ATDI

Doctoral School on Material Sciences and Technologies
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Óbuda University

Semester Report - Fall 2021/2022

Modeling lead-free interconnect reliability under creep in advanced packaging.

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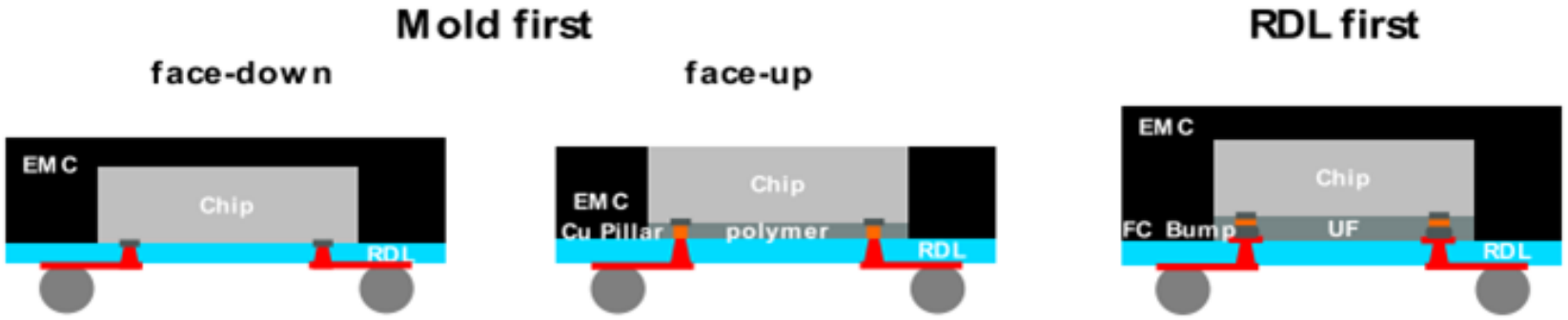
Contents

- **Introduction**
  - Fan - Out Wafer Level Packaging
  - Failure prediction models.
- **Results**
  - Previous semesters.
  - Current semester.
- **Plans for future work**

Fan – Out Wafer Level Packaging

- Increase the number of I/O while reducing ICs size rapidly
- Substrate-less package (Patented in 2017)
- Lower thermal resistance
- Higher performance due to shorter interconnects



Short video on package substrate technology by Samsung: https://youtu.be/J5V49-bucD0

Failure prediction models

- COFFIN MANSON

$N_f(\Delta\varepsilon_p)^n = C$	N_f number of cycles to failure n empirical constant $\Delta\varepsilon_p$ inelastic strain range C is the proportionality factor/fatigue ductility coefficient.

- MORROW

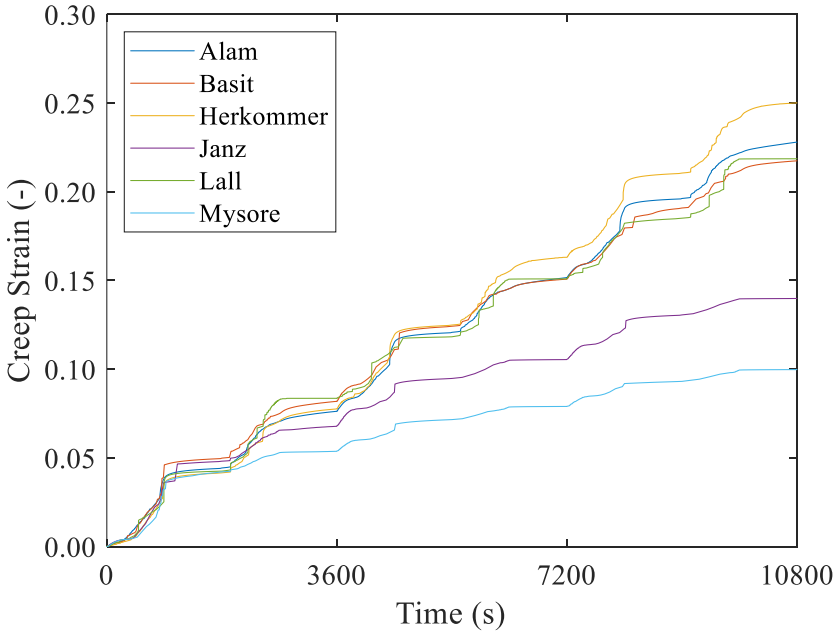
${N_f}^{n'} W_p = A$	n' fatigue exponent A material ductility coefficient W_p inelastic strain energy density.

According to Che and Pang, an approximation of the average of strain energy density can be computed taking values from the second and third thermal cycles.

Results - previous semesters (1/3)

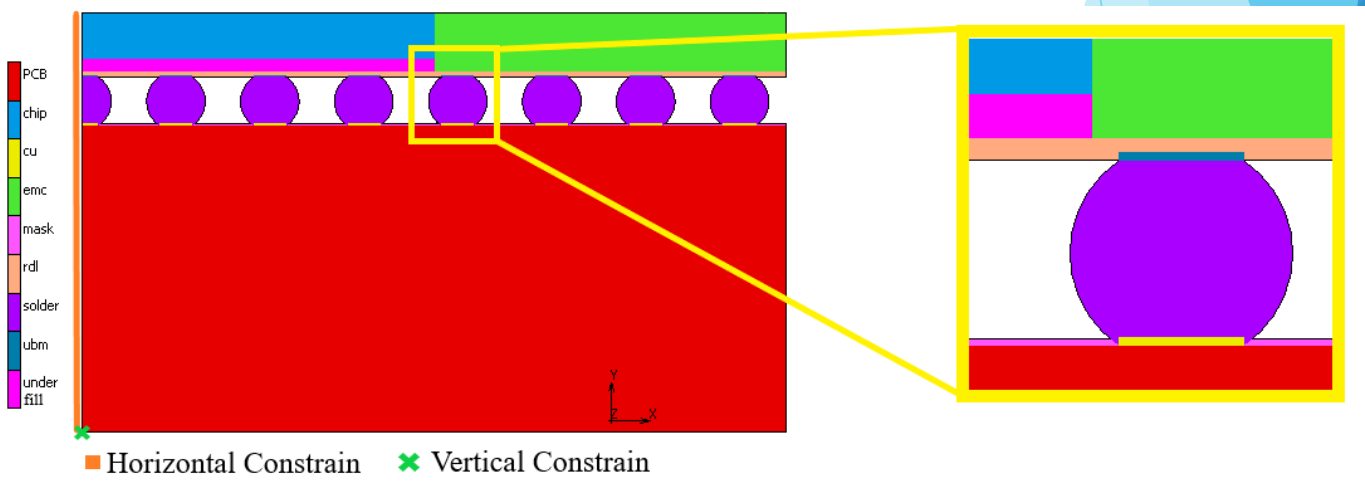
Most relevant conclusion

Since Alam, Basit and Lall present a significant similitude of curves with a substantial range of time-steps, it is advisable to use the set of viscoplastic parameters that takes the shortest time (Basit) for simulation purposes.



Total Equivalent of Creeps Strain at critical location.

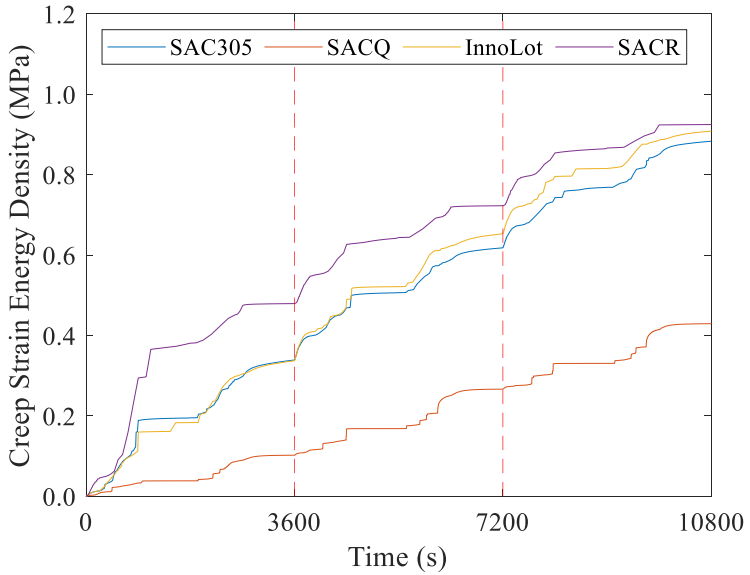
2-D finite element model of an FO-WLP package.



Results - previous semesters (2/3)

Most relevant conclusion

- Doped SAC solders are more advantageous than SAC305 solder in terms of a working lifetime, as the simulation results agreed with similar experimental comparisons.
- The qualitative results suggest that SACQ has a significant advantage in the operational lifetime compared to SACR, InnoLot, and SAC305



Creep Strain Energy Density Comparison.

Approximation of the Average of Creep Strain Energy Density (MPa).

CSED	SAC305	SACQ	InnoLot	SACR
Cycle 2	0.617905	0.266476	0.653259	0.722654
Cycle 3	0.883068	0.429206	0.908353	0.924602
ΔWav	0.265163	0.162730	0.255094	0.201948

Results - previous semesters (3/3)

Publications

SACI 2021
IEEE 15th International Symposium on
Applied Computational Intelligence and Informatics
May 2021 | Timisoara, Romania

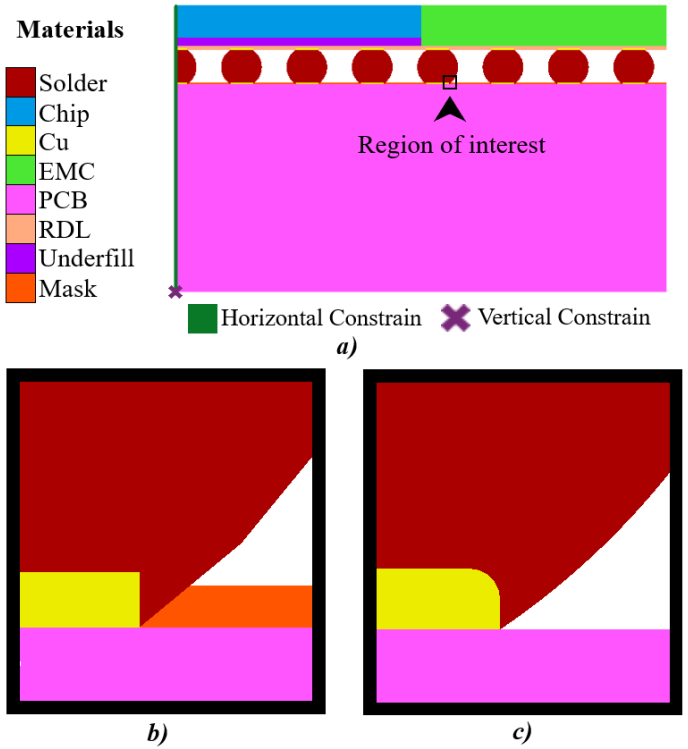
Sensitivity of the structural behavior of SAC305 interconnects on the variations of creep parameters

MSE 2021
10th INTERNATIONAL CONFERENCE
ON MANUFACTURING SCIENCE AND EDUCATION
June 2021 | Sibiu, Romania

Solder joint reliability based on creep strain energy density for SAC305 and doped SAC solders

Results - current semester (1/2)

Creep and Reliability Prediction of a Fan-Out WLP Influenced by the Visco-Plastic Properties of the Solder



The modelled section: *a)* Materials description and boundary conditions, *b)* Augmented view of the squared Cu pad profile, and *c)* Augmented view of the rounded Cu pad profile.

Case	Material	Edge Shape		Case	Material	Edge Shape	
		Sq.	Ro.			Sq.	Ro.
SAC305 Authors Comparison				**Doped SAC Solders**			
01	Alam	×		07	SACQ	×	
02	Basit	×		08	SACR	×	
03	Herkommer	×		09	InnoLot	×	
04	Janz	×		**Edge shape comparison purposes**			
05	Lall	×		10	Basit		×
06	Mysore	×		11	SACQ		×

Results - current semester (2/2)

Effect of the bond pad geometry

T. Equivalent of Creep Strain Variation

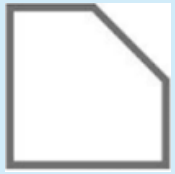
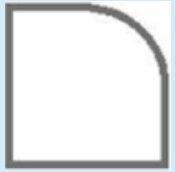
	SAC305	SACQ	variation
Squared	0.883068	0.429206	51.40%
Rounded	0.242973	0.078260	67.79%
variation	72.49%	81.77%	

Strain Energy Density Variation

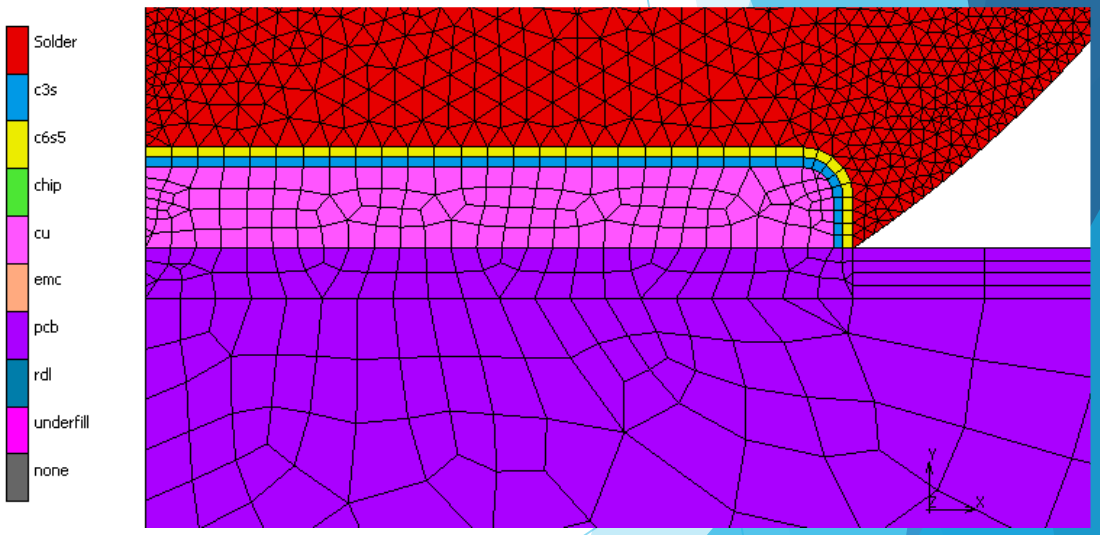
	SAC305	SACQ	variation
Squared	0.217427	0.277605	21.68%
Rounded	0.082941	0.109619	24.34%
variation	61.85%	60.51%	

Future work

Effect of inter-metallic compound and bond shape on strain: a comparison.

	Corner Geometry		
IMC	 Edge	 Chamfer	 Fillet
With	IP	TBD	IP
Without	Completed	TBD	Completed

IP = In progress; TBD = To be designed



Thanks for your kind attention

Questions?