Understanding Warpage Behavior on Different Handling Platforms of FOWLP

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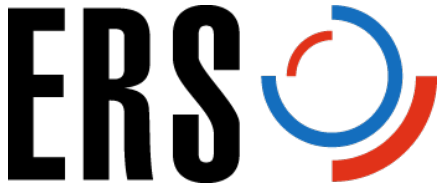
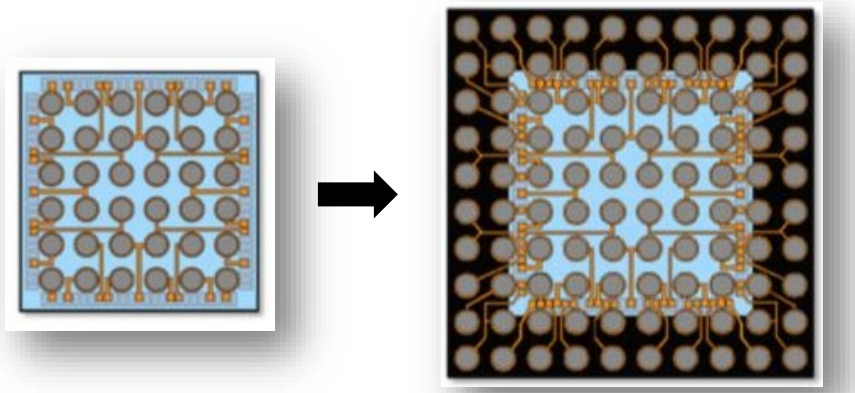


Contents of the Presentation

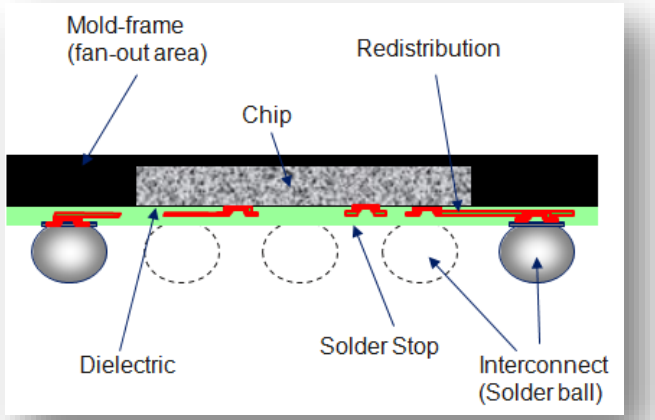
- What is Fanout
- Warpage in Fanout
- Issues in the Production
- Test Set-up and Result
- Conclusion

What is Fanout

- **Fan-out** is a type of advanced chip packaging where the redistribution layer (RDL) are routed outside the surface area of the die.
- Several noted advantages are:
  - Good electrical performance
  - Enables high density routing
  - Enables multi die package configuration

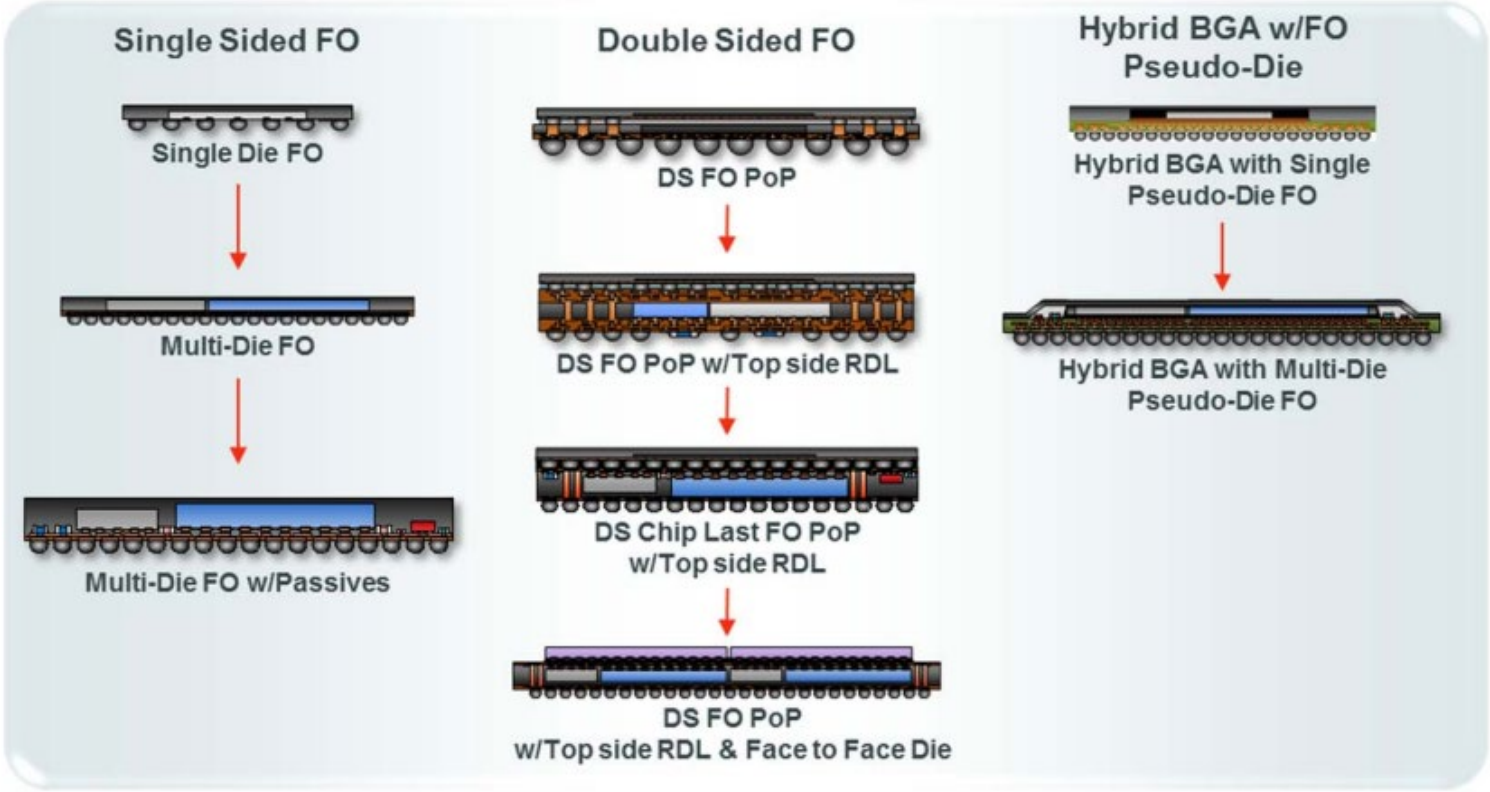


Credits: ASE



Credits: Infineon

What is Fanout



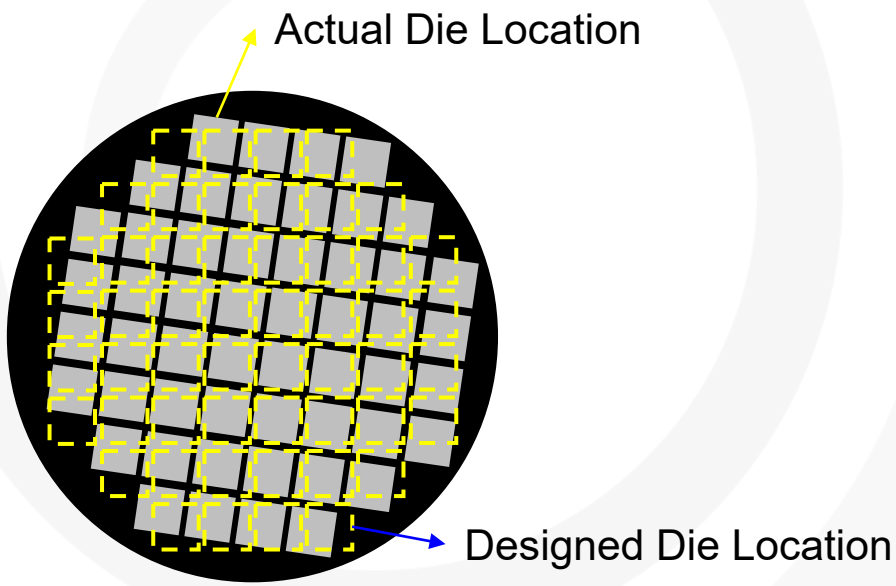
Credits: HIR Annual Symposium 2020

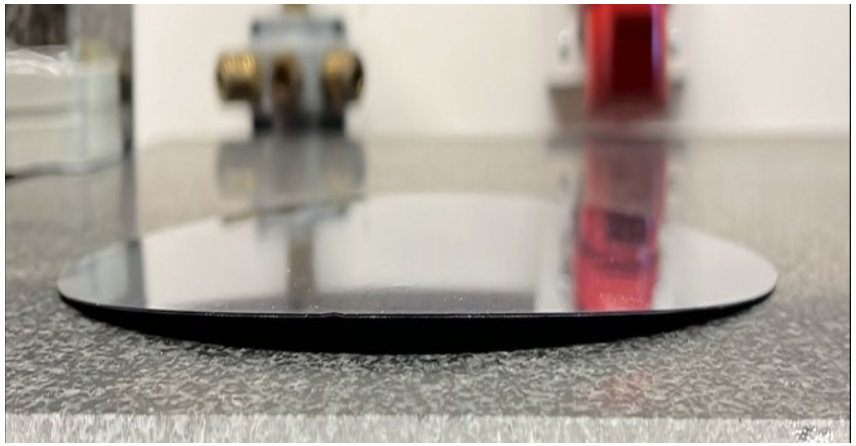
As the complexity increases newer challenges are being encountered.

- Finer line and space features in RDL formation
- 3D through-mold connectivity
- Incorporation of passive components into the fan-out structure
- Die placement speed and accuracy
- Mold compound development
- Thinner fan out packages

What is Fanout

FOWLP, FOPLP

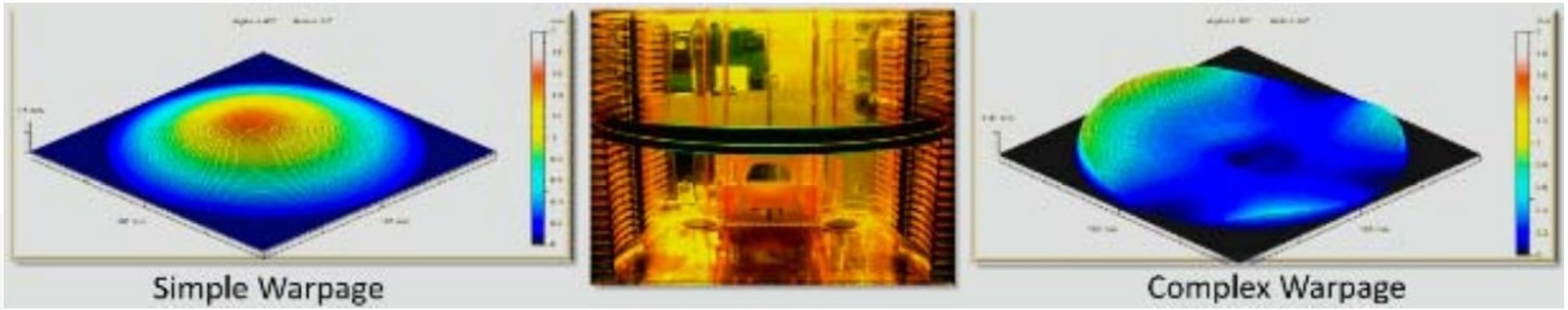




Die Shift is a defect in which the actual die location has an offset from the pre-defined position by a certain distance.

Warpage is the physical deformation encountered by the wafer due to coefficient of thermal expansion (CTE) mismatch between silicon and mold

Warpage in Fanout



Credits: HIR Annual Symposium 2021; J. Hunt ASE

Process and Yield Impact

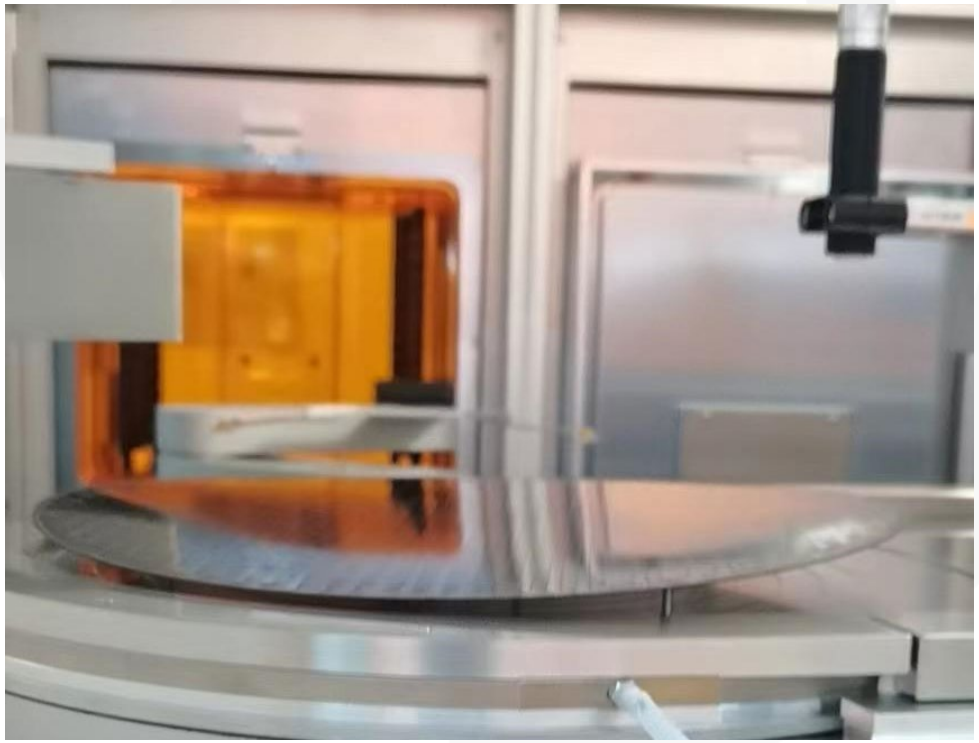
- Via Formation
- RDL and UBM Formation
- Soldering and Balling
- Package Singulation

Production and Equipment Impact

- Production Downtime
- Equipment Excursion
- Frequent Handling Design Changes

Issues in the Production

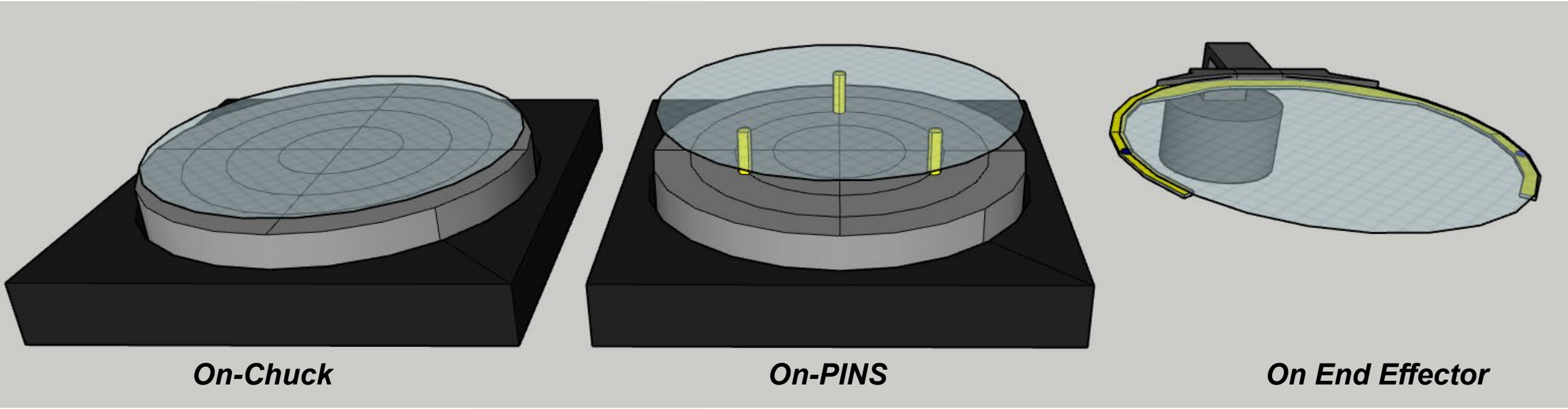
Production and Equipment Impact



- Frequent machine alarm requiring operator intervention
  - Vacuum failure on chuck
  - Robot handling failure
  - Wafer alignment failure
  - Wafer sagging on pins

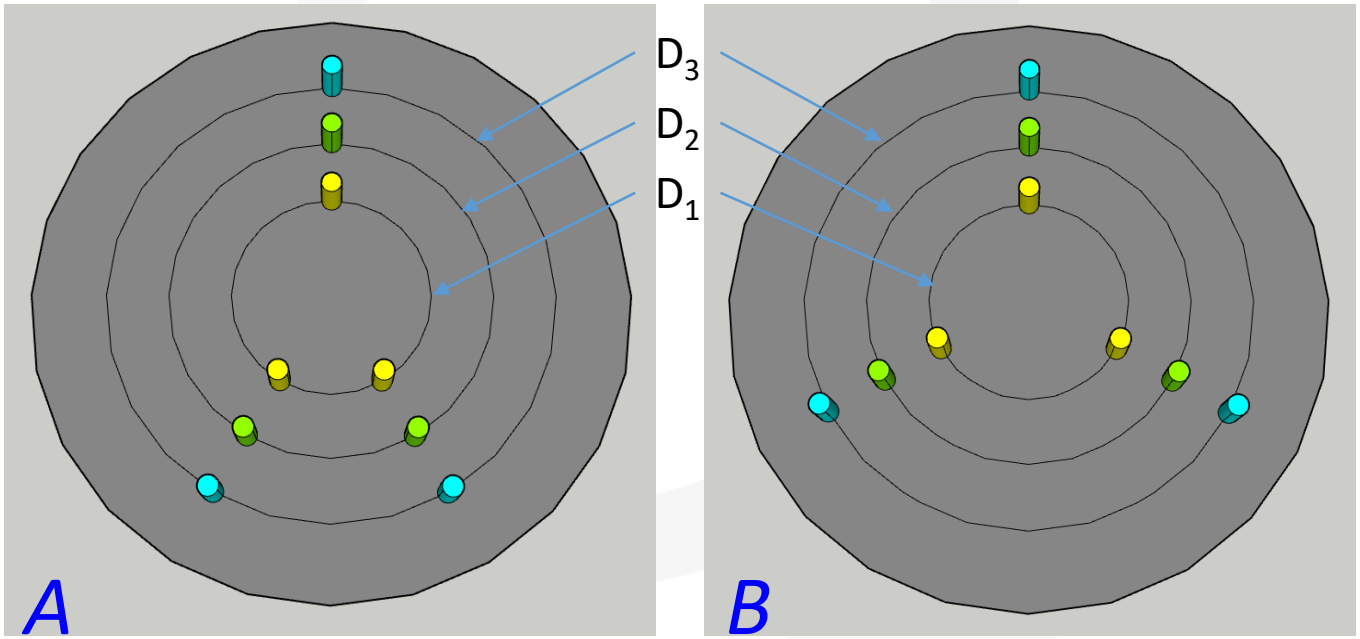
Test Set-up and Motivation

Understand how the warp wafers behave in different design of pins as well as end-effector suctions.



On-Chuck ***On-PINS*** ***On End Effector***

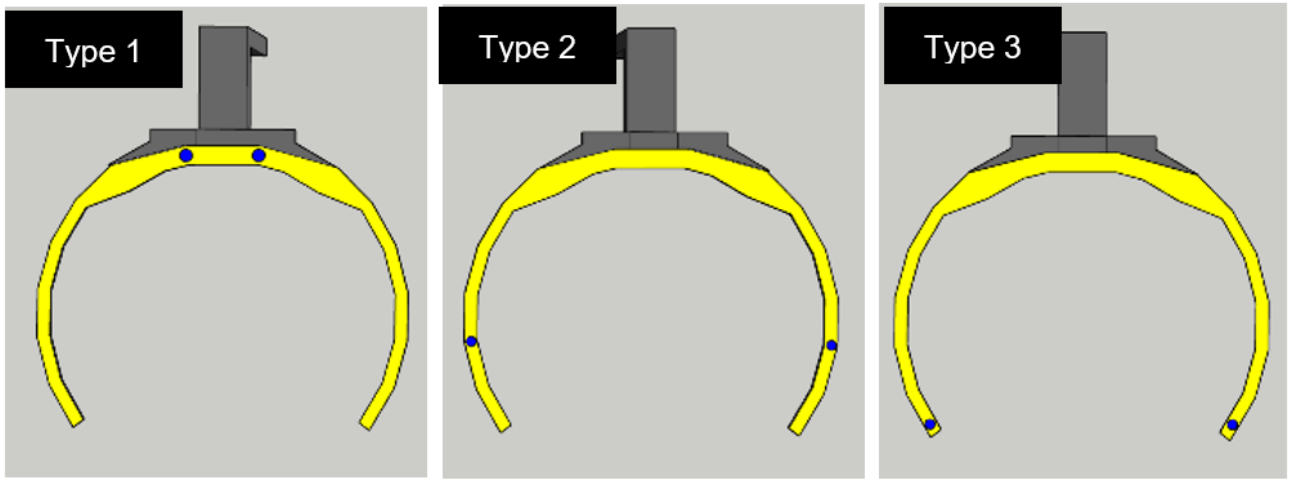
Test Set-up



On-pins:

The pins will be positioned in **three different diameters** arranged both ***symmetrical*** (equal distance between each other) and ***asymmetrical*** (two bottom pins are closer)

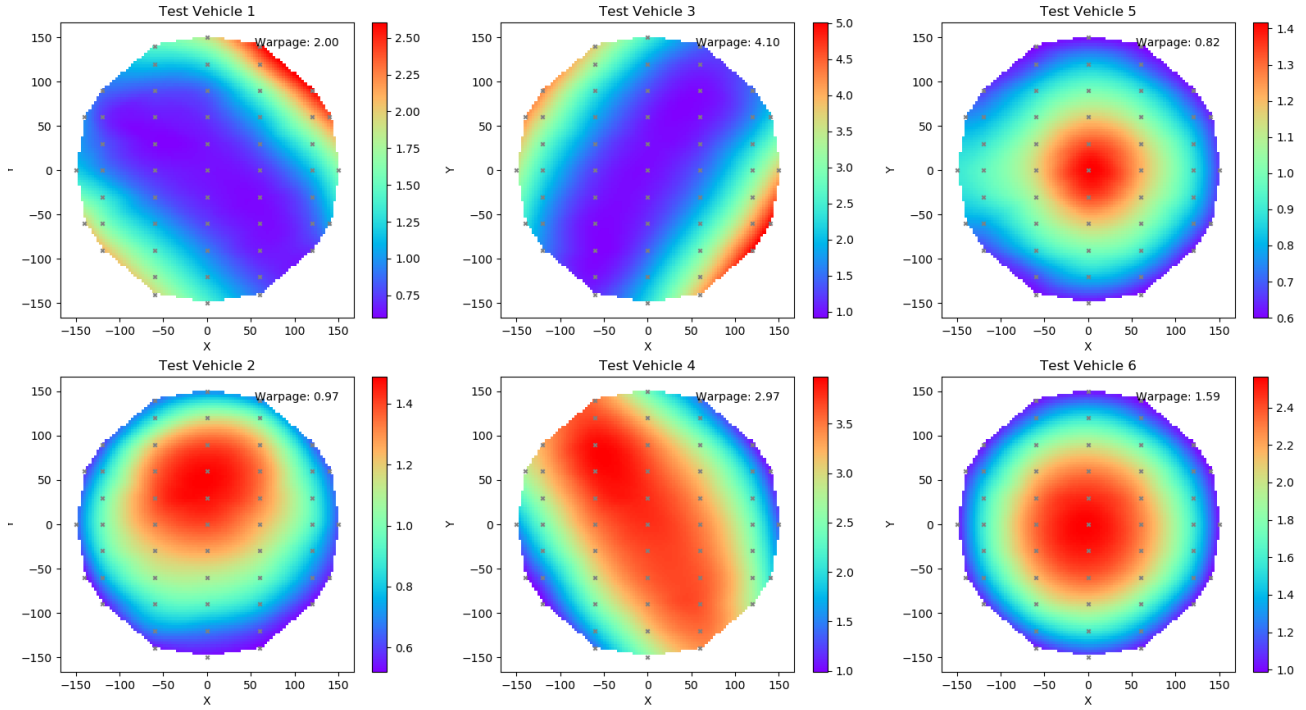
Test Set-up and Motivation



On- end effector:

The suction cups will be placed in three different positions; base , middle and tip which corresponds to Type 1, 2, and 3 respectively.

Test Vehicles

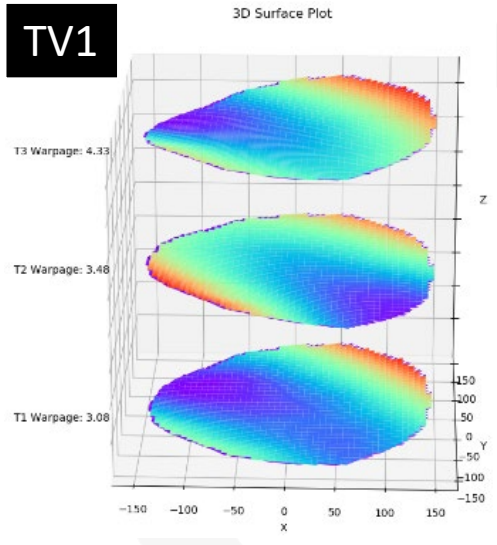


TV	Thickness	Shape	Mold Volume	Warpage
1	0.45mm	Smile	>80%	2.00mm
2	0.45mm	Frown/ Concave	>80%	0.97mm
3	0.90mm	Smile	>80%	4.10mm
4	0.90mm	Frown	>80%	2.97mm
5	0.55mm	Concave	>60%	0.82mm
6	0.90mm	Concave	>60%	1.59mm

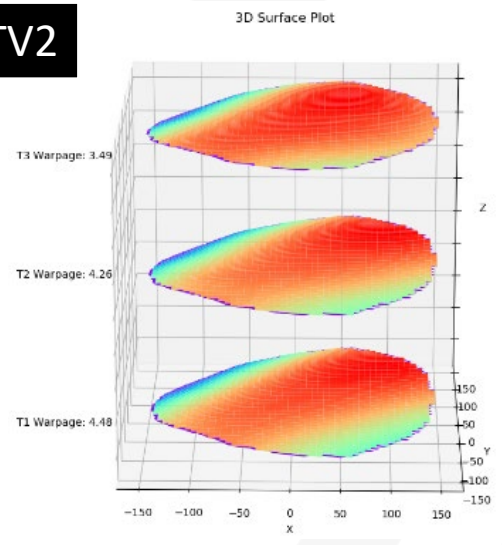
Note: All samples uses one type of mold compound, different material may have different result. The wafers are tested post debonding process.

Warpage Response: On-Pins

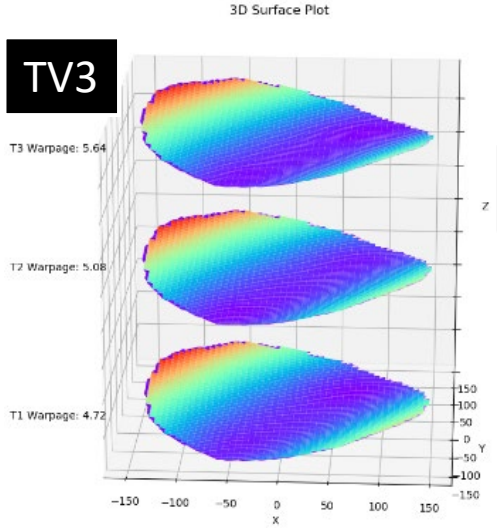
TV1



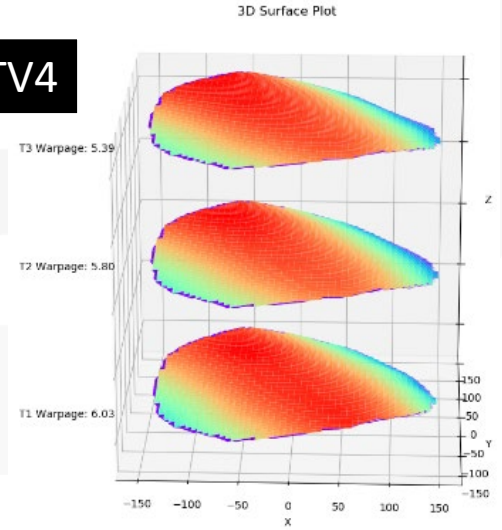
TV2



TV3

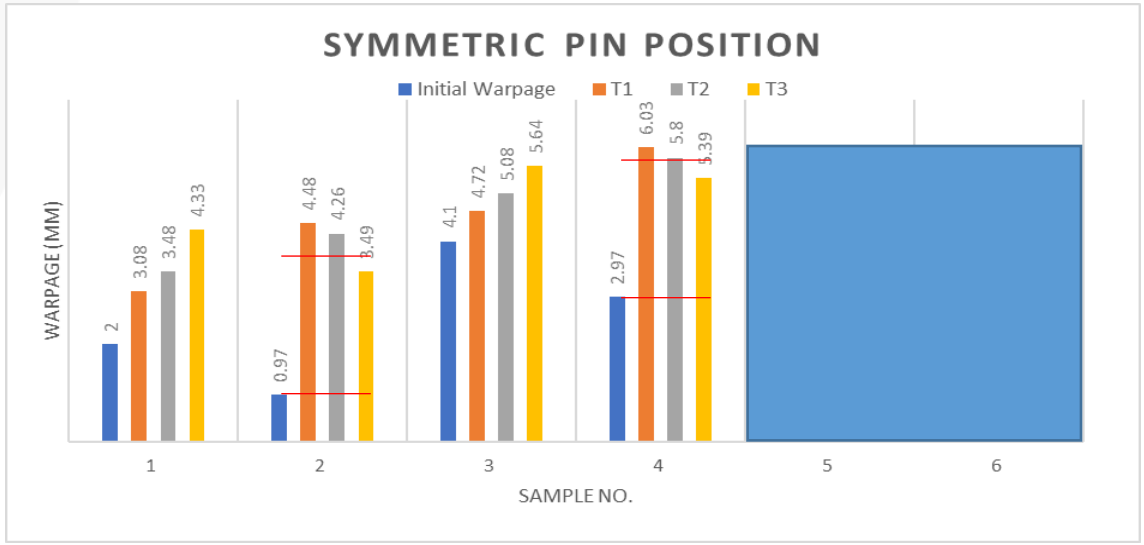


TV4



Symmetric Pin Placement

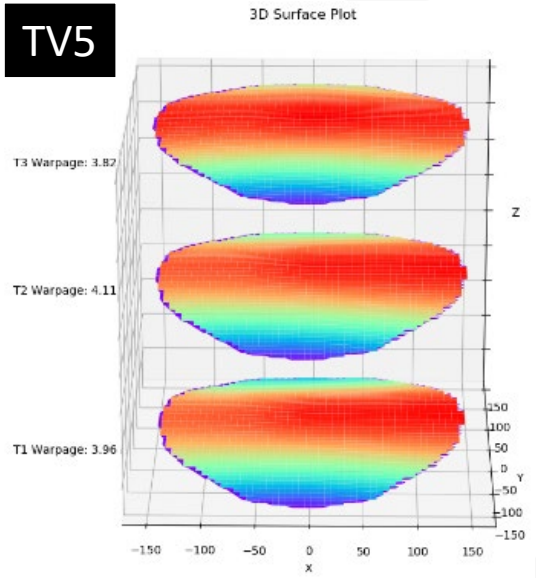
Sample		1	2	3	4
Initial Warpage		2.00	0.97	4.10	2.97
Symmetric	T3	4.33	3.49	5.64	5.39
	T2	3.48	4.26	5.08	5.80
	T1	3.08	4.48	4.72	6.03



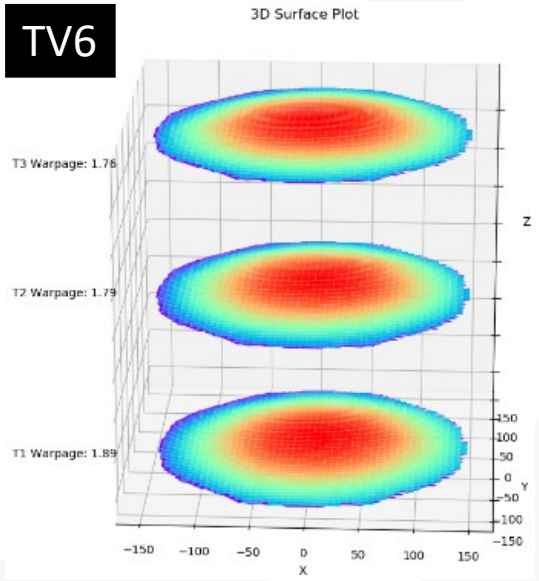
Warpage Response: On-Pins

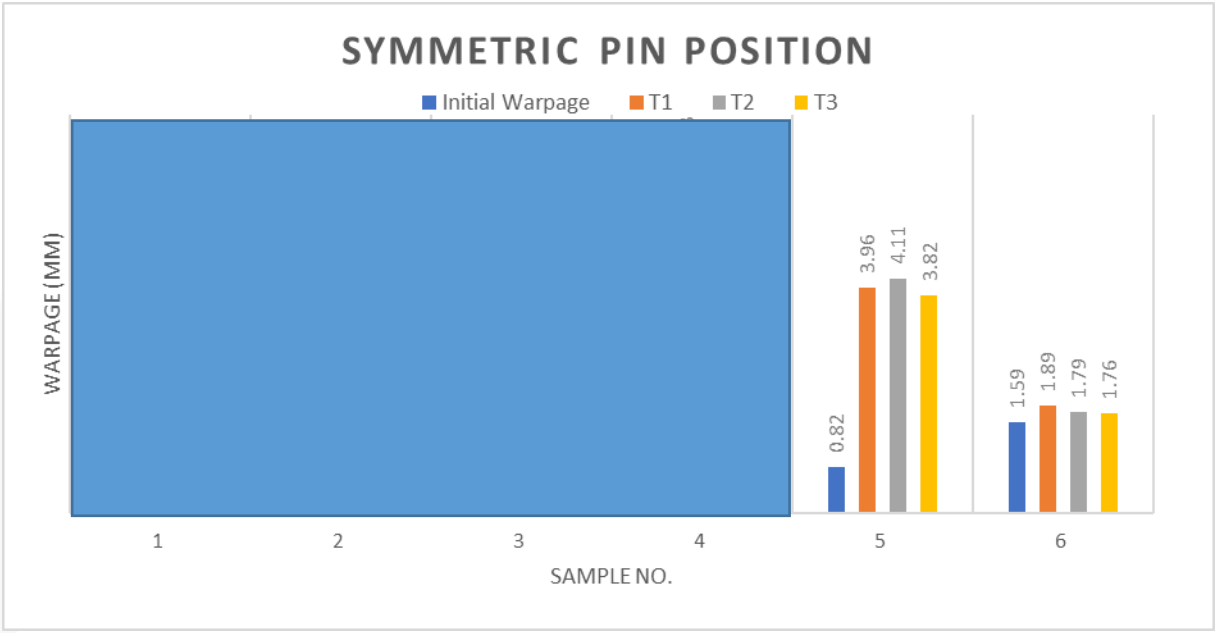
Symmetric Pin Placement

TV5



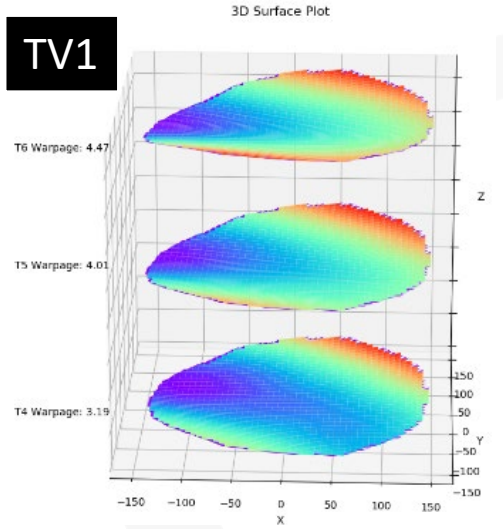
TV6





Warpage Response: On-Pins

TV1



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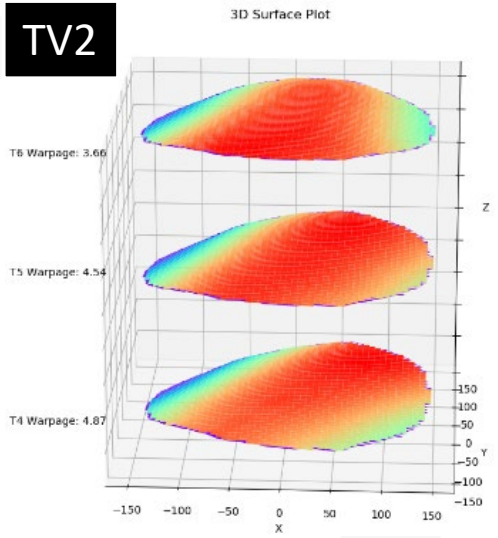
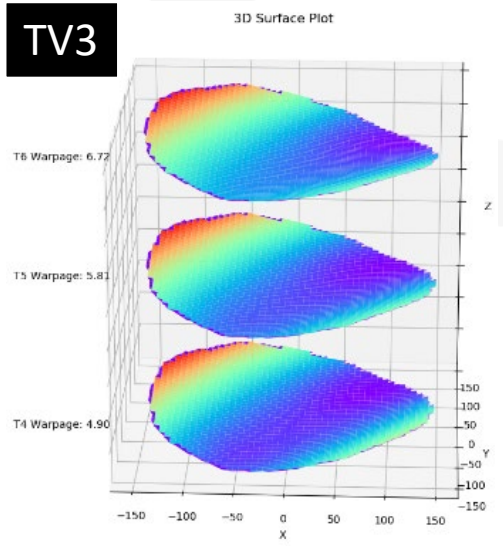


TV3



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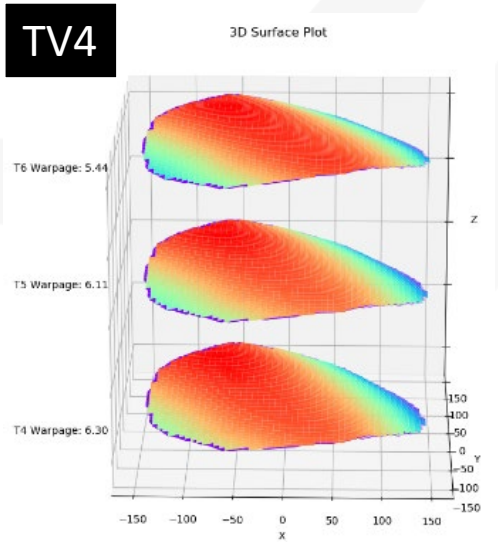
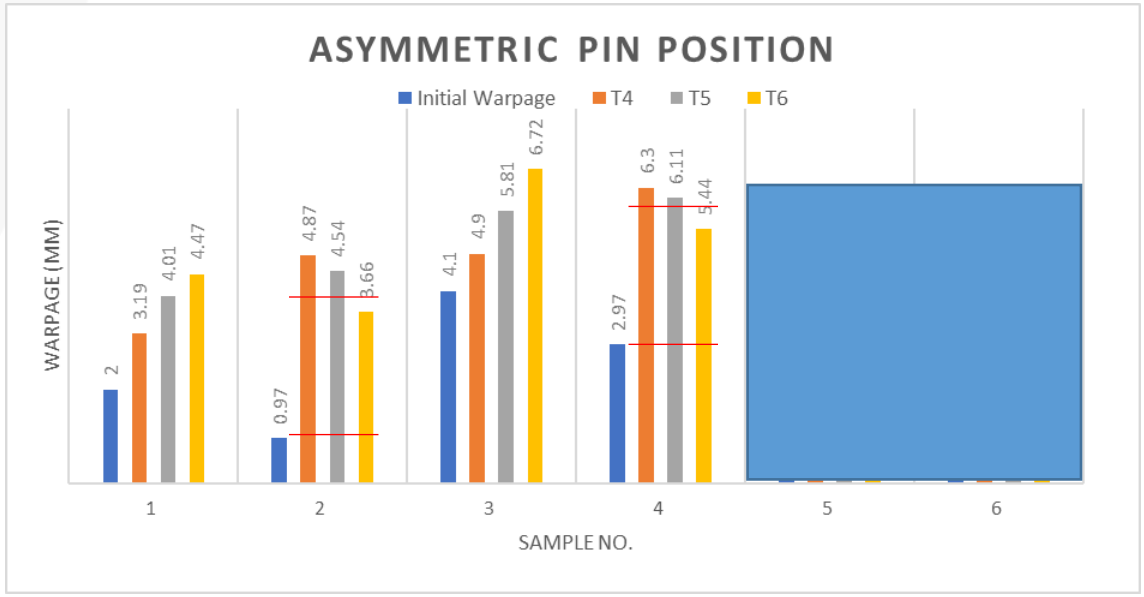


Asymmetric Pin Placement

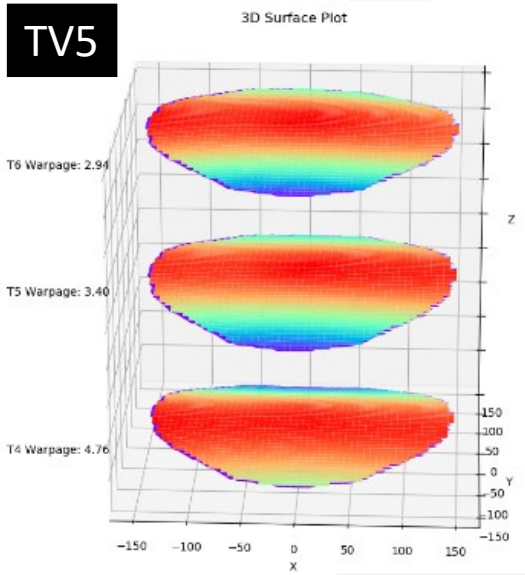
Sample		1	2	3	4
Initial Warpage		2.00	0.97	4.10	2.97
Asymmetric	T6	4.47	3.66	6.72	5.44
	T5	4.01	4.54	5.81	6.11
	T4	3.19	4.87	4.9	6.3



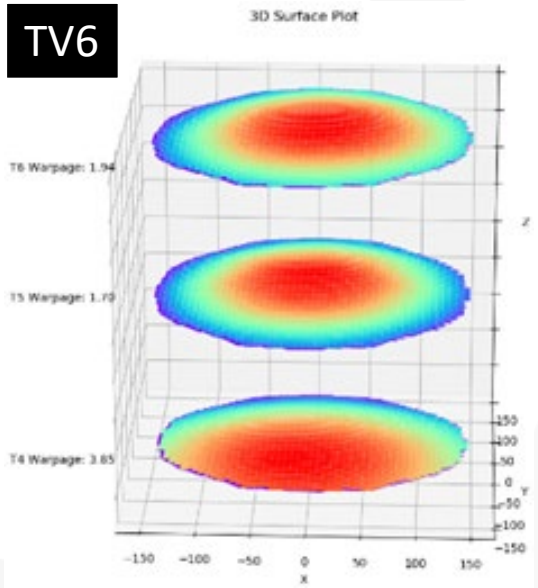
Warpage Response: On-Pins

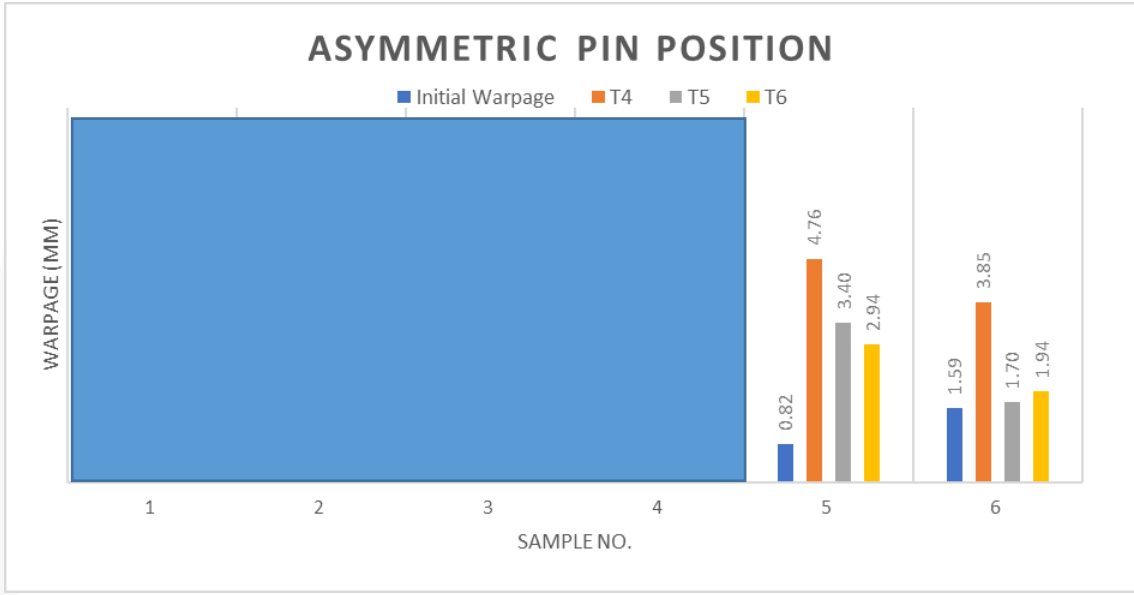
Asymmetric Pin Placement

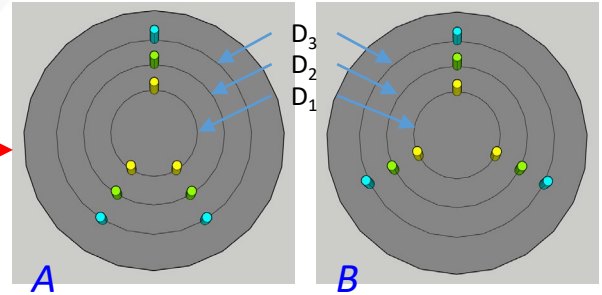
TV5



TV6

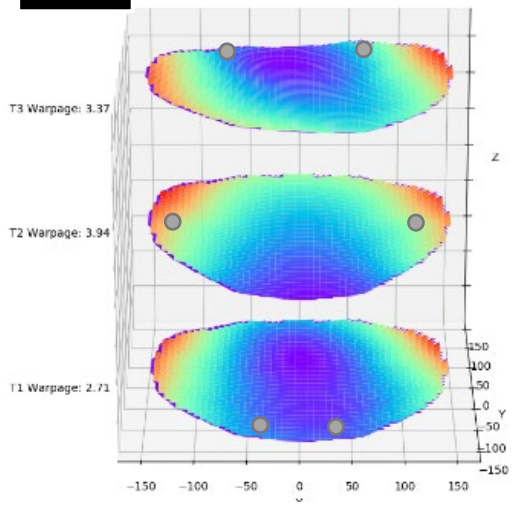






Warpage Response: On-End Effector

TV1



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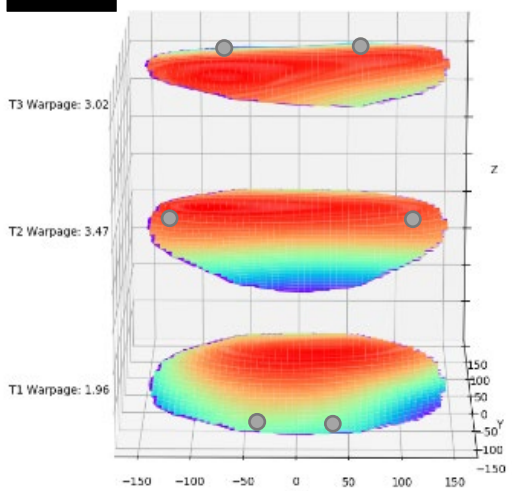

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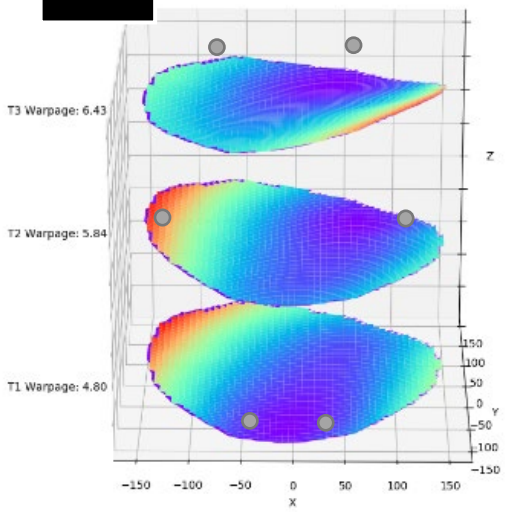

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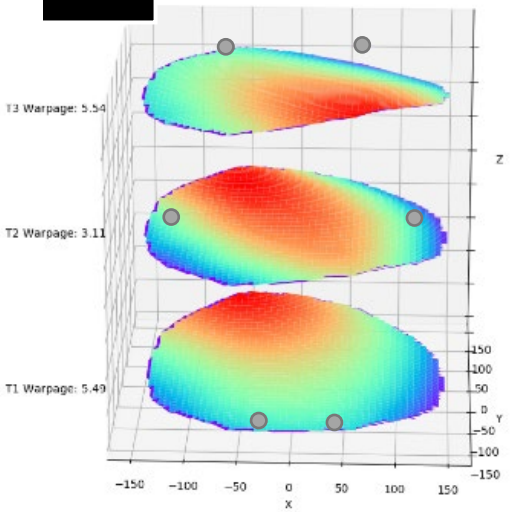
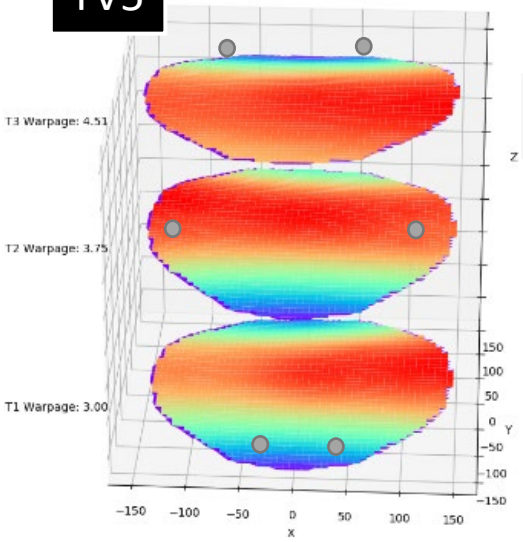
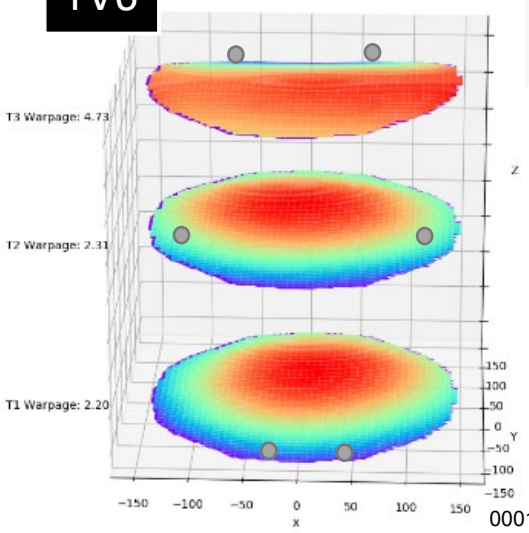


TV5



TV6



TV	Initial Warpage	Type 1	Type 2	Type 3
1	2.00mm	2.71	3.94	3.37
2	0.97mm	1.96	3.47	3.02
3	4.10mm	4.80	5.84	6.43
4	2.97mm	5.49	3.11	5.54
5	*0.82mm*	*3.04*	*3.75*	*4.51*
6	*1.59mm*	*2.20*	*2.31*	*4.73*

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Observations and Conclusion

Addressing warpage issues in the production line can be expensive and time consuming. Changing the end-effector and pin positioning are some of the common ways to mitigate warpage effects in the production and enable high volume manufacturing.

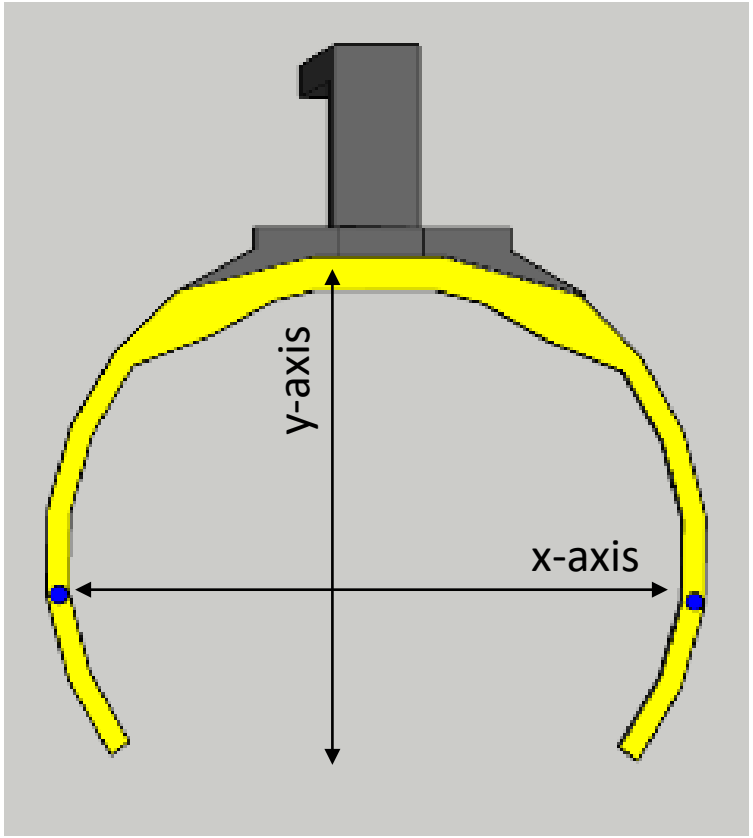
On pins:

- Pins cause warpage regardless of initial attributes.
- Smiling wafers show increasing warpage with distance, frowning wafers show opposite, but have higher change (~3mm).
- Lower mold density wafers hold shape better, no warpage change with pin distance. Asymmetric pin positions cause is assumed to cause weight imbalance and resulted to higher warpage.

Observations and Conclusion

On end-effector:

- Thin wafers show a slight correlation between increasing warpage with increasing suction cup distance on the x-axis.
- Thick wafers show no correlation and resist vacuum.
- Wafers with low mold density show increasing warpage with increasing suction cup distance from the base of the tip of the end effector on the y-axis.



Thank You!