PUBLIC

Novel in-situ button shear methodology for efficient assessment of mold compound encapsulation

David Guillon

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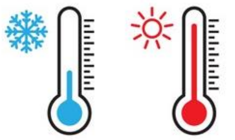
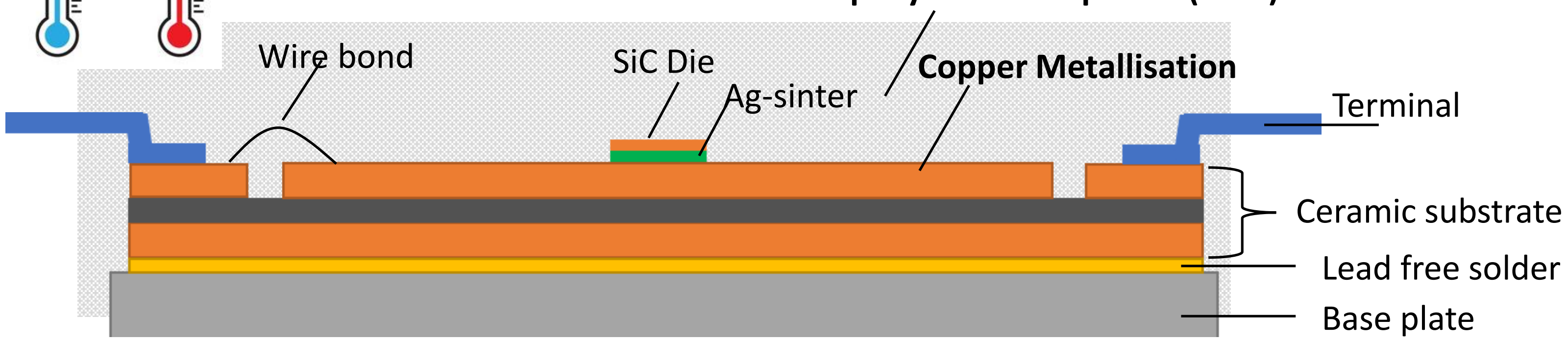
Agenda

- Motivation
- Integrity of Button sample preparation
- In-situ button shear methodology
- Comparison of button preparation methods
- Impact of Plasma preconditioning on EMC adhesion
- Impact of reliability tests on EMC adhesion strength
- Conclusion

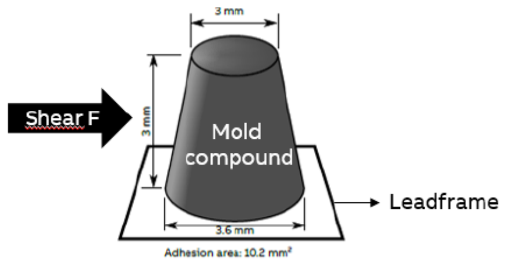
Introduction

- Technology trend of large volume epoxy molding for power modules in e-mobility application
- Reliability of the device depends on good adhesion of back-end encapsulation material
- Limitations from the establish test method [SEMI G69-0996] used by Epoxy mold compound supplier





Transfer molded Power module package

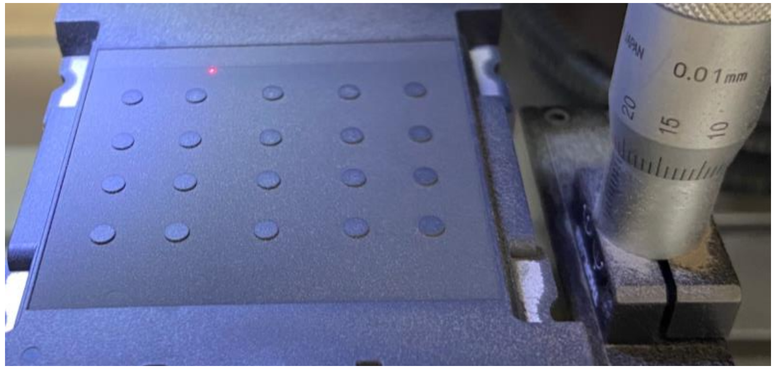


Adhesive area	Leadframe thickness	Height of mold compound
10 ± 0.5mm²	0.15mm	3 ±0.15mm

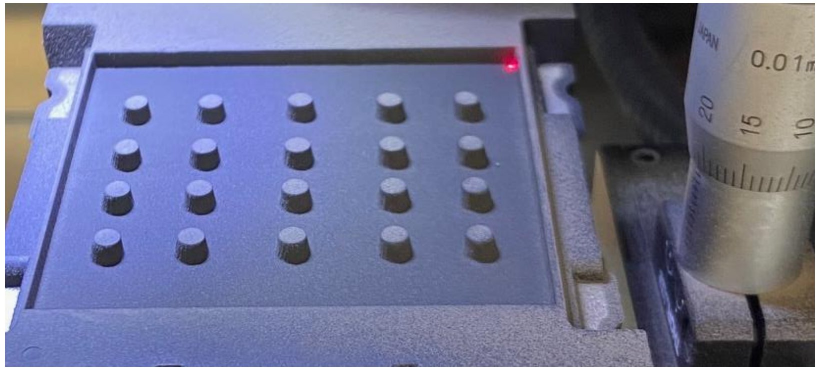
Std. button shear test

Demonstration of the novel in-situ button shear methodology ECTC 2021 & 2022, PCIM 2023

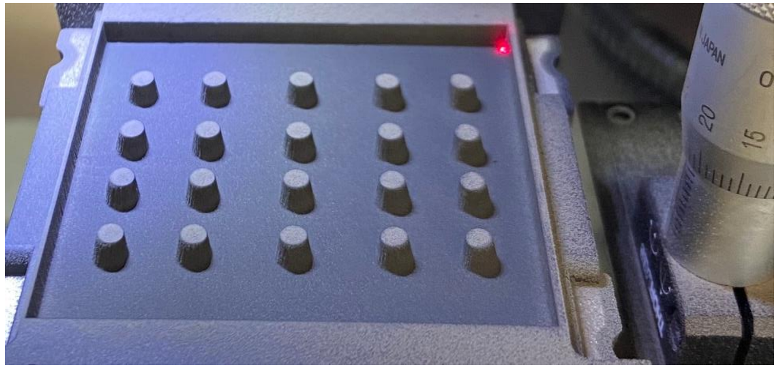
Button shaping by laser ablation



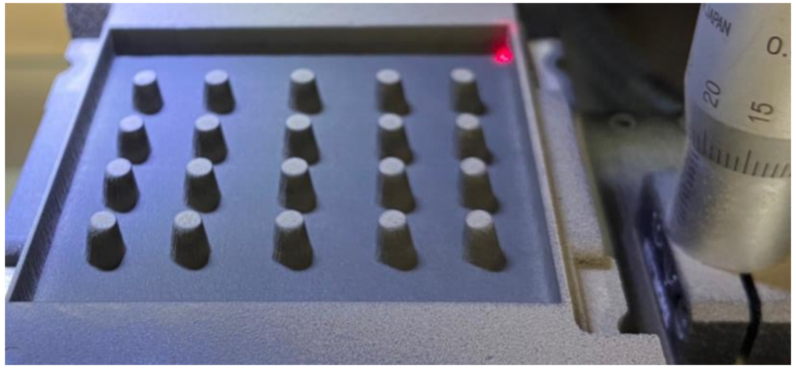
X10repetitions



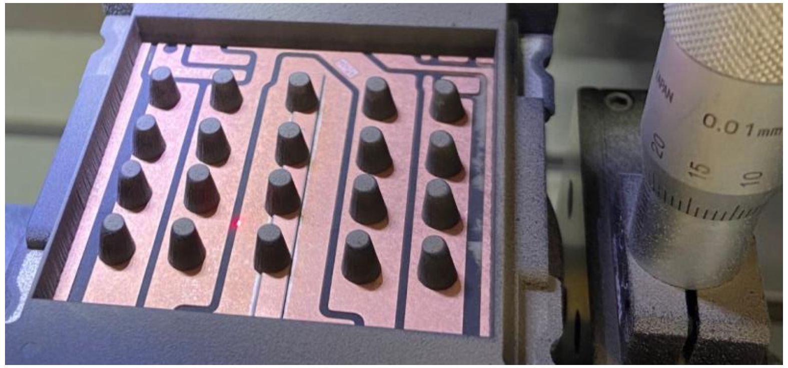
X30repetitions



X60repetitions



X80repetitions



X100repetitions

Ablation rate optimized with process parameters

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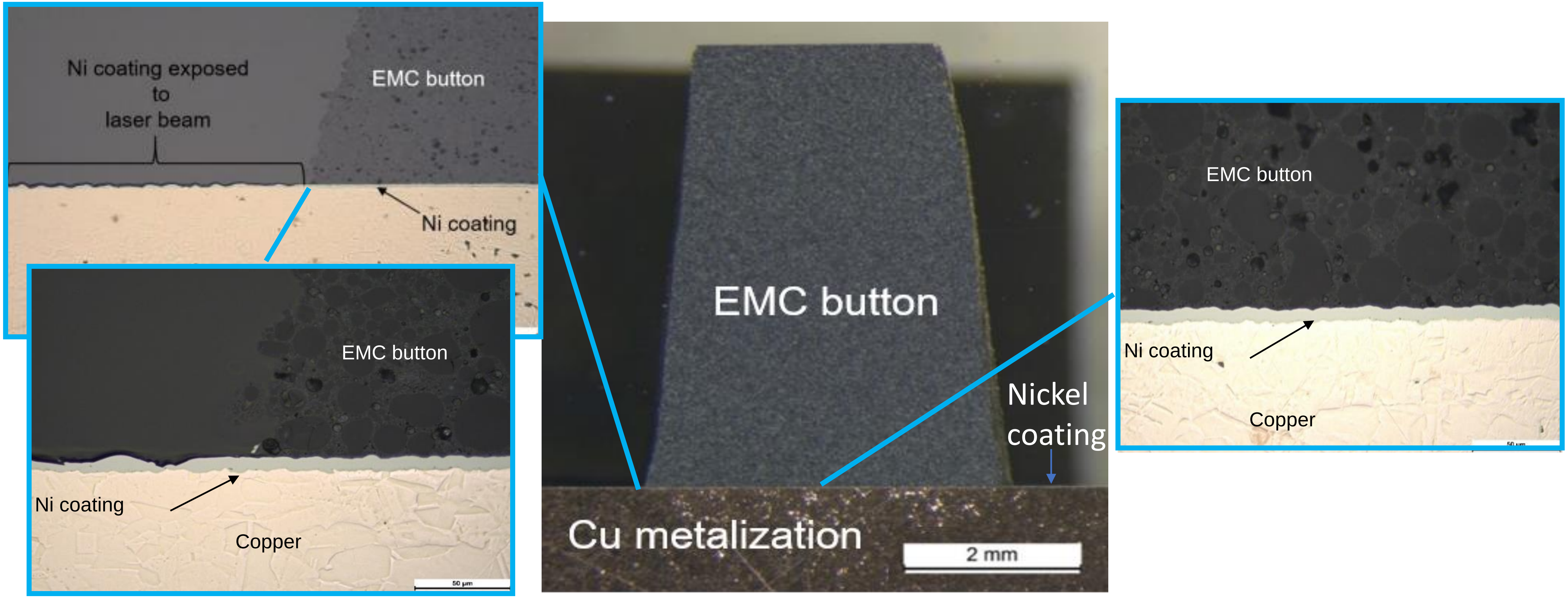
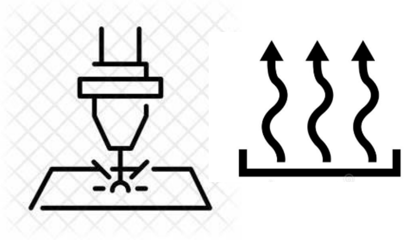
Integrity check of Button sample preparation

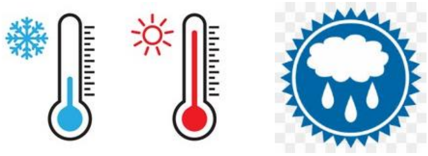


No harmful impact at Region of Interest

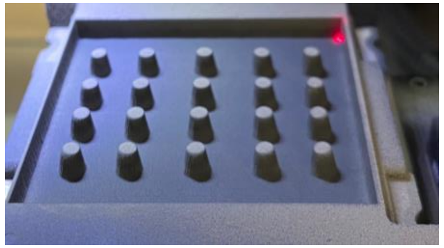
In-situ button shear methodology

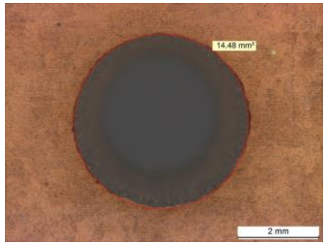
Pre-assembly → Pre-conditioning → Transfer molding → Post-mold curing → Reliability tests

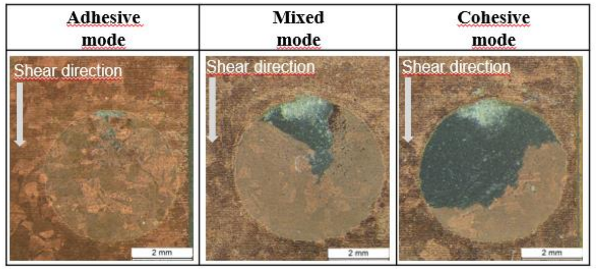




Button shape by laser ablation → Measurement of contact area → Shear test → Grading of Failure mode

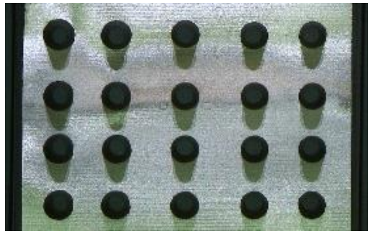
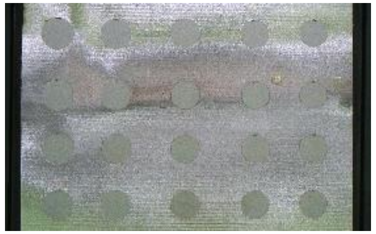
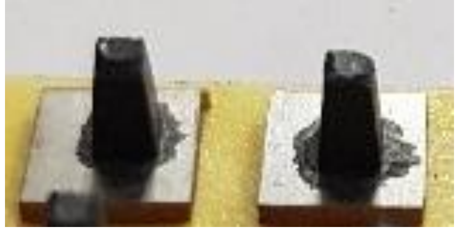






Through process on EMC characterization

Comparison of button preparation methods

		Buttons prepared according to **novel in-situ laser ablation method**	Buttons prepared according to **SEMI G69-0996 by EMC supplier (standard)**
Buttons before Shearing	Surface after Shearing	 	  
# of buttons		**40**	**6**
Failure mode		**100% adhesive**	**50% adhesive & 50% mixed**
Average shear strength		**8.6 ± 2.2Mpa**	**17.6 ±7.4Mpa**
Assessment +/-		**+ Distinct button edges and contact area** **+ failure mode grading** **+ narrow data distribution**	**- EMC Flash around buttons** **-Large data distribution** **-Dedicated mold tool**

Advantage towards standard methodology

Plasma preconditioning impact on EMC adhesion (1/3)

Motivation:

- Test efficiency of In-situ button shear method by optimizing Argon plasma recipe for Copper surface pre- conditioning prior molding

DOE setup:

- 3 splits with Argon plasma programs (Low, Medium, High intensity)
- 1 reference without plasma
- 40 buttons per each split
- Response: shear strength, failure mode

EMC Buttons before shearing

Checking impact from surface preparation on EMC adhesion

Plasma preconditioning impact on EMC adhesion (2/3)

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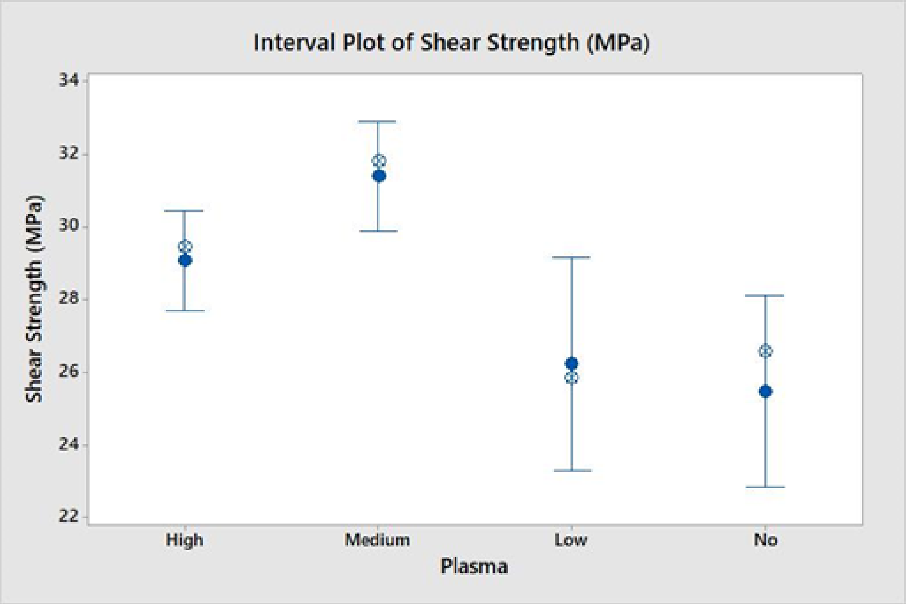
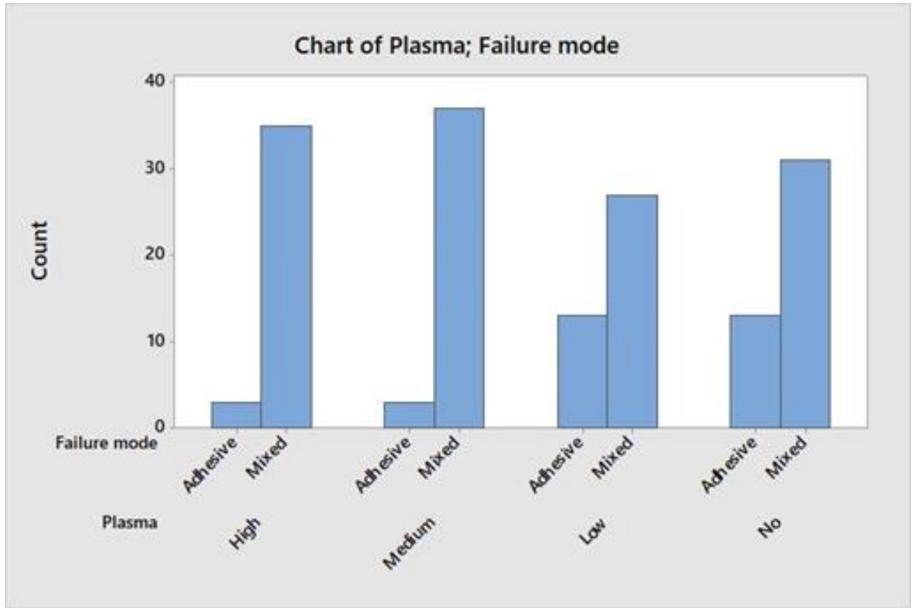
Shear strength vs. Plasma pre-conditioning



Medium & **High** plasma activitation have similar average shear strength & lower spread of the data compared to **Low** or **No** plasma activation

Failure mode vs. Plasma pre-conditioning



Frequency of **Adhesives** failure mode increases with **No** or **Low** plasma pre-conditionning

Validation of button shear methodology

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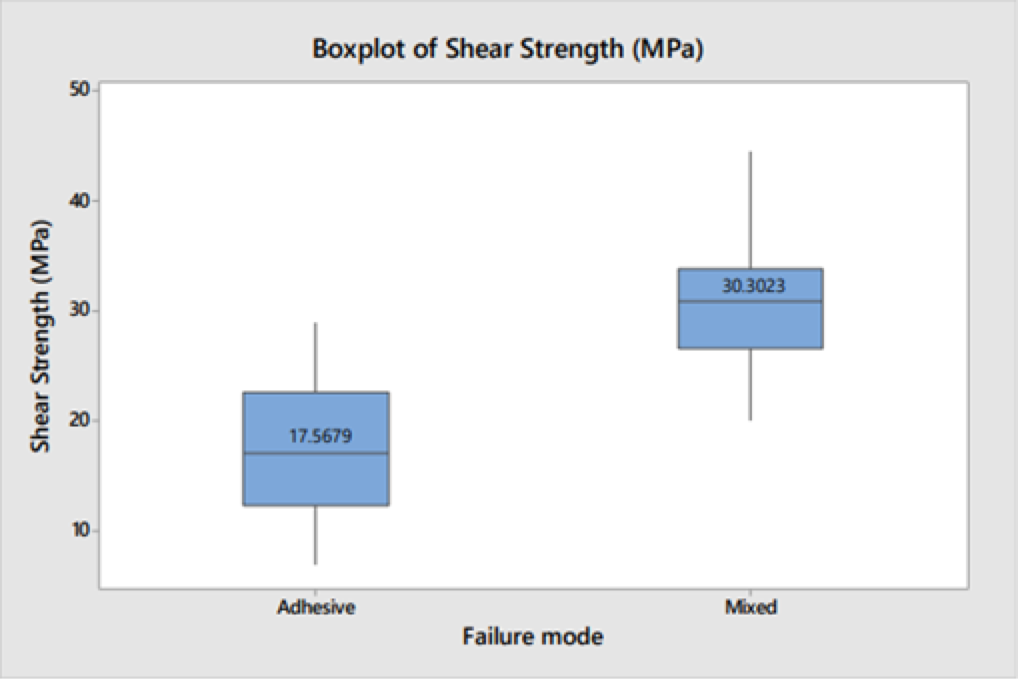
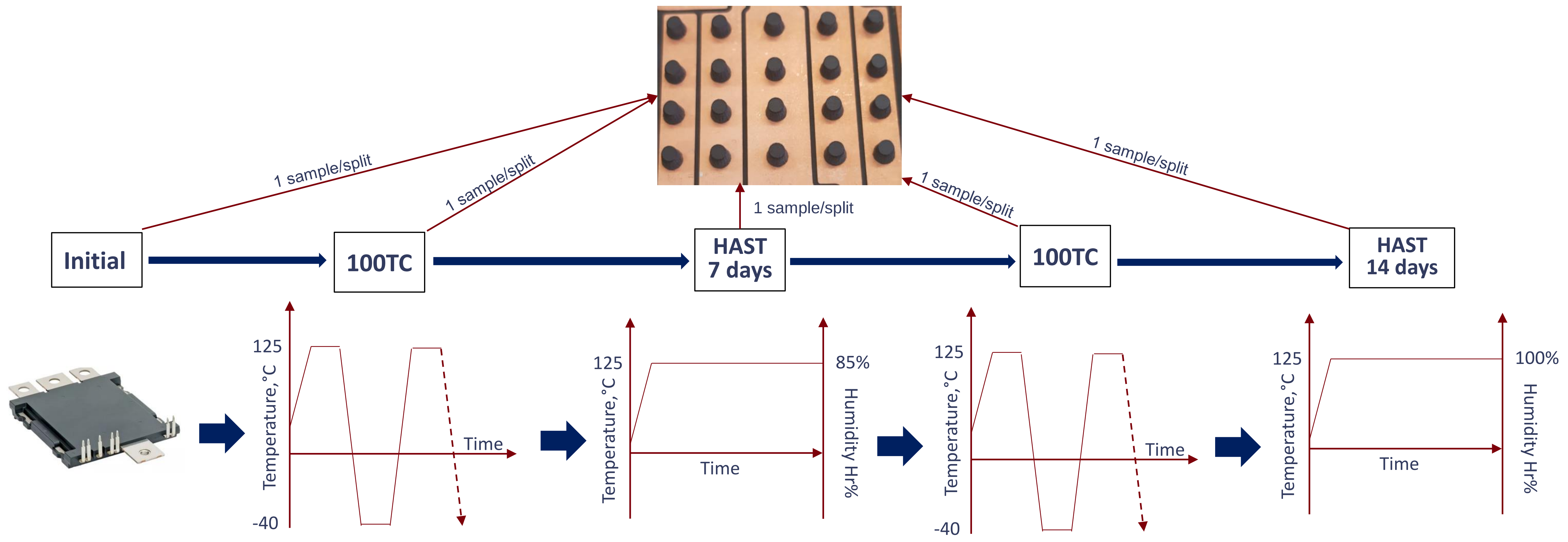
Shear strength vs. Failure mode



Overall adhesive failure mode shows lower shear strength value compared to mixed mode

Reliability testing methodology –DOE setup



After each reliability test one sample/split was prepared for button shear

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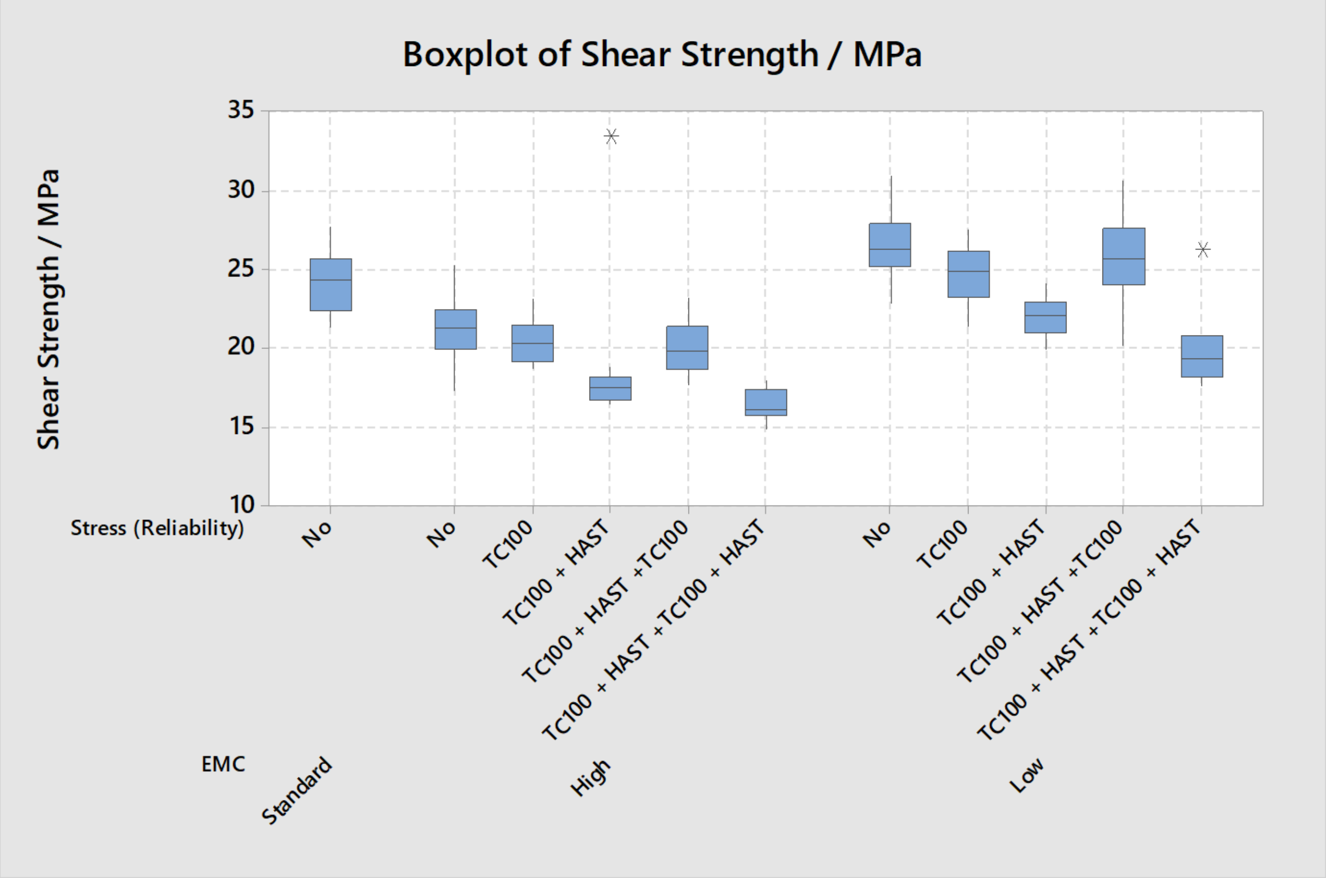
Impact of reliability tests on adhesion strength

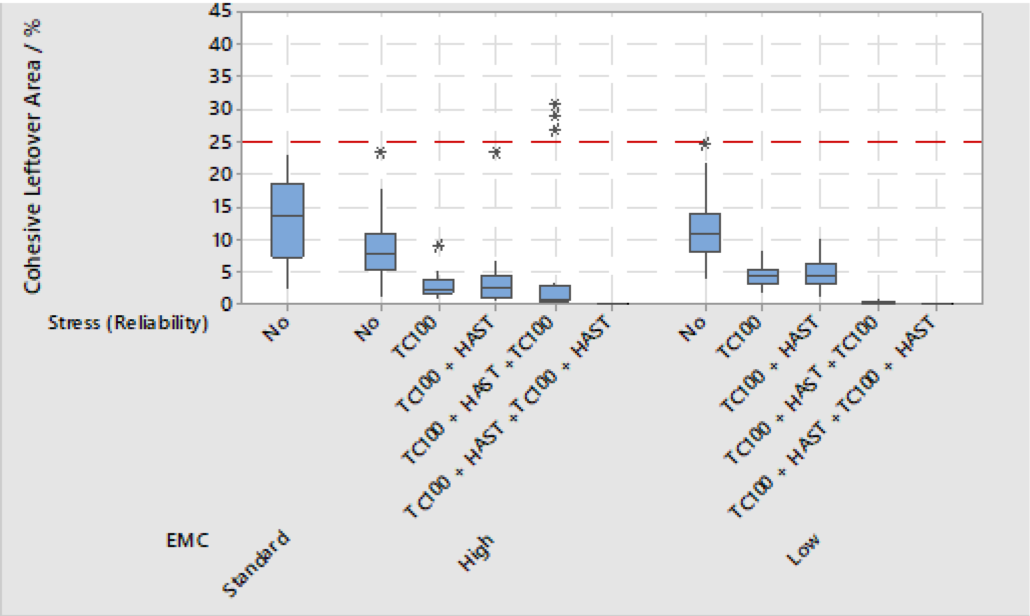
- Significant decrease after TC100 & HAST
- After the 2nd TC100 the shear strength values recover
- The 2nd HAST shows shear strength values even lower than after 1st HAST



EMC adhesion strength sensitive to Humidity and Temperature exposure

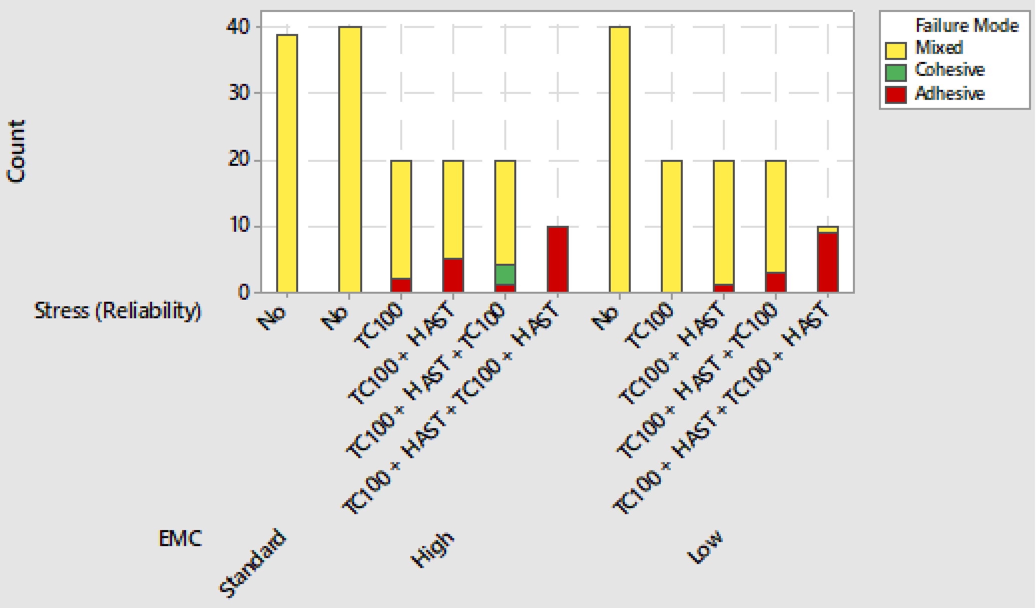
Impact of reliability tests on failure mode

Cohesive leftover area in % of ≠ EMC materials after testing



- Largest amount of cohesive area before reliability tests
- Cohesive area decreases after each tests

Count of failure mode of ≠ EMC materials depending on testing



- Cohesive mode after TC stress indicates signs of material degradation , whereas adhesive mode after humidity stress indicates signs of interface degradation

Humidity and thermal stress leading to different failure modes

Summary & outlook

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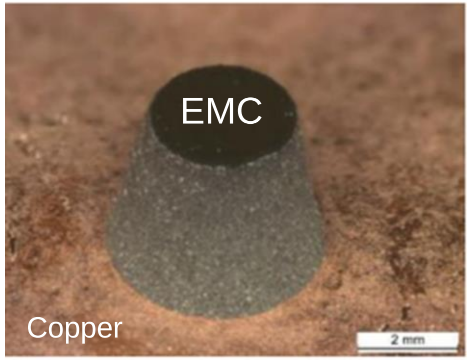
Conclusion

- Integrity of EMC Button validated
- Comparative DOE's performed on standard vs. In-situ button method
- Efficiency of the In-situ button test method demonstrated through positive impact of plasma as pre-conditioning before molding
- Efficiency of the In-situ button test method to demonstrate the reliability performance of the molded product
- After humidity/ thermal stress exposure the failure mode changes to adhesive mode leading to significant shear force reduction

Outlook

- Optimization of Pre-conditioning steps
- Optimization of mold process parameters
- Impact of flow behaviour & material homogeneity
- Impact from product geometry & residual stress
- Impact of reliability tests performed on product level
- …



Learnings use to define material specification for our molded product

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