A LOW-T_g BONDING MATERIAL FOR USE WITH WAFER-LEVEL SYSTEM-IN-PACKAGE (WLSIP) AND FAN-OUT WAFER-LEVEL PACKAGING (FOWLP) PROCESSES

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brewer science

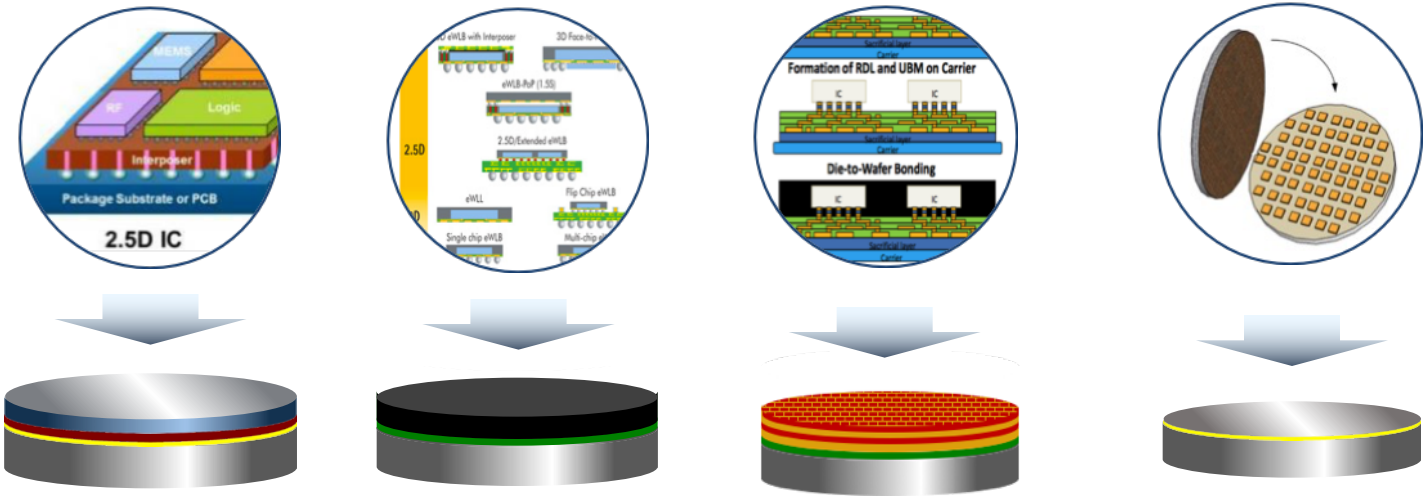
OUTLINE

- Introduction to Wafer-Level Packaging (WLP)
- Material Overview
- Experimental Work
- Conclusions
- Acknowledgements

INTRODUCTION TO WLP

TEMPORARY BOND AND DEBOND IN WLP

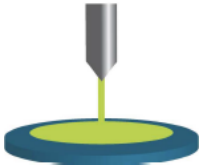
Temporary bond and debond technologies have been widely developed and adopted in many technologies for wafer-level packaging (WLP)



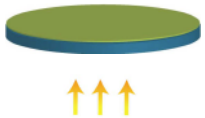
Thin wafer | EMC wafer | RDL build | Substrate transfer

TEMPORARY BOND/DEBOND (TB/DB) GENERAL PROCESS FLOW

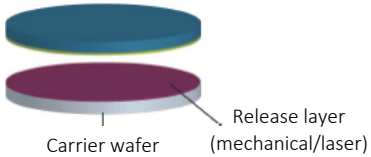
Spin coat Brewer Science bonding material



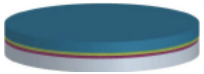
Bake bonding material



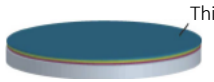
Flip device wafer



Bond device wafer to carrier

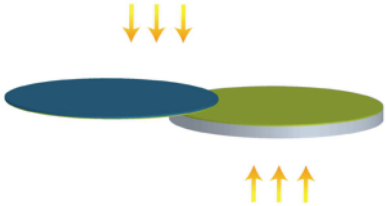


Backside processing

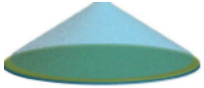


CHEMICAL

THERMAL SLIDE



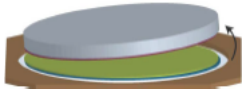
Clean



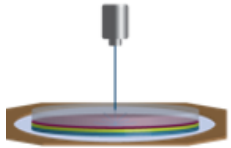
Mount on film frame

Mount on film frame

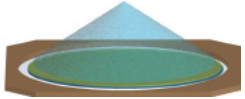
MECHANICAL



LASER

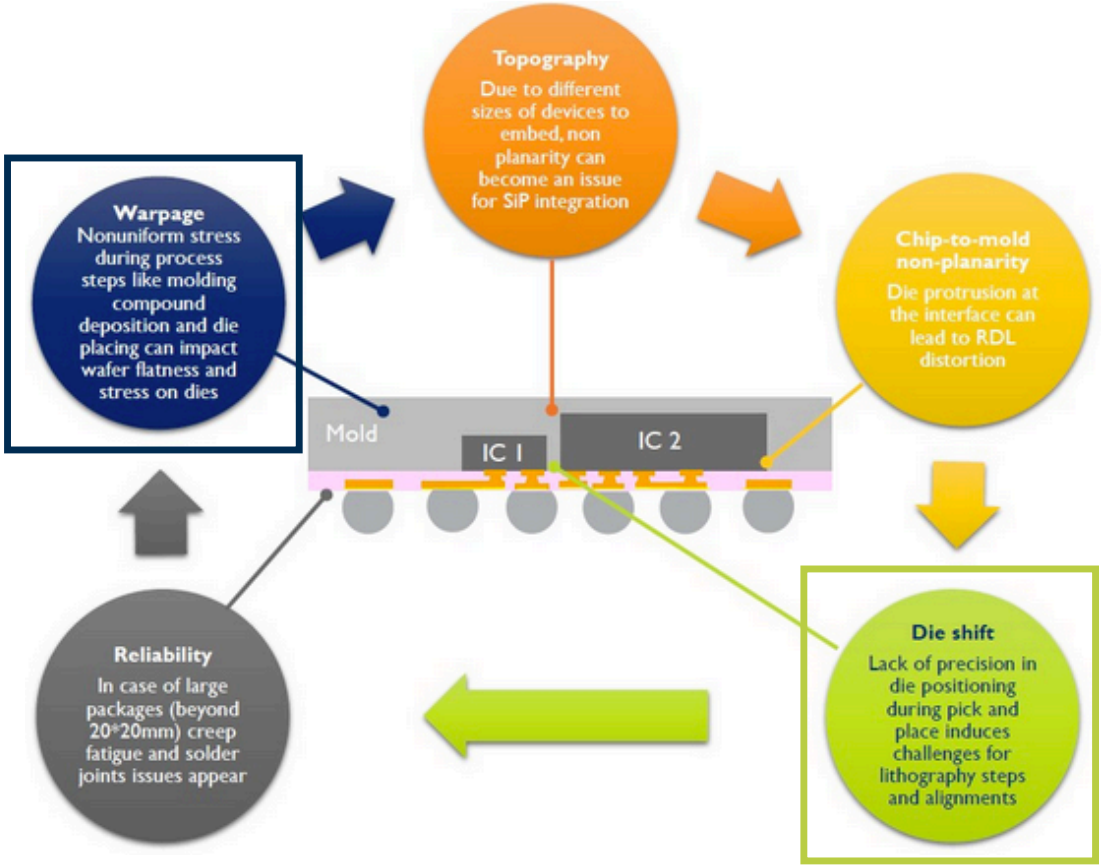


Clean



Processed device wafer on film frame

FOWLP TECHNOLOGY CHALLENGES

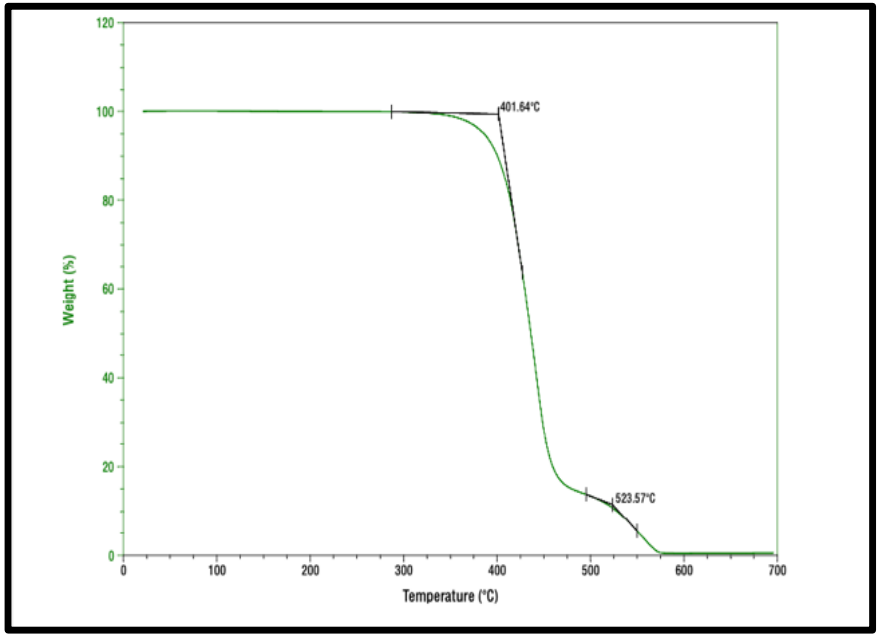


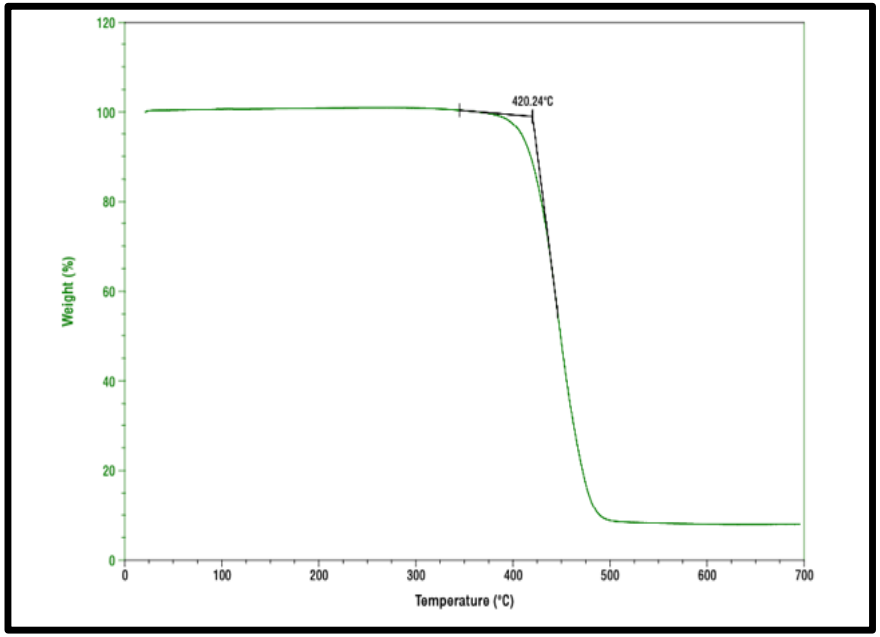
Courtesy of Yole Developpement

MATERIAL OVERVIEW

THERMAL DEGRADATION DATA IN AIR AND NITROGEN

	T_g (°C)	2% Weight loss T_d in Air (°C)	2% Weight loss T_d in Nitrogen (°C)
Material A	40	365	397

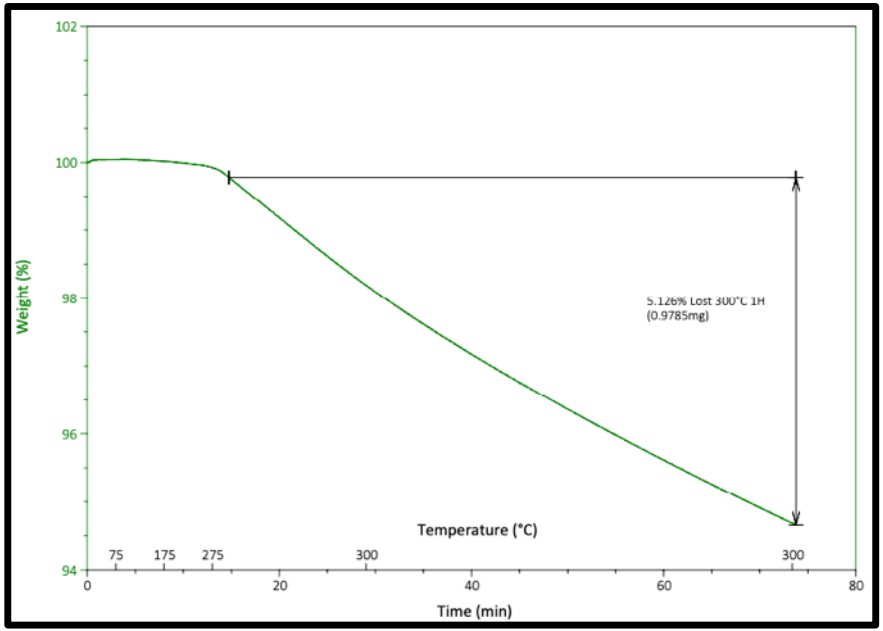




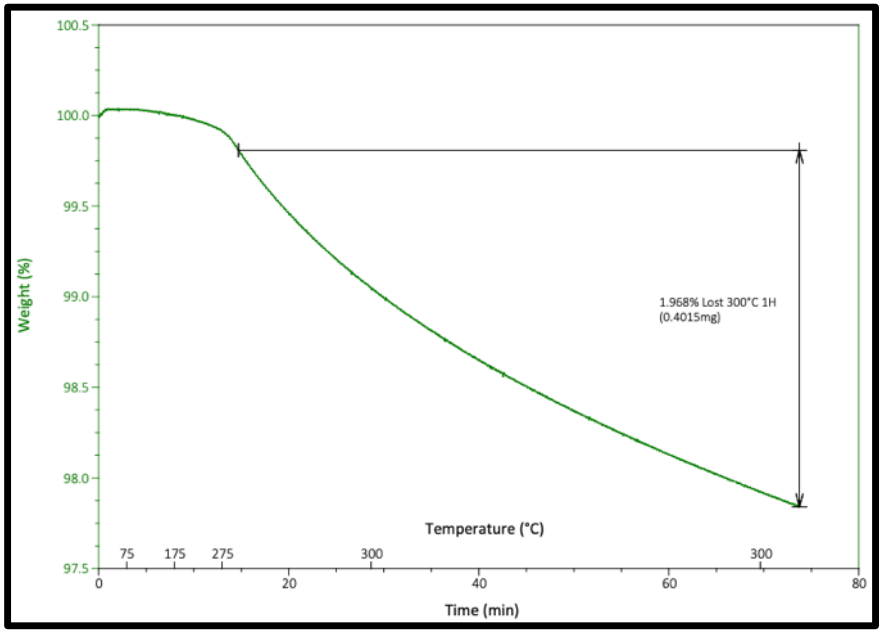
Material A shows great thermal stability for a low-T_g thermoplastic material

MATERIAL A THERMAL STABILITY

Material A shows good thermal stability at 300°C in both air and nitrogen

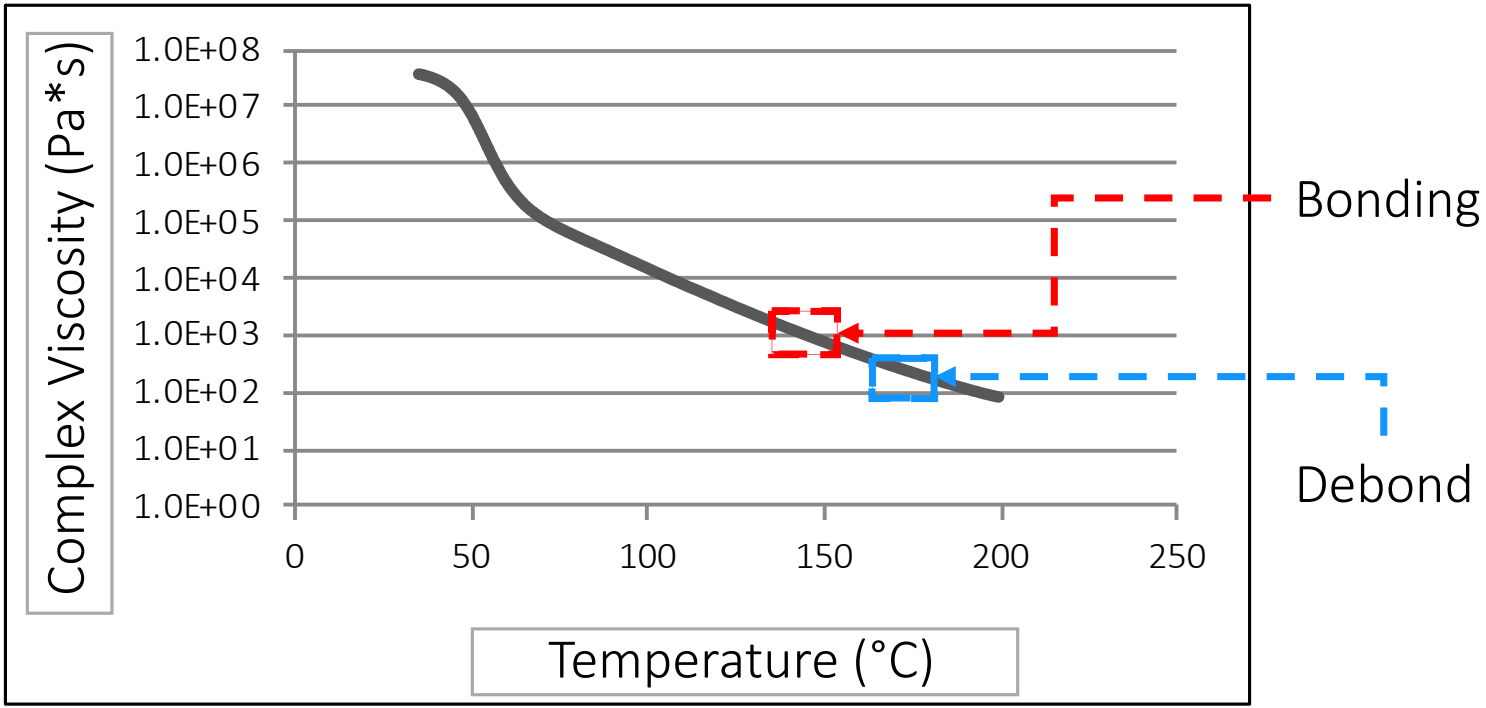


~ 5% loss in Air



~ 2% loss in Nitrogen

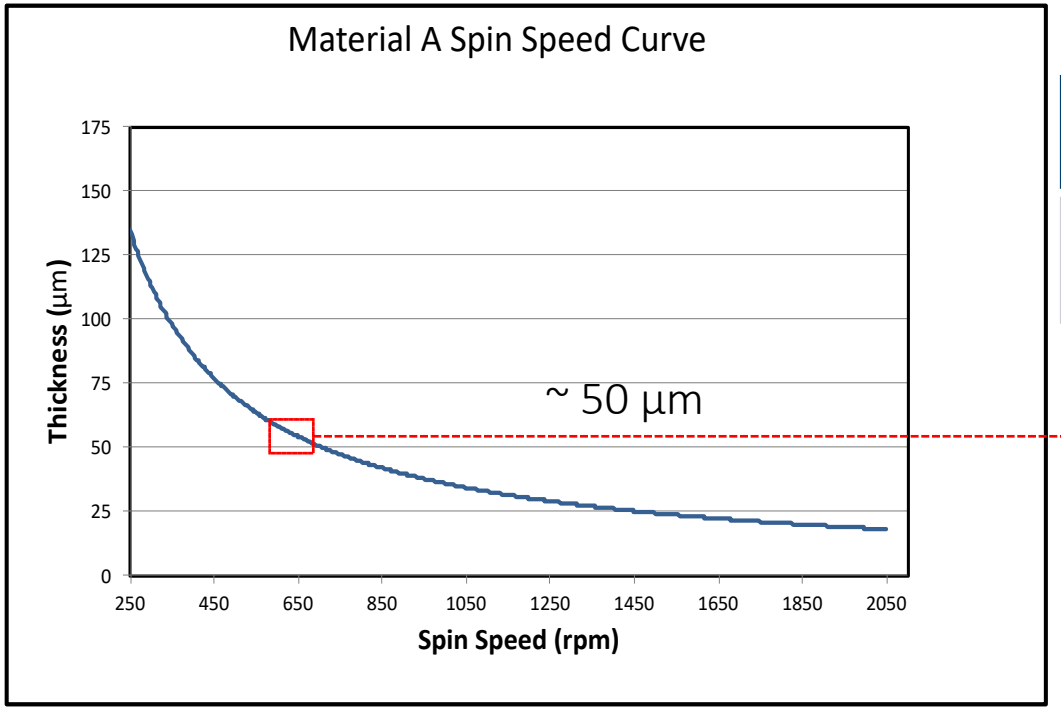
RHEOLOGY OF MATERIAL A



- Bond at temperatures above 140°C
- Thermal slide debonded at 170°C and above

EXPERIMENTAL WORK

COATING AND BONDING CONDITIONS FOR MATERIAL A

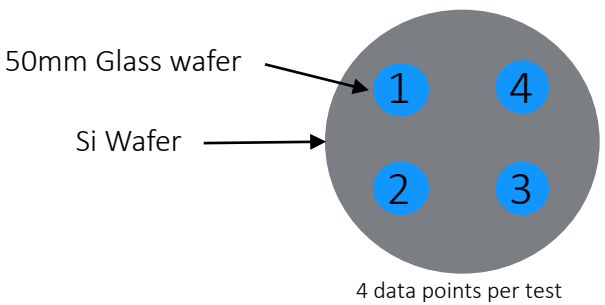


Material A Solution has a wide range of thicknesses that can be obtained

Spin Conditions	Bake Conditions	Bond Conditions*
600 rpm 500 rpm/s 60 s	80°C, 3 min 120°C, 3 min 180°C, 6 min	140°C 4500 N 3 min

* Bond conditions for 300-mm wafers

ADHESION AND WARP DATA (SLIDE 1 OF 2)



4 data points per test

PosiTest® ATA adhesion tester conforms to international standards including ASTM D4541/D7234, ISO 4624/16276-1, AS/NZS 1580.408.5 and others

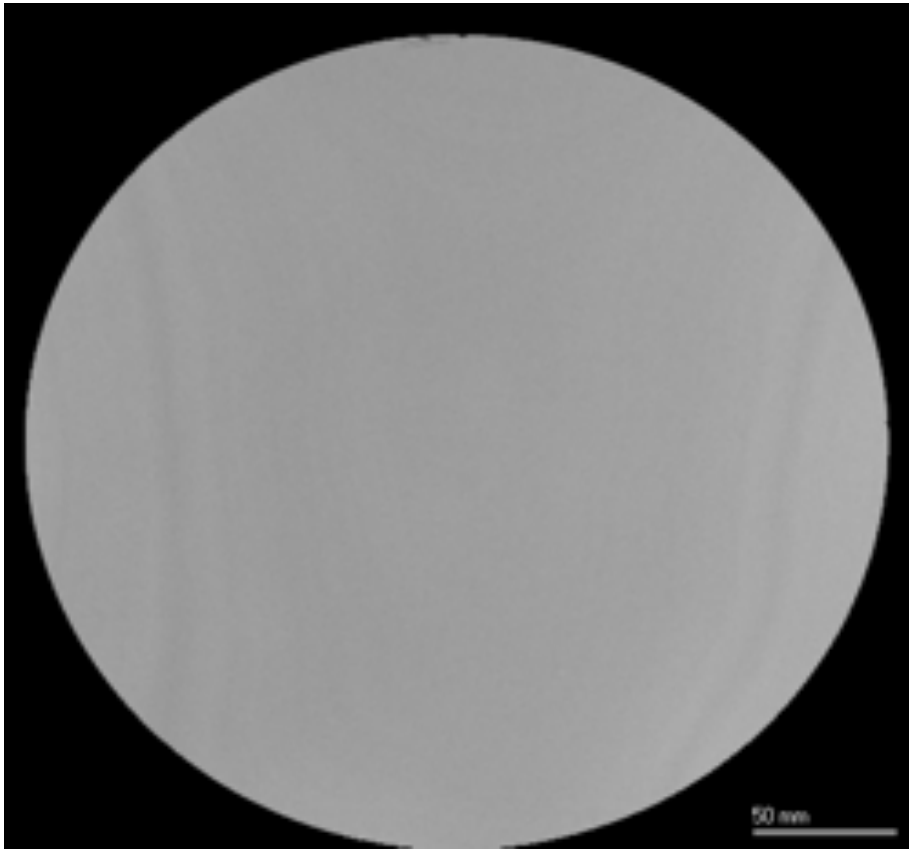
ADHESION AND WARP DATA (SLIDE 2 OF 2)

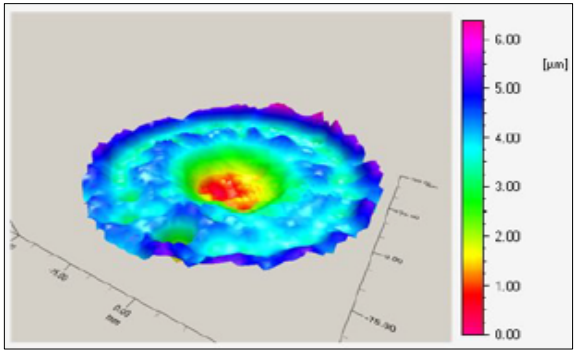
Material	Pre-Coat Warp (µm)	Bonded Warp (µm)	Heat Treated Warp (µm)	Average Stud pull Adhesion on SI
Material A	36.0	49.4	76	> 26
Material B	39.7	150.1	190.4	~ 10

Substrate	Average Adhesion of Material A (psi)
Sapphire	> 30
Eagle XG Glass	> 20
Silicon Oxide	> 32

As a comparison, Material B's average stud pull adhesion is ~ 10 psi (less than half of Material A's adhesion).

BONDING PERFORMANCE OF MATERIAL A

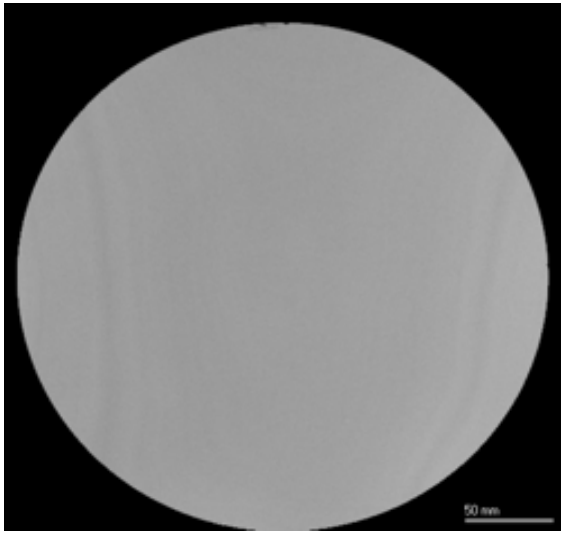




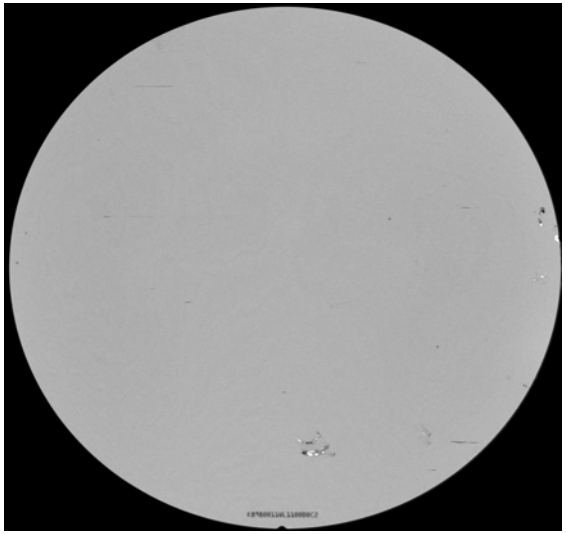
Material Thickness (µm)	TTV (µm)
~ 55	5.3

- The CSAM to the left shows a bonded pair after thermal compression bond with no defects

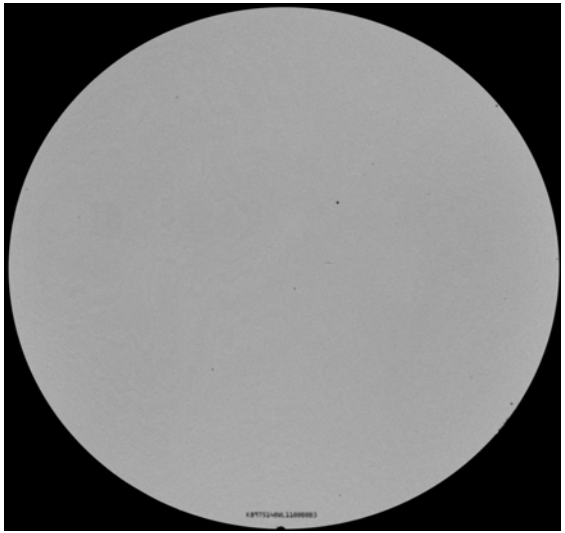
PERFORMANCE OF MATERIAL A AFTER HEAT TREATMENT



Control



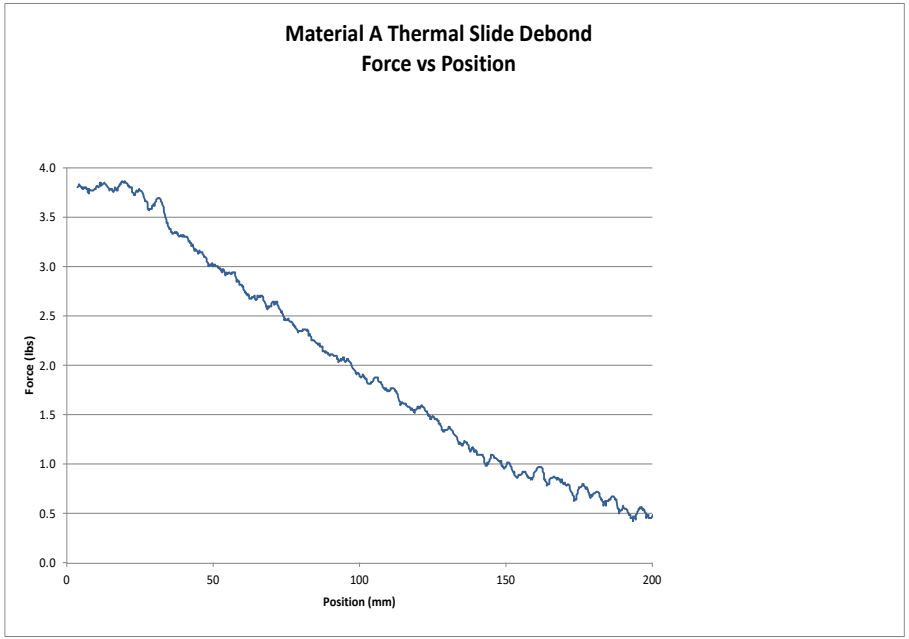
250°C for 1 hour
in Air



300°C for 1 hour
in Air

- The mark on the 250°C pair was there after bond due to a bubble in the film before bonding

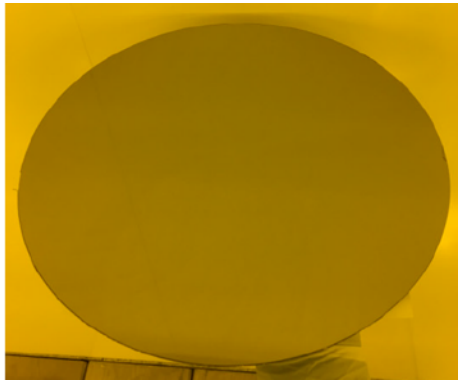
THERMAL SLIDE DEBOND DATA



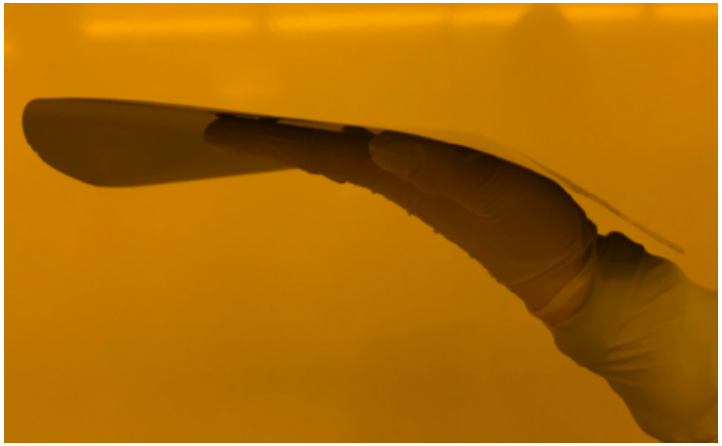
*Unoptimized Thermal Slide Debond

- Material A takes low force to slide debond due to rheology

20 µm thinned wafer still bonded



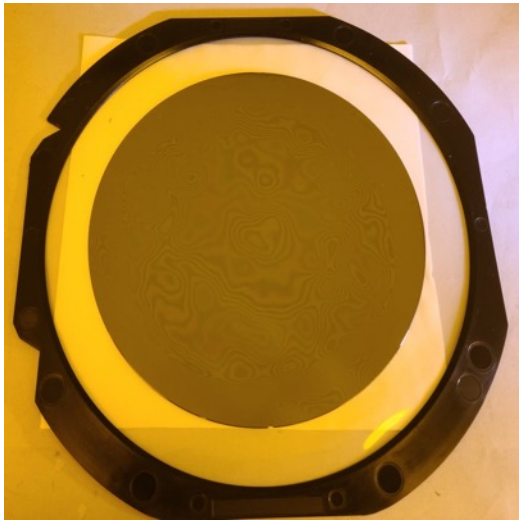
20 µm thinned wafer debonded

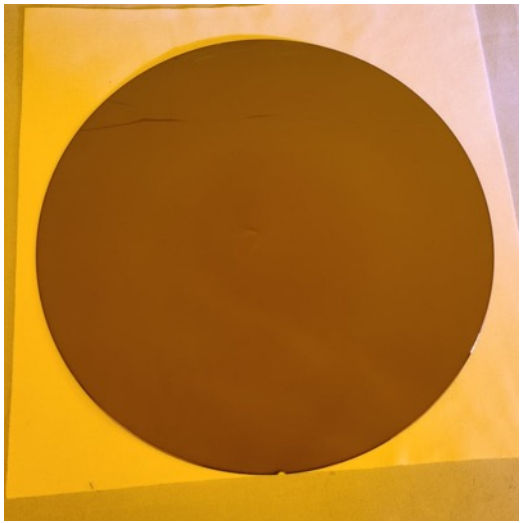


Pictures courtesy of EVG

MECHANICAL DEBOND DATA

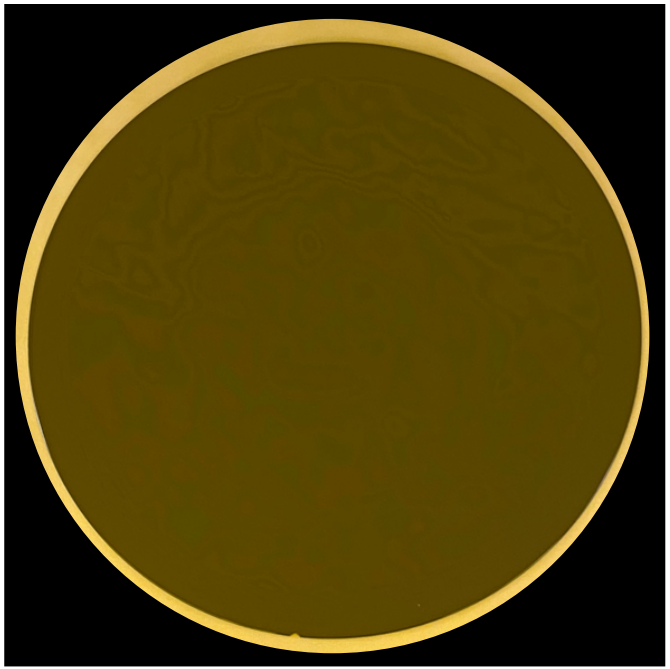
Material A was mechanically debonded with an in-house CEE® mechanical debonder.



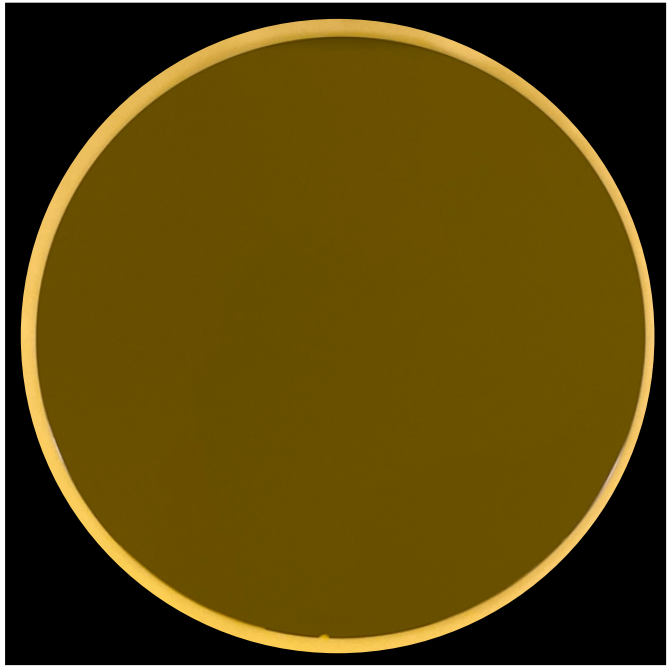


Force required to Debond = 15.5 psi

Material A was clean within 2 minutes with cyclopentanone using a spin coater cleaning process



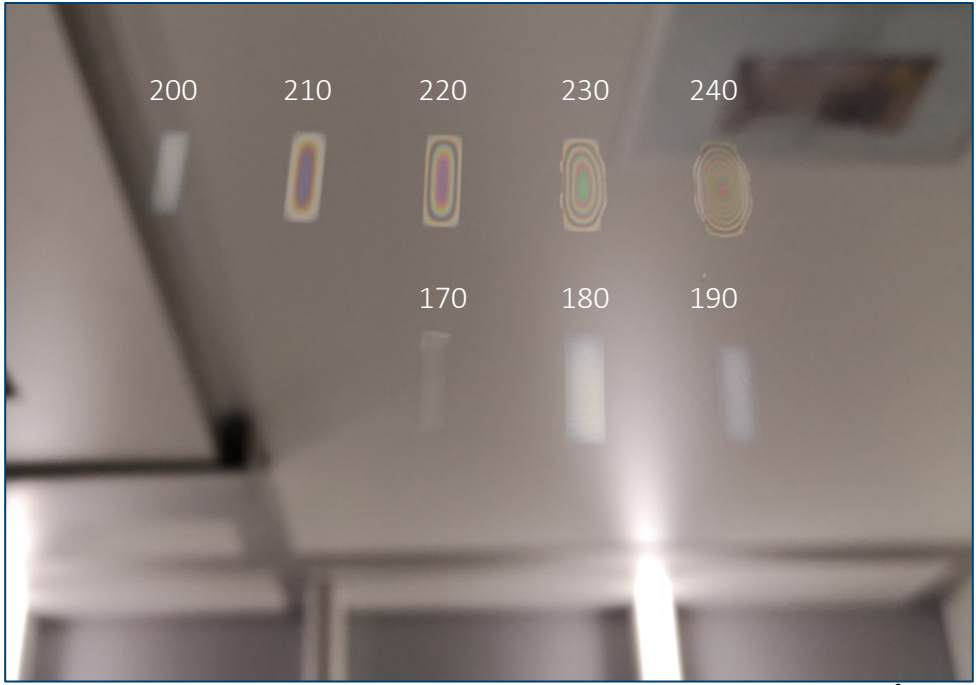
After Coat



After Clean

PRELIMINARY LASER DEBOND DATA

Material A was used with a Brewer Science laser release material. The initial fluence test results show that debond is possible. Future studies will do more optimization.



Courtesy of IMEC

CONCLUSIONS

CONCLUSIONS

- Material Properties
  - Great adhesion versus other materials
  - High thermal stability
  - Low T_g
  - Low warp and bow

- Bond and Debond
  - Low bonding temperature allowing for less thermal stress to be applied
  - Has shown a versatile nature that allows for many different bond stacks and different ways of debonding

ACKNOWLEDGEMENTS

- External
  - EV Group
  - IMEC
- Internal
  - Nathan Parker
  - Seth Molenhour
  - Kim Yess
  - Dongshun Bai
  - Rachel Cartaya
  - Cristina Matos
  - Daojie Dong
  - Analytical Testing Group

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THANK YOU!

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