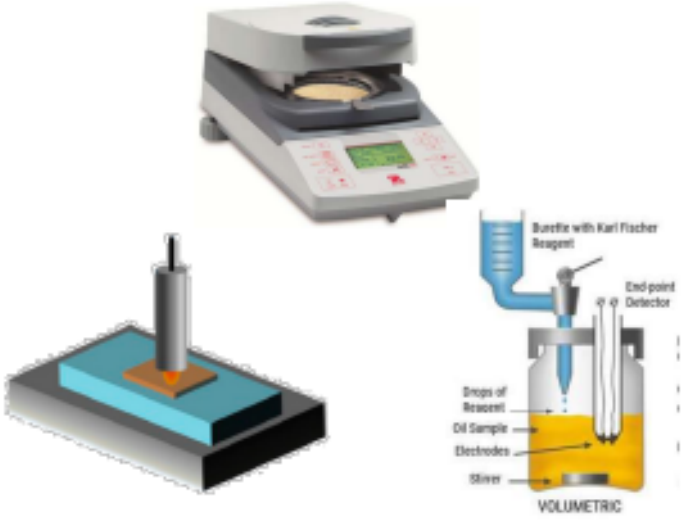
Task 02: Test techniques study

- **Introduction**

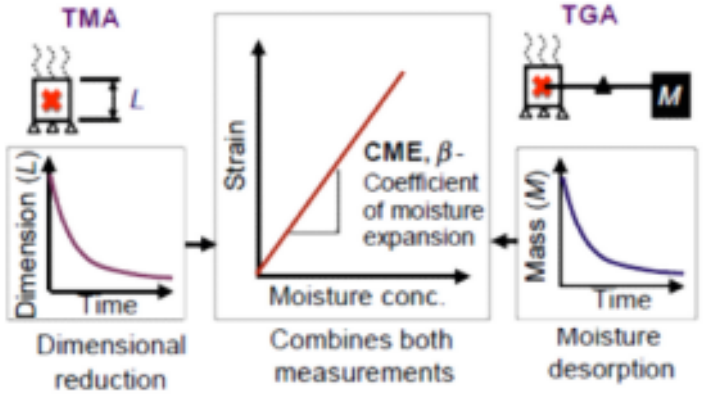
MOISTURE ABSORPTION/DESORPTION MEASUREMENTS

- **Weight gain/loss**
- **MW resonant sensor**
- **Chemical analysis**



FUNCTIONAL TEST

- **Hygroscopic swelling**
- Tg shifting
- CTE modification



OTHER CHARACTERISATION TECHNIQUES

- **Porosimetry**
- **Wetability**

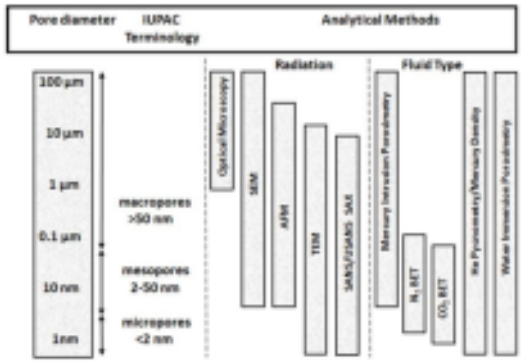
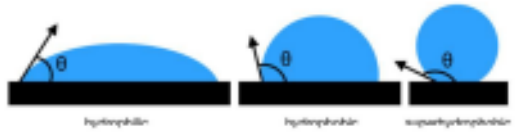


Figure 1. Methods used to determine porosity and pore size distribution (PSD).



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Task 02: Test techniques study

- **Introduction**

Non specific techniques

Gravimetric method

Weight gain/loos is analysed

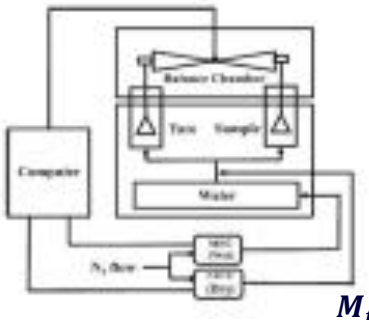
MW resonant sensor

Water content is assesses through systems impedance

Specific techniques

FT-IR spectroscopy
Karl Fisher Titration
Humidity sensors

- Environmental chamber + precision balance.
- Halogen lamp moisture analyser
- Thermogravimetric analyser
- Dynamic vapor sorption analysers



$$M_t = \frac{W_t - W_{dry}}{W_{dry}}$$

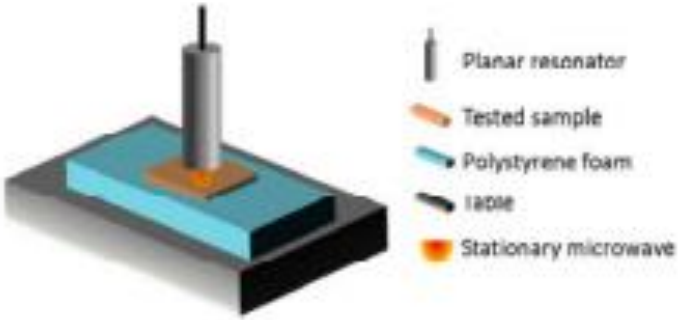
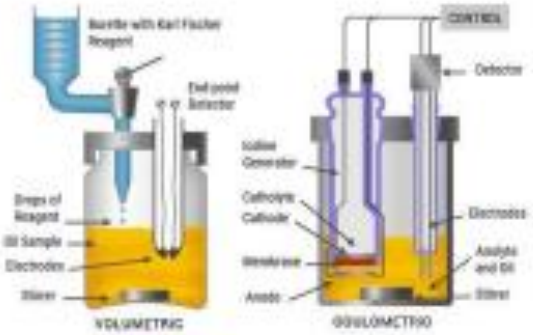


Fig. 1. Set-up of the microwave measurement.



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Task 03: Test technique trade-off

- **Qualitative pros and cons of the different techniques analyzed**

Technique	Test method	Absorption / desorption	Readability[1] (% wt)	In situ / real time monitoring	Sample size	Availability	Price
Environmental chamber + precision balance		Both					300-30K€
Moisture analyser							10K€
Thermogravimetric analysis							> 50K€
Dynamic Sorption Analysis		Both			12-14 mm of diameter		65 K€
Karl Fisher							15 K€
RH based moisture analysers							20 K€
MW resonant moisture sensing		Both					
FT-IR		Both					>150 k€

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Task 03: Test technique trade-off

- **Qualitative pros and cons of the different techniques analyzed**

Dynamic sorption analysis →
- ✓ Widely known.
- ✓ Accurate.
- ✓ Used as a reference.

RH based moisture analysis →
- ✓ More affordable.
- ✓ Interesting theoretical properties.

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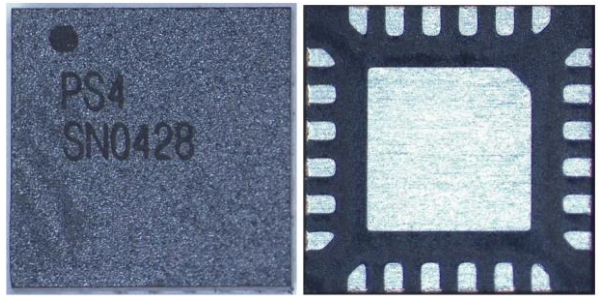
Task 04: Test sample selection criteria

Optimum materials/process parameters previously defined.

Assembly house as a project partner (ALTER UK).



Modify the manufacturing process to promote deffects and increase moisture absorption in the selected test vehicles: QFN 4X4.

Material
Leadframe 4x4 Selective Plating with Cu Adhesion Enhancement (AE)
Leadframe 4x4 Fully Plated
GR900CQ1L4E Black Epoxy Mould
Ablebond 84-1LMISR4 Epoxy

Obtention of test vehicles:

- ✓ **With several moisture sensitive levels.**
- ✓ **Exhibing typical manufacturing deffects.**
- ✓ **Exhibing typical degradation post-enviromental tests.**
- ✓ **That are representative of other devices found in the market.**

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Task 05: Test samples manufacturing

Equipment	Process Step	Sample 1 (golden)	Sample 2	Sample 3	Sample 4
LF number		PS1	PS2	PS3	PS4
Serial Number		1-120	121-240	241-360	361-480
Leadframe Plating type		Selective with AE	Selective with AE	Selective with AE	**Fully Plated**
Dispenser & Convection Oven	Epoxy Dispense & Oven Cure	Time/Temp: 90 mins@175°C Loctite 84-1	Time/Temp: **60 mins@150°C** Loctite 84-1	Time/Temp: 90 mins@175°C Loctite 84-1	Time/Temp: 90 mins@175°C Loctite 84-1
Fico MMSI	Mould ENCAP	Time/Temp: 90s@175°C Pressure: 9MPa Force: 150kN EMC Pellets in sealed bag thaw @RT for 2-3hours GR900C	Time/Temp: 90s@175°C Pressure: 9MPa Force: 150kN EMC Pellets in sealed bag thaw @RT for 2-3hours GR900C	Time/Temp: 90s@175°C Pressure: 9MPa Force: 150kN EMC Pellets in sealed bag thaw @RT for 2-3hours GR900C	Time/Temp: 90s@175°C Pressure: 9MPa Force: 150kN EMC Pellets in sealed bag thaw @RT for 2-3hours GR900C
Convection Oven	Mould ENCAP Post Cure	Time/Temp: 6 Hours@175°C Force: 1Kg	Time/Temp: 6 Hours@175°C Force: 1Kg	Time/Temp: **2 Hours@150°C** Force: 1Kg	Time/Temp: 6 Hours@175°C Force: 1Kg

Task 06: Test plan design

- **Objectives and test blocks**

✓ To assess the performance of the two selected test techniques, including sensitivity, industrial process, benefits and drawbacks.

✓ Investigate **how** and **where** this kind of test could be allocated within the classical validation test sequences used at EEE level, considering the different test usage: as part of the device screening, evaluation test, etc.

Task 06: Test plan design

Samples	Manufacturing modification
Sample 1 golden type	None
Sample type 2	Less time & curing temperature (60 min & 150 °C)
Sample type 3	Less time & post-curing temperature (2 h & 150 °C)
Sample type 4	Fully plated

- **Test plan**

  - ✓ **1st test group:** Initial status of the samples.

		Sample 1 Golden	Sample type 2			Sample type 3			Sample type 4		
Step	Test	Q0	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
1	1st test group	3	3	3	3	3	3	3	3	3	3
1.1	External visual inspection	3	3	3	3	3	3	3	3	3	3
1.2	Dimensions check	3	3	3	3	3	3	3	3	3	3
1.3	Weight measurements	3	3	3	3	3	3	3	3	3	3
1.4	X-ray	3	3	3	3	3	3	3	3	3	3
1.5	SAM inspection	3	3	3	3	3	3	3	3	3	3
1.6	Low pressure SEM	1	1			1			1		

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Task 06: Test plan design

Samples	Manufacturing modification
Sample 1 golden type	None
Sample type 2	Less time & curing temperature (60 min & 150 °C)
Sample type 3	Less time & post-curing temperature (2 h & 150 °C)
Sample type 4	Fully plated

- **Test plan**

✓ **2nd test group:** Environmental stresses → Different degradation levels →Different moisture ingress levels.

		Sample 1 Golden	Sample type 2			Sample type 3			Sample type 4		
Step	Test	Q0	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
2	2nd test group	3	3	3	3	3	3	3	3	3	3
2.1	No stress tests	3	3			3			3		
2.2	TC (-55 to +125 ºC / 100 cycles)			3			3			3	
2.3	RH (250 h / 85ºC / 85% RH)				3			3			3
2.4	TS (-55 ºC to 125 ºC / 25 cycles)				3			3			3
2.5	RH (250 h / 85ºC / 85% RH)				3			3			3
2.6	TS (-55 ºC to 125 ºC / 25 cycles)				3			3			3
2.7	Baking (24 h/ 125 ºC)	3	3	3	3	3	3	3	3	3	3

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Task 06: Test plan design

Samples	Manufacturing modification
Sample 1 golden type	None
Sample type 2	Less time & curing temperature (60 min & 150 °C)
Sample type 3	Less time & post-curing temperature (2 h & 150 °C)
Sample type 4	Fully plated

- **Test plan**

  - ✓ **3rd test group:** Moisture sorption measurements (previously selected techniques).

		Sample 1 Golden	Sample type 2			Sample type 3			Sample type 4		
Step	Test	Q0	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
3	3rd test group	3	3	3	3	3	3	3	3	3	3
3.1	Dynamic sorption analysis	3	3	3	3	3	3	3	3	3	3
3.2	RH based moisture analysis	3	3	3	3	3	3	3	3	3	3

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Task 06: Test plan design

Samples	Manufacturing modification
Sample 1 golden type	None
Sample type 2	Less time & curing temperature (60 min & 150 °C)
Sample type 3	Less time & post-curing temperature (2 h & 150 °C)
Sample type 4	Fully plated

- **Test plan**

✓ **4th test group:** Final samples status → Correlation with the moisture sorption measurements.

		Sample 1 Golden	Sample type 2			Sample type 3			Sample type 4		
Step	Test	Q0	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
4	4th test group	3	3	3	3	3	3	3	3	3	3
4.1	External visual inspection	3	3	3	3	3	3	3	3	3	3
4.2	SAM inspection	3	3	3	3	3	3	3	3	3	3
4.3	Cross section	3	3	3	3	3	3	3	3	3	3
4.4	SEM inspection	3	3	3	3	3	3	3	3	3	3

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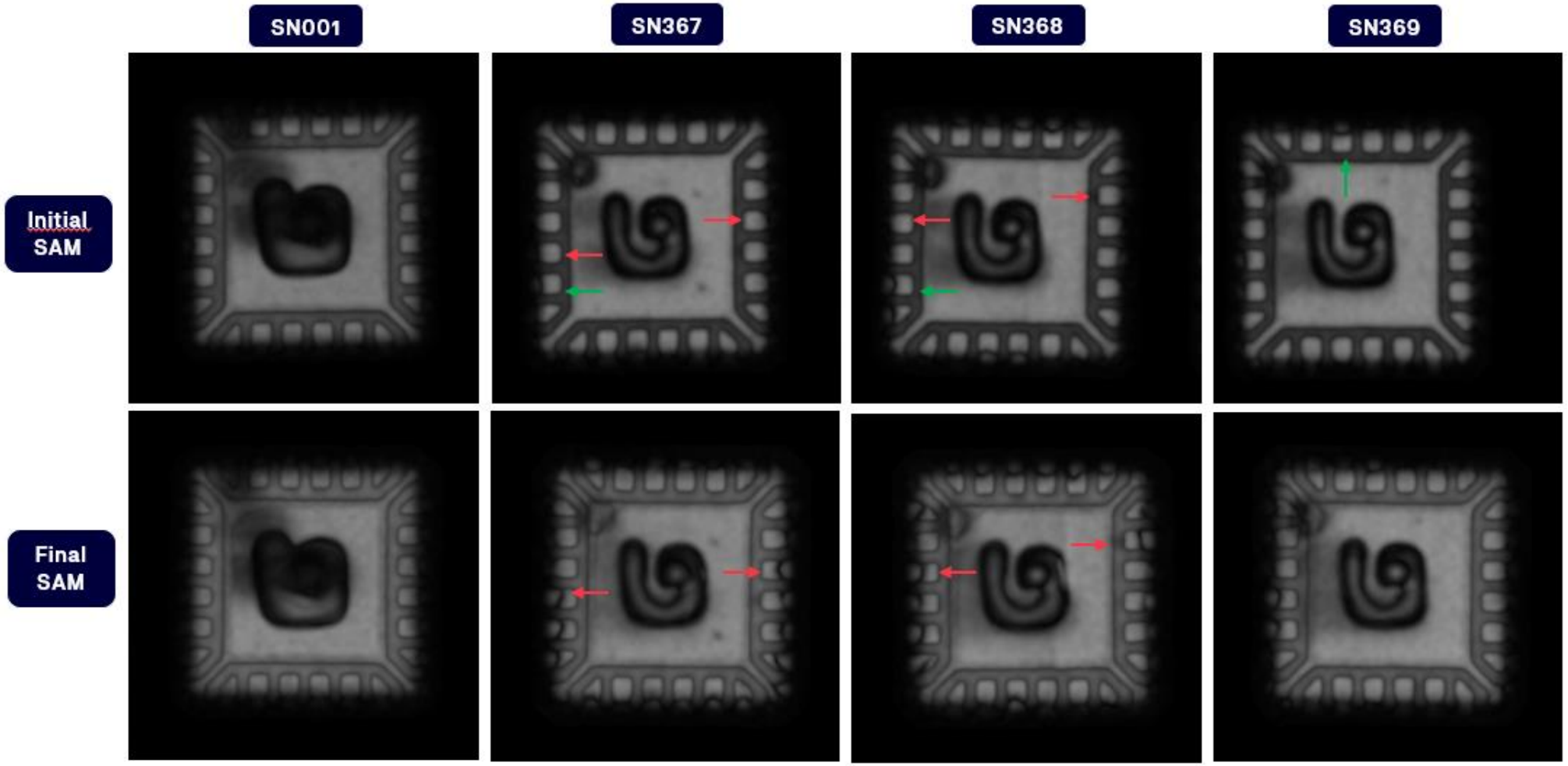
Preliminary results

Samples	Sample Type	Subgroup
SN001	1 Golden type	Q0
SN367	4	Q3
SN368	4	Q3
SN369	4	Q3

- **SAM results**



- SN001: Ideal manufacturing process.
- SN367, SN368 & SN369: Delaminations in the lead fingers.
- SN367 & SN368: Evolution of the delaminated area.

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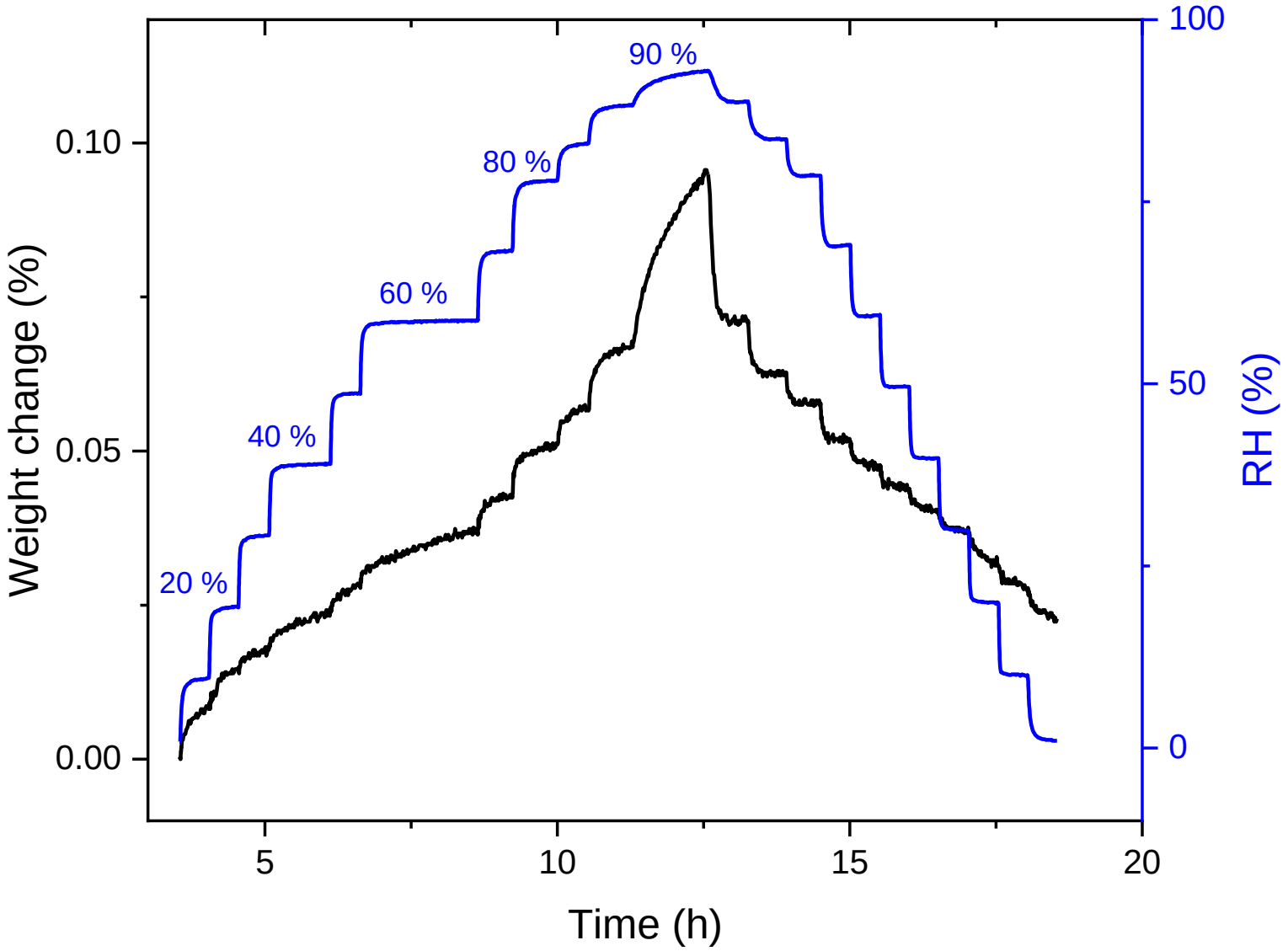
Preliminary results

- **Dynamic sorption analysis**

- ✓ **In situ monitoring** of the weight change.
- ✓ Real time response to **different humid environments** (RH and temperature control).
- ✓ **Absorption and desorption** measurements.



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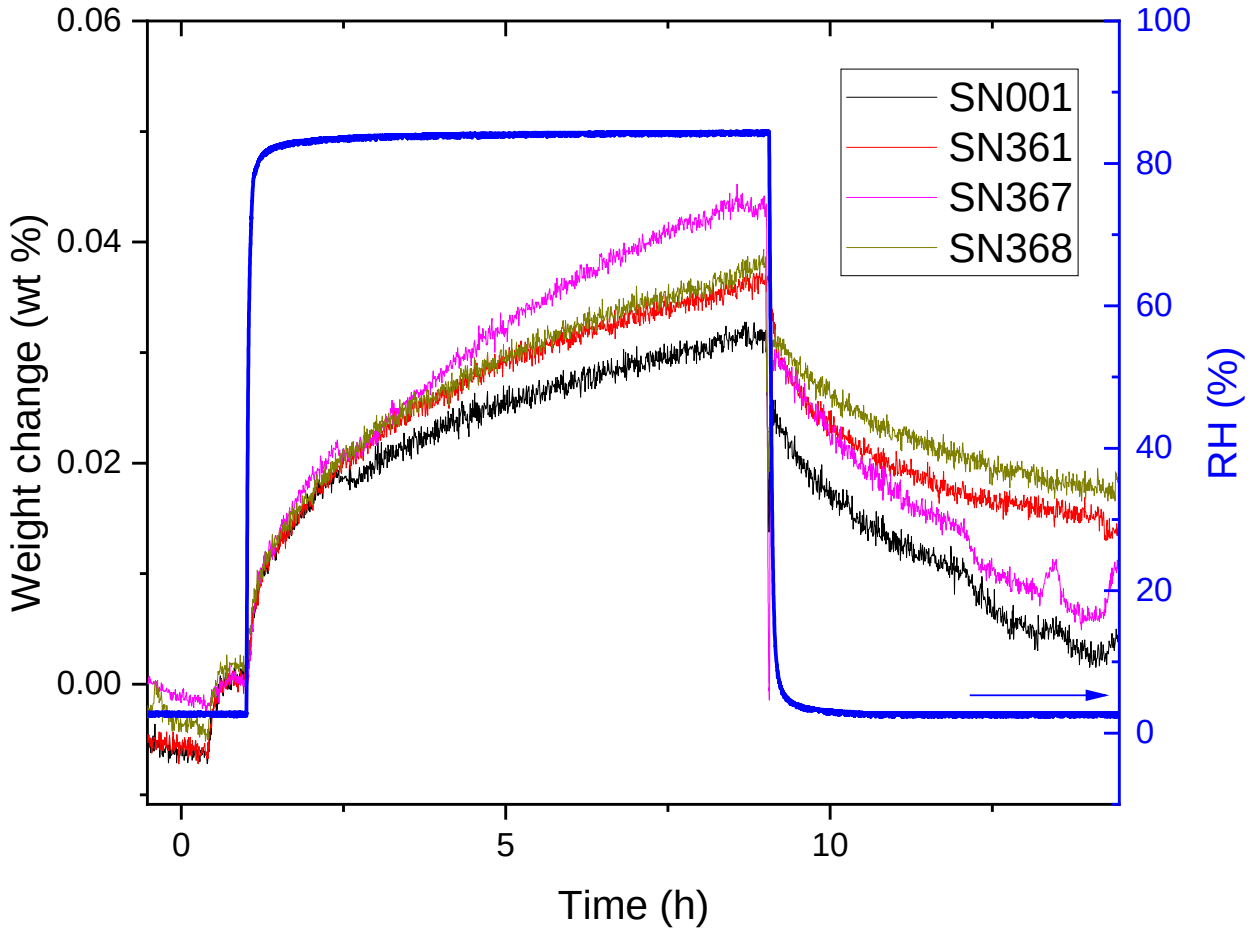
Preliminary results

- **Dynamic sorption analysis**



Samples	Sample Type	Subgroup
SN001	1 Golden type	Q0
SN361	4	Q1
SN367	4	Q3
SN368	4	Q3
SN369	4	Q3

- SN001: No delaminations
- SN367 & SN368: Evolution of the delaminated area.

First analysis discloses higher moisture absorption on those samples that experienced delamination evolution.

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Gathered data summary and future work

- Dynamic sorption analysis allows to characterize the moisture absorption of the QFN 4x4 test vehicles.
- The modified manufacturing process and the environmental stresses seem to affect the integrity of the samples and the moisture absorption response.
- RH based moisture analysis must be performed and validated after completing the dynamic sorption analysis of the remaining samples.
- Final physical characterization of the samples must be completed.

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THANK YOU!

For any question, please contact:

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