

MULTIPURPOSE USE OF LASER-SENSITIVE MATERIALS FOR TEMPORARY BONDING AND DEBONDING APPLICATIONS IN WAFER-LEVEL PACKAGING

Luke Prenger, Brewer Science, Inc.

iMAPS Device Packaging Conference

March 3rd, 2020

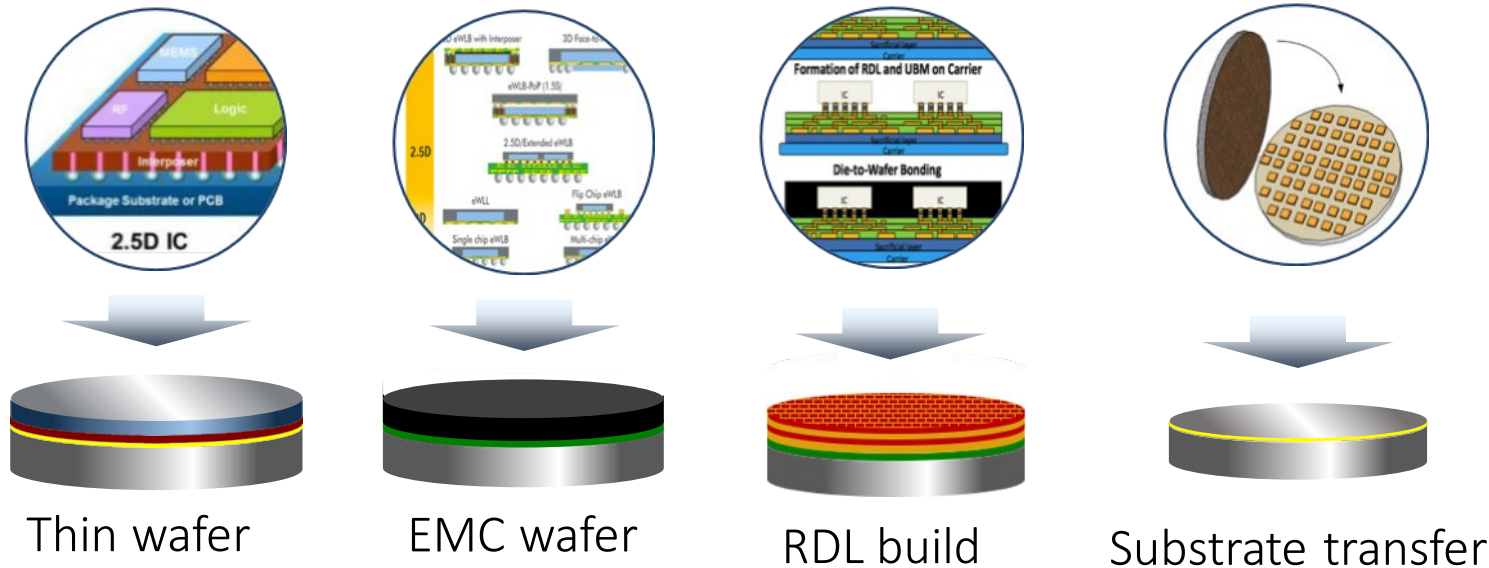
Overview

- Introduction
- Two-Layer Laser Material System
- Single-Layer Thermoplastic Laser Material System
- Single-Layer Thermoset Laser Material System
- Laser Etching and Patterning Laser Material System
- Conclusions

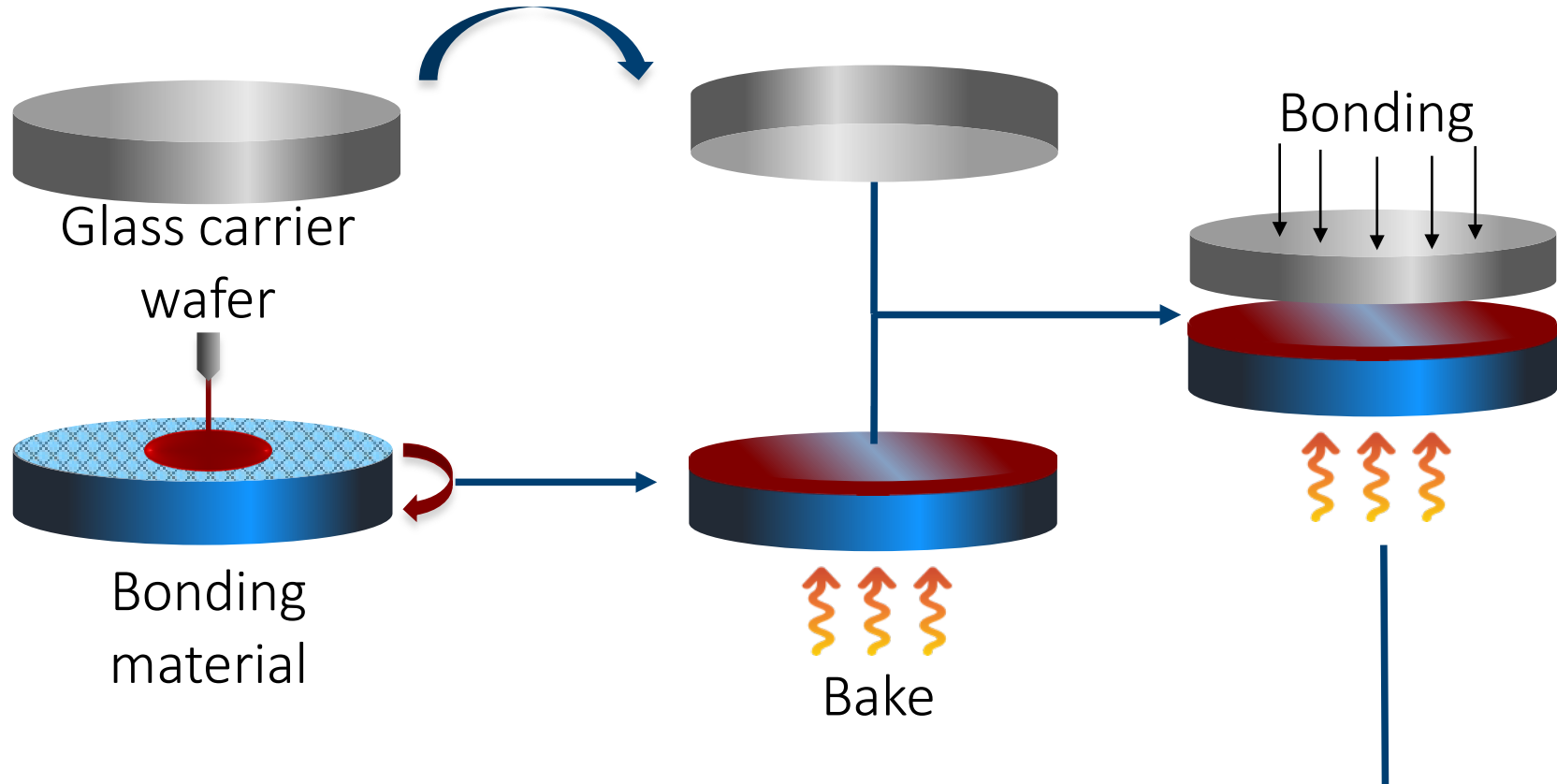
INTRODUCTION

Temporary Bonding Applications

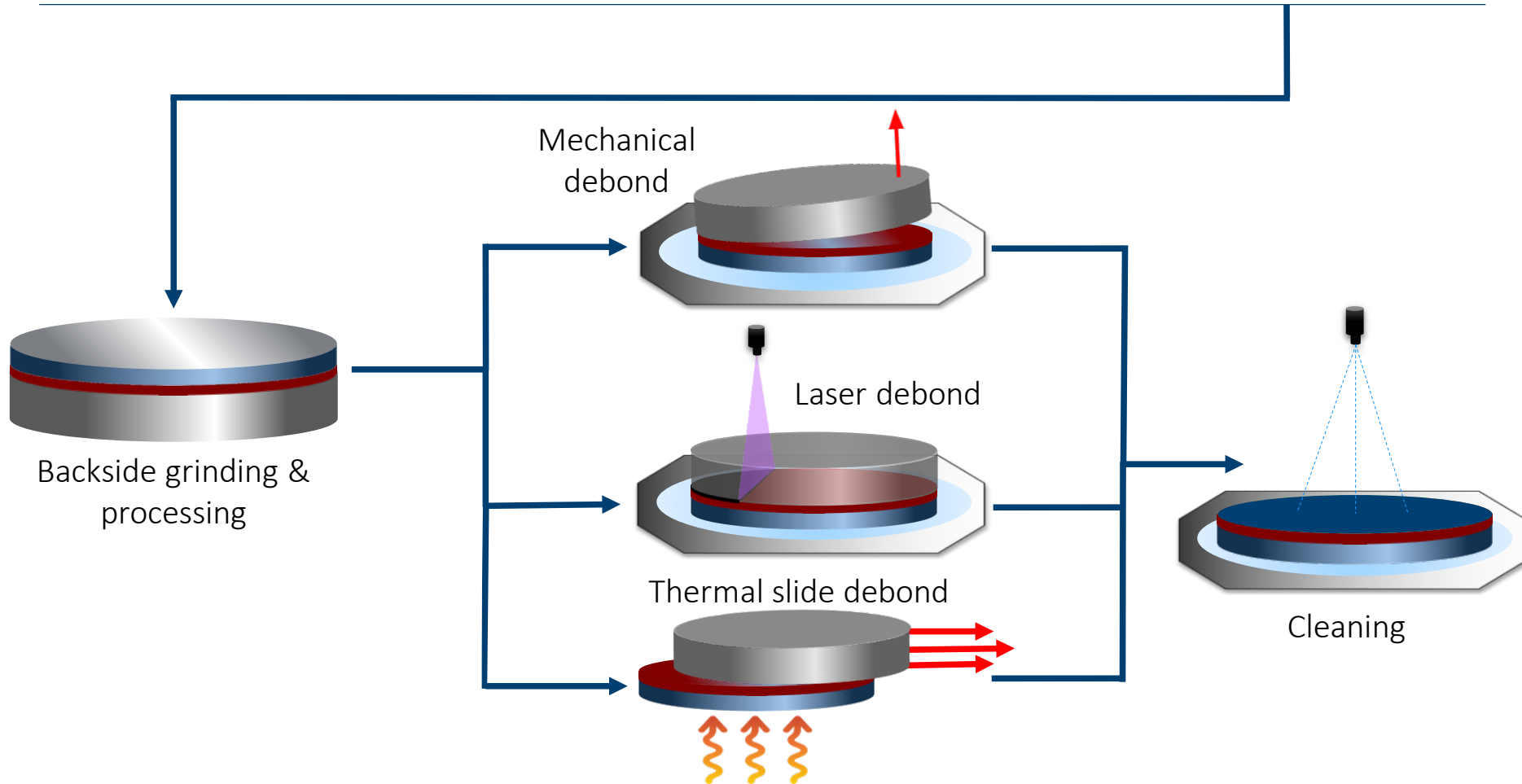
Temporary bond and debond technologies have been widely developed and adapted in many technologies within wafer-level packaging (WLP)



Temporary Bonding and Debonding Process Flow



Temporary Bond and Debond Process Flow

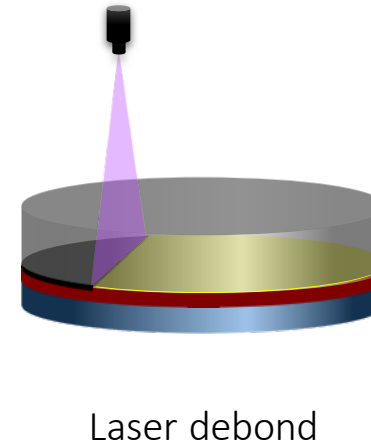
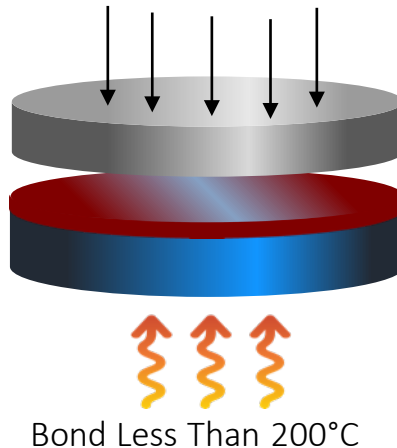
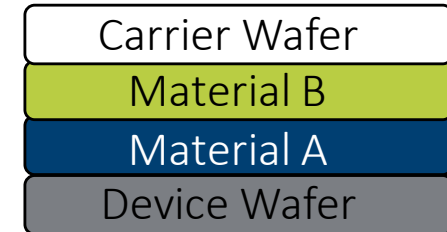


TWO-LAYER SYSTEM

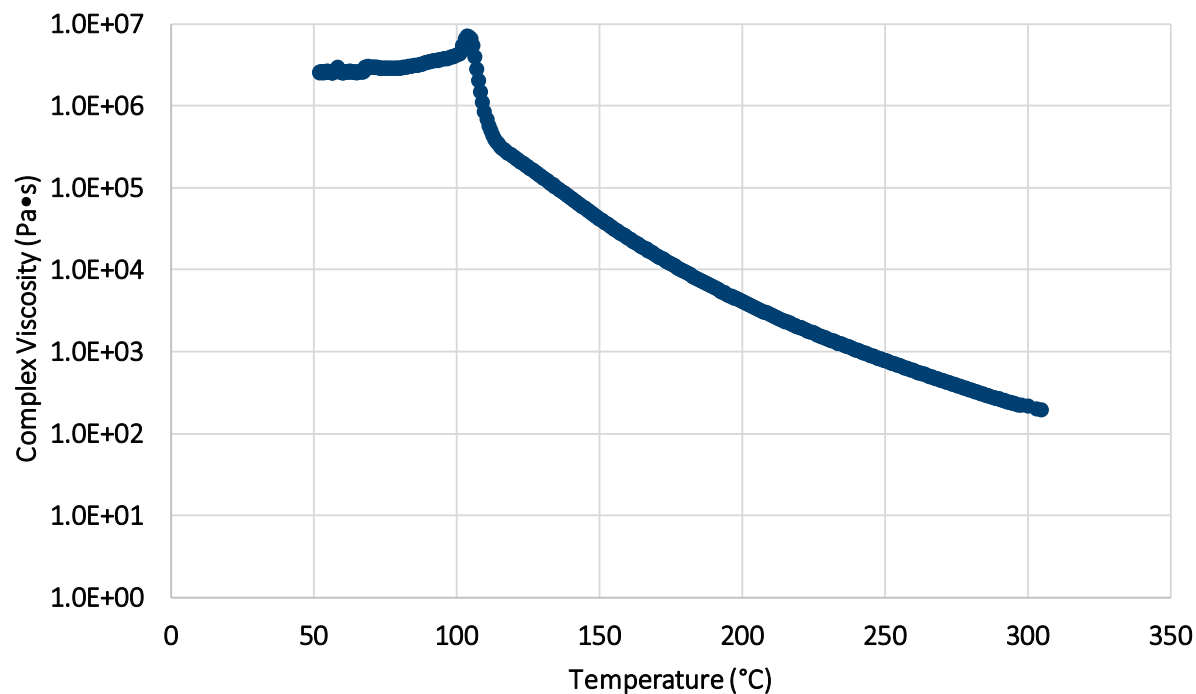
Material A & B

Overview of Two-Layer Material System

- Two-Layer Material System for Laser Materials
 - Consists of thermoplastic or thermoset bonding material and laser release material
 - Thermoplastic Bonding Layer – Material A
 - Bonds at or below 200°C
 - Has high adhesion to the substrate it is applied to and the laser release layer
 - Can be coated at a thickness of 10 μm and above
 - Thermoplastic Laser Release Layer – Material B
 - Laser Sensitive at near-UV wavelengths (300-400 nm)
 - Has high adhesion to the substrate it is applied to and the bonding layer
 - Minimizes laser energy reaching the device

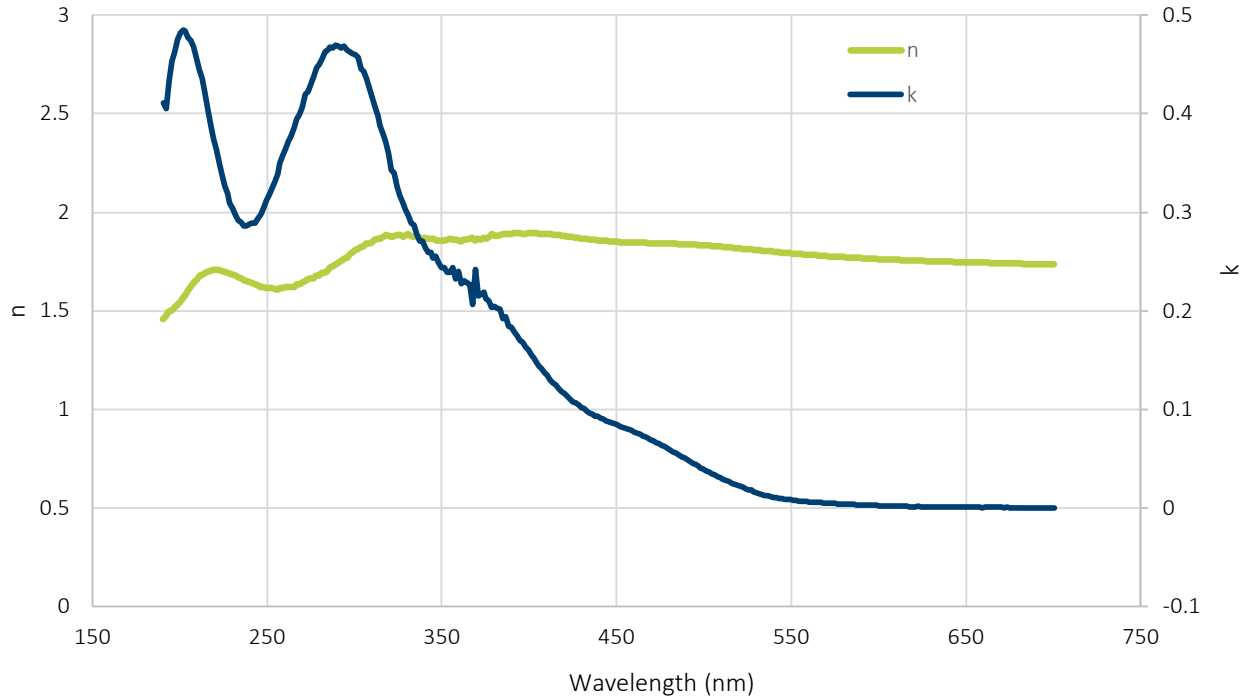


Two-Layer Material System – Material Characterization



	Thermal Decomposition Under N ₂ (°C)	Glass Transition Temperature(°C)	Melt Viscosity at 200°C (Pa·s)	Thickness
Material A	351	98	4052	35μm
Material B	407	N/A	N/A	180 nm

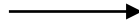
Two-Layer Material System – Material Characterization



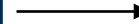
Wavelength (nm)	N	K
308	1.84	0.43
355	1.86	0.24

Two-Layer Material System – Results – Processing

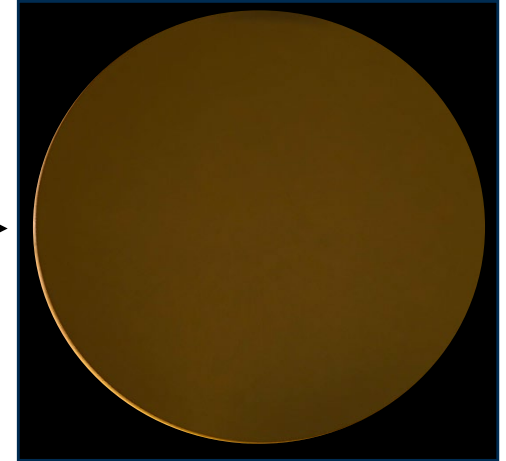
Wafer Pair Post-Bonding



Wafer Pair Post-Grind

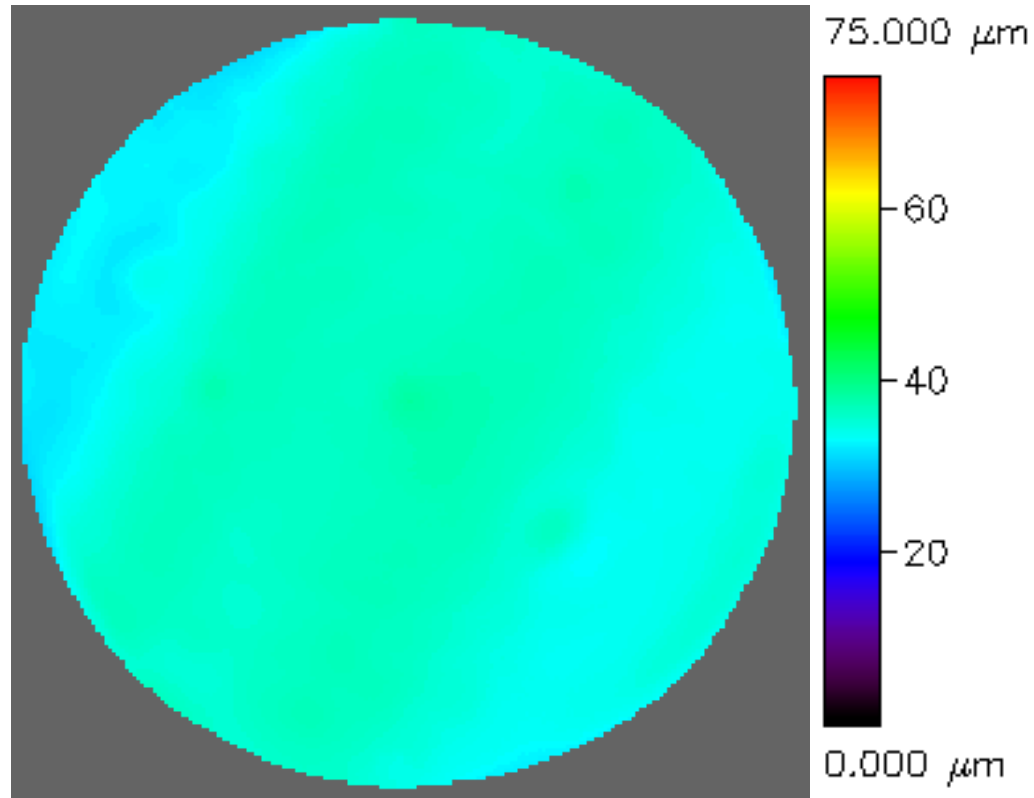


Wafer Pair Post-Heat Treatment



No bond line defects appear during full processing

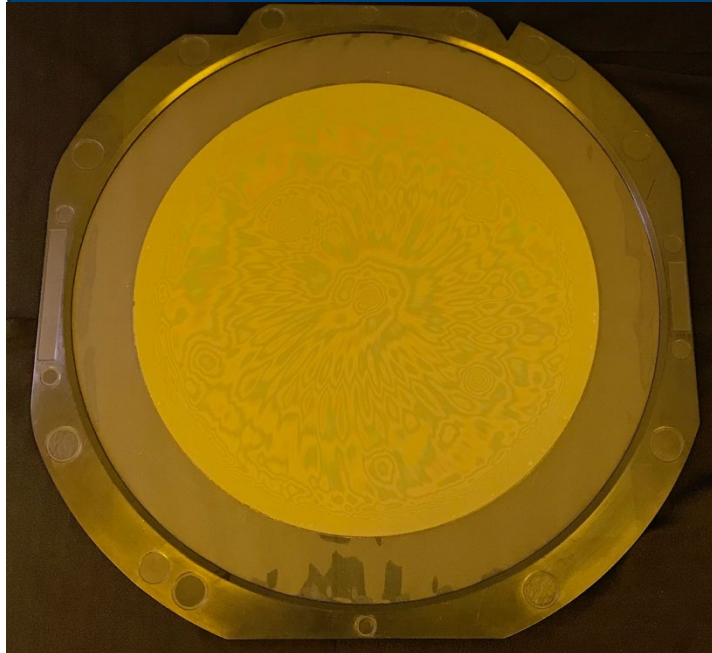
Two-Layer Material System – Results – Grind



Average Thickness: 35 μm

Two-Layer Material System – Results For Laser Debond

Thinned Wafer Post 308 nm Laser Debond



Debond Fluence: 160 mJ/cm²

Thinned Wafer Post 355 nm Laser Debond



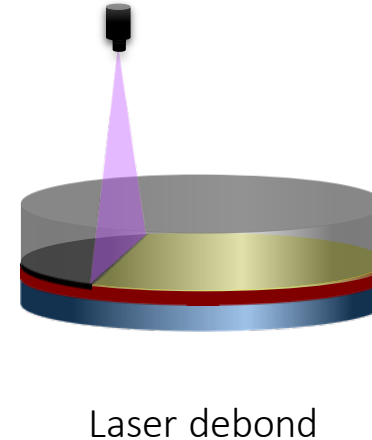
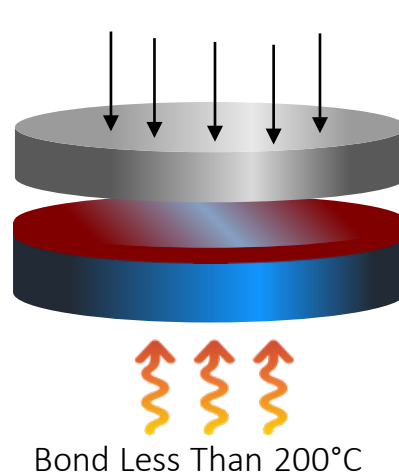
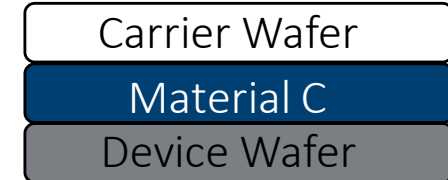
Debond Power: 1.3 W
Debond Time: 103 s

SINGLE-LAYER THERMOPLASTIC MATERIAL SYSTEM

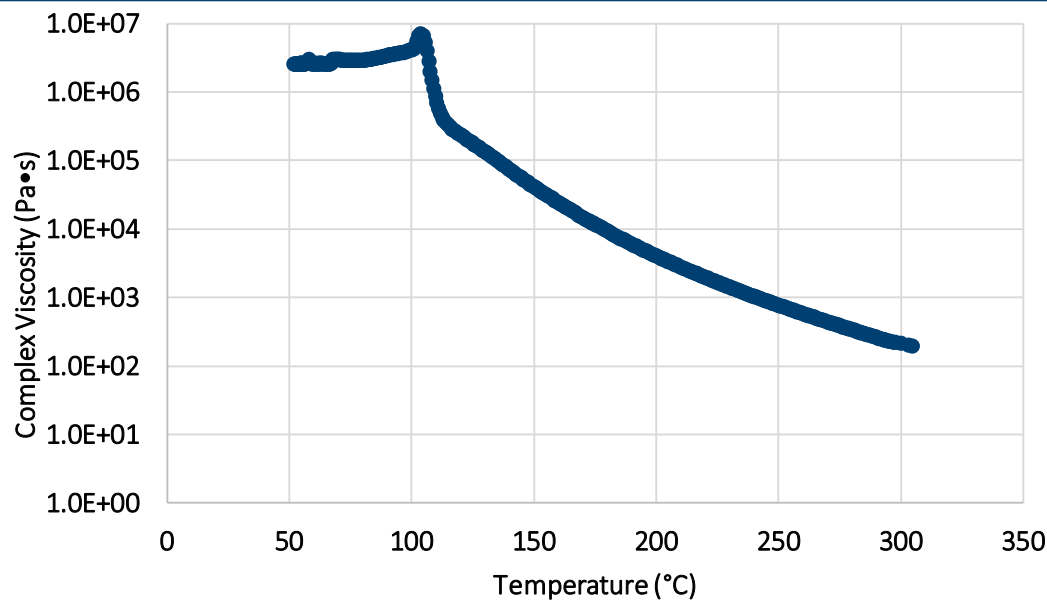
Material C

Overview Of Single-Layer Thermoplastic Material System

- Consists of a single thermoplastic layer that acts as bonding layer and release layer
 - Bonds at or below 200°C
 - Has high adhesion to a variety of substrates
 - Can be coated at a variety of thicknesses
 - Laser Sensitive at near-UV wavelengths (300-400 nm)



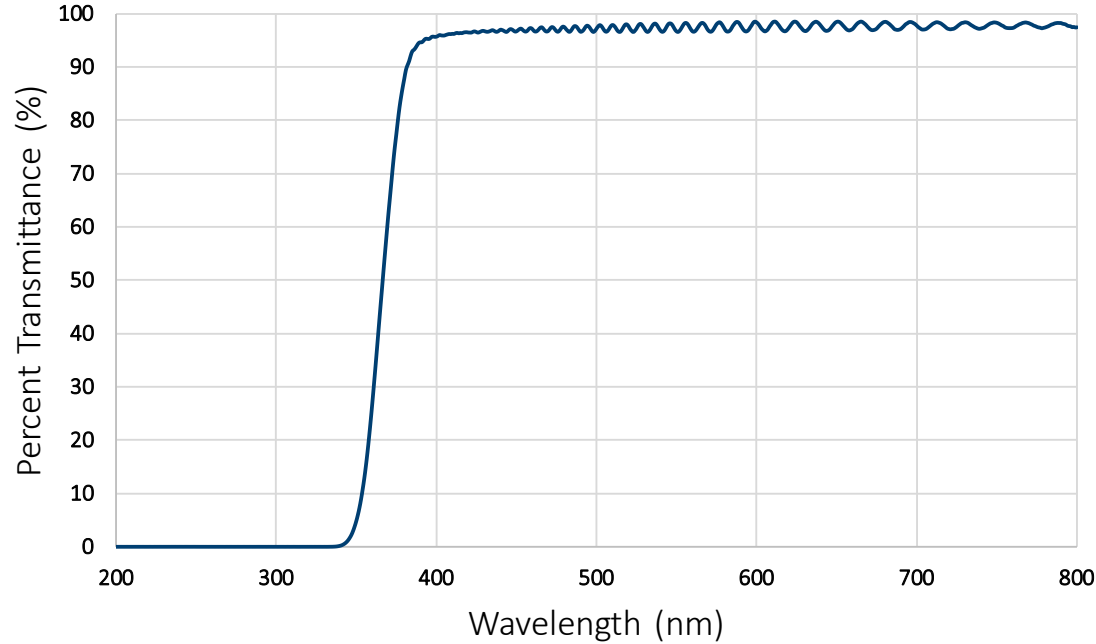
Thermoplastic Material System – Material Characterization



Substrate Type	Si	Glass	Si ₃ N ₄	SiO _x
Adhesion (PSI)	>39	>31	>27	37

	Thermal Decomposition Under N ₂ (°C)	Glass Transition Temperature(°C)	Melt Viscosity at 210°C (Pa·s)	Thickness (μm)
Material C	334	101.6	337	20

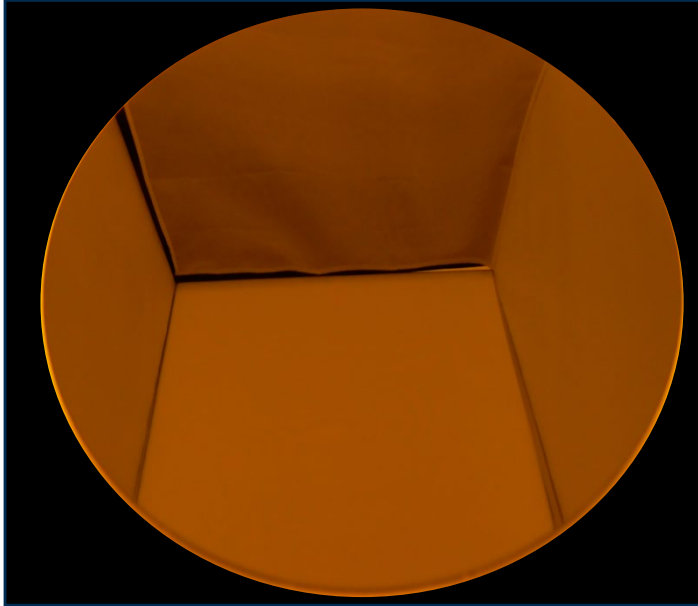
Thermoplastic Material System – Material Characterization



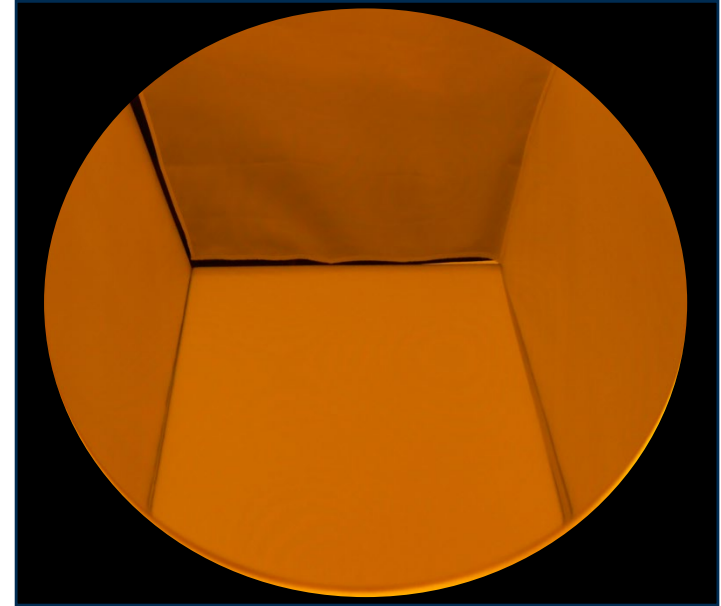
Wavelength (nm)	Percent Transmittance
248	0
308	0
355	0.28

Thermoplastic Material System – Material Characterization

Wafer Pair Post-Bonding



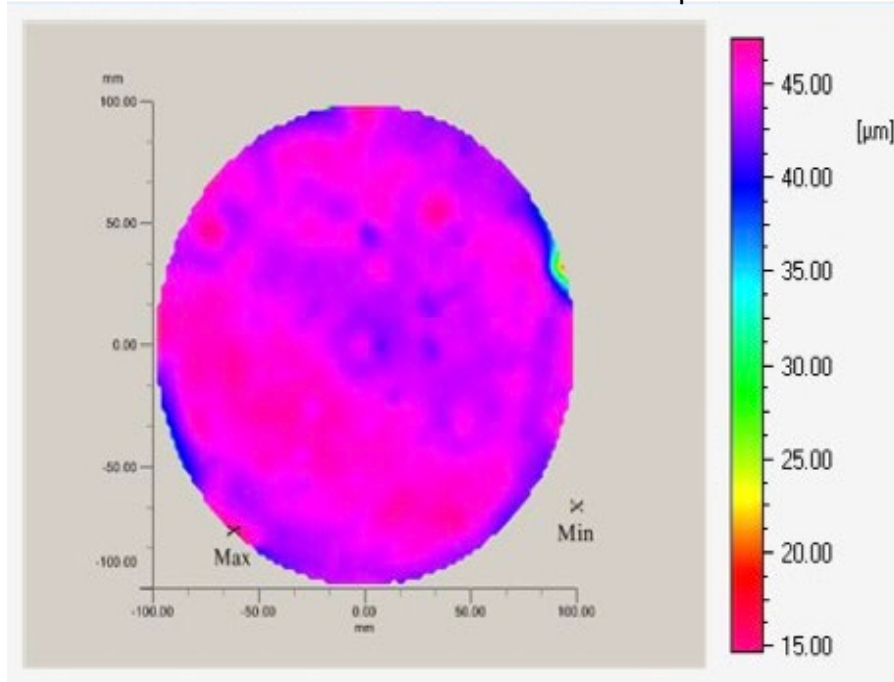
Wafer Pair Post-Heat Treatment



No bond line defects appear during full processing

Thermoplastic Material System – Results

Thinned Silicon Thickness Map



Average Thickness: 46 μm

Wafer Post-308 nm Laser Debond



Debond Fluence: 220 mJ/cm^2

SINGLE-LAYER THERMOSET MATERIAL SYSTEM

Material D

Overview For Single-Layer Thermoset Material System

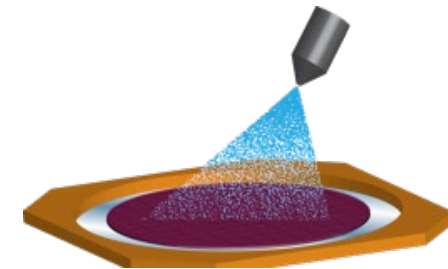
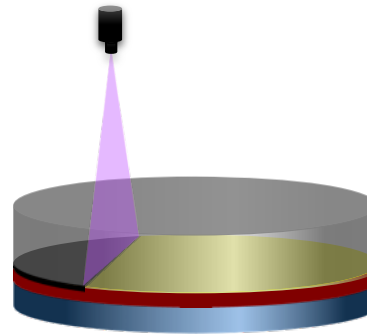
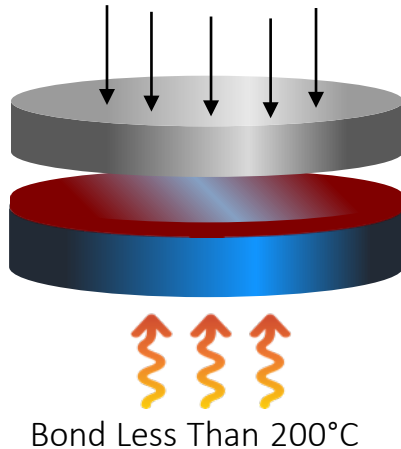
- Single-Layer Thermoset Materials

- Have a bonding temperature of less than 200°C
- Able to laser debond at commercially available laser wavelengths
- Crosslink by UV or thermal cure
- Able to clean cured material by wet chemistries

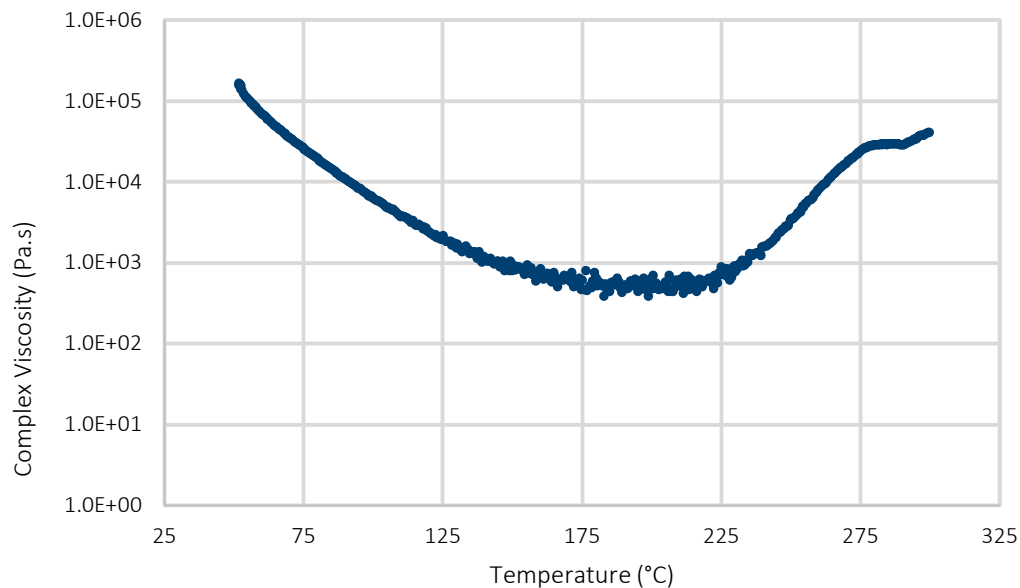
Carrier Wafer

Material D

Device Wafer



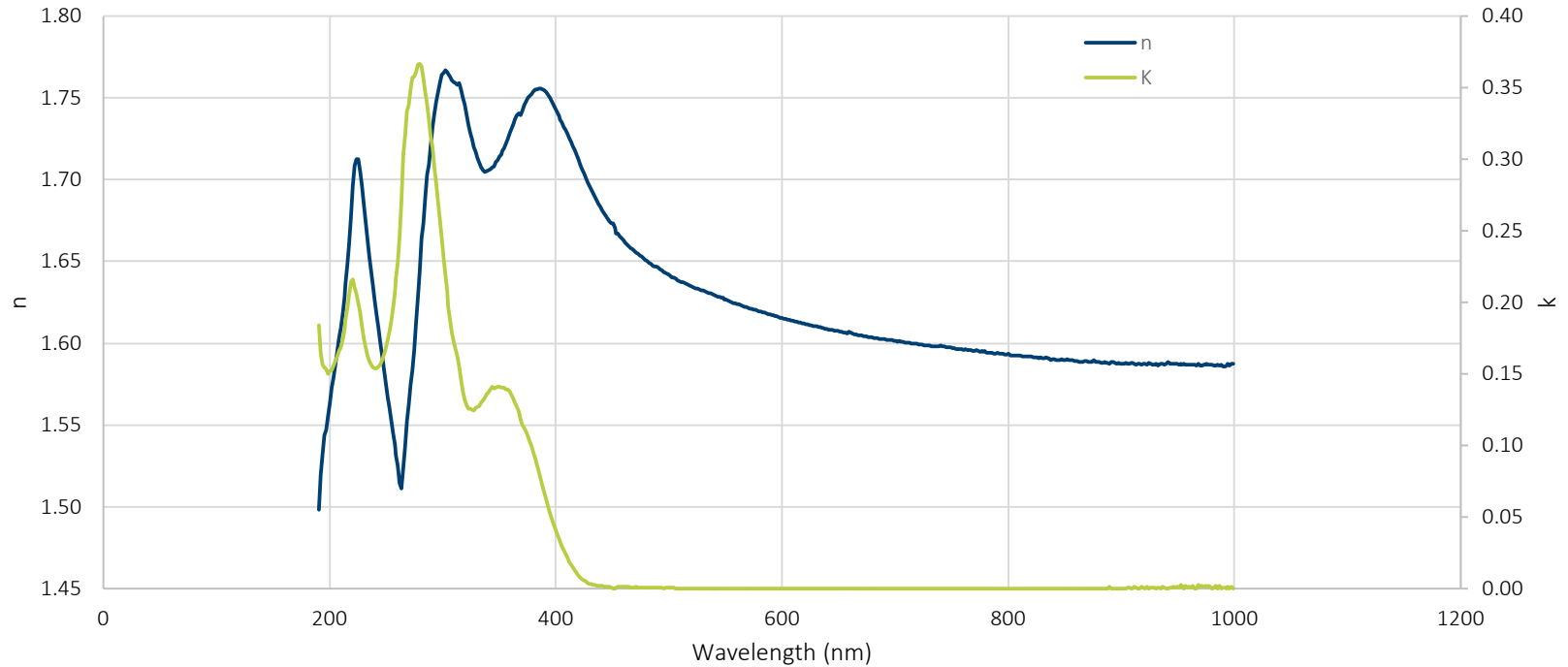
Thermoset Material System – Material Characterization



Substrate Type	Si	Glass	EMC	SiO _x
Adhesion (PSI)	28	23	15	31

	Thermal Decomposition Under N ₂ (°C)	Glass Transition Temperature (°C)	Melt Viscosity at 145°C (Pa·s)	Thickness (μm)
Material D	371	25	883	20

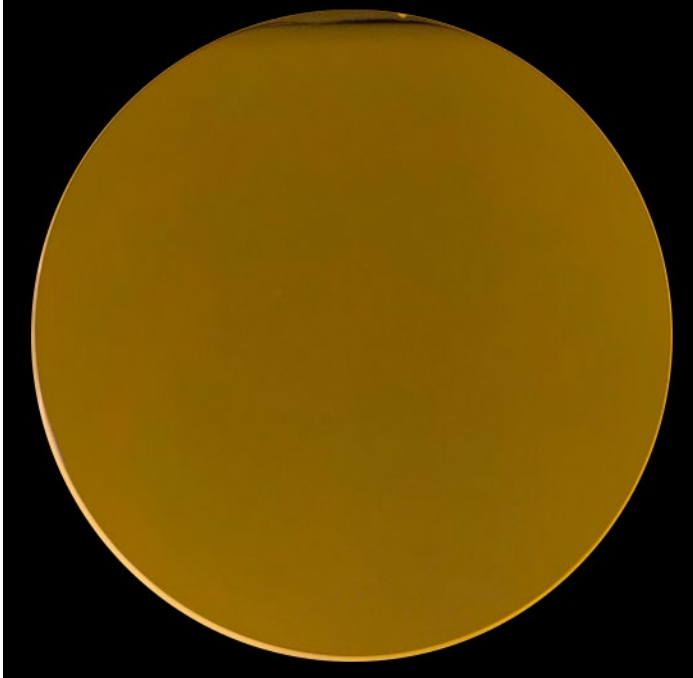
Thermoset Material System – Material Characterization



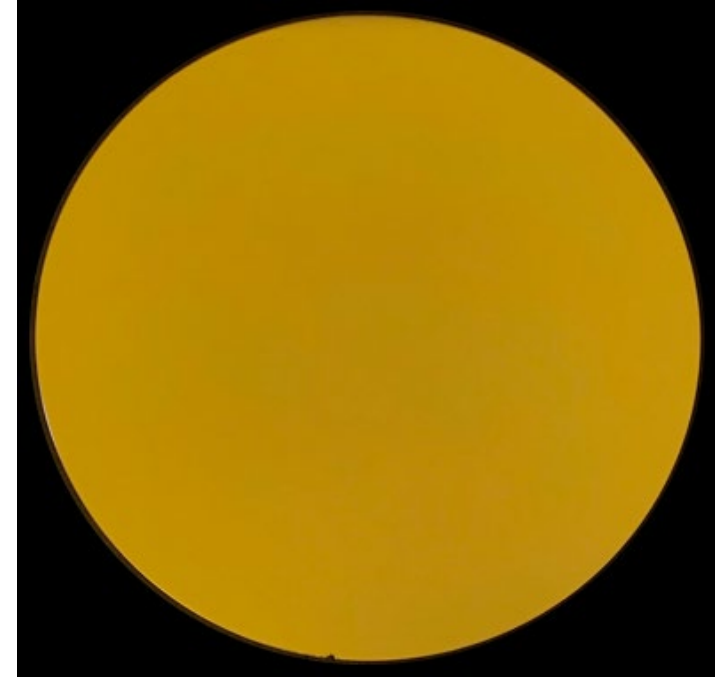
Wavelength (nm)	n	k
308	1.76	0.18
355	1.72	0.14

Thermoset Material System – Results

Wafer Pair Post-Bonding



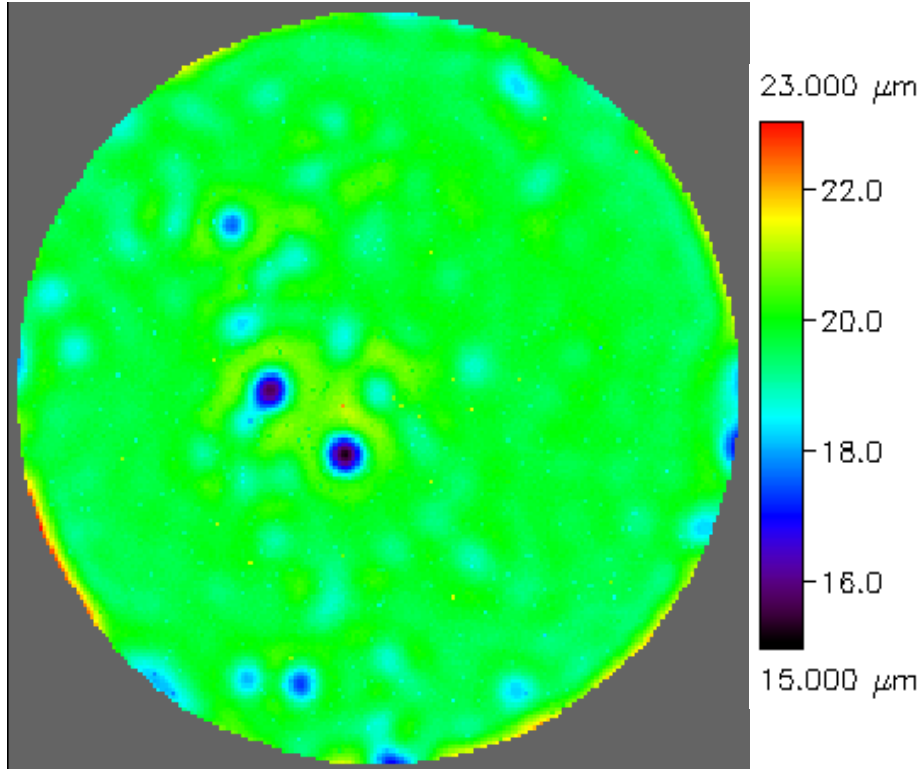
Wafer Pair Post-Heat Treatment and Cure



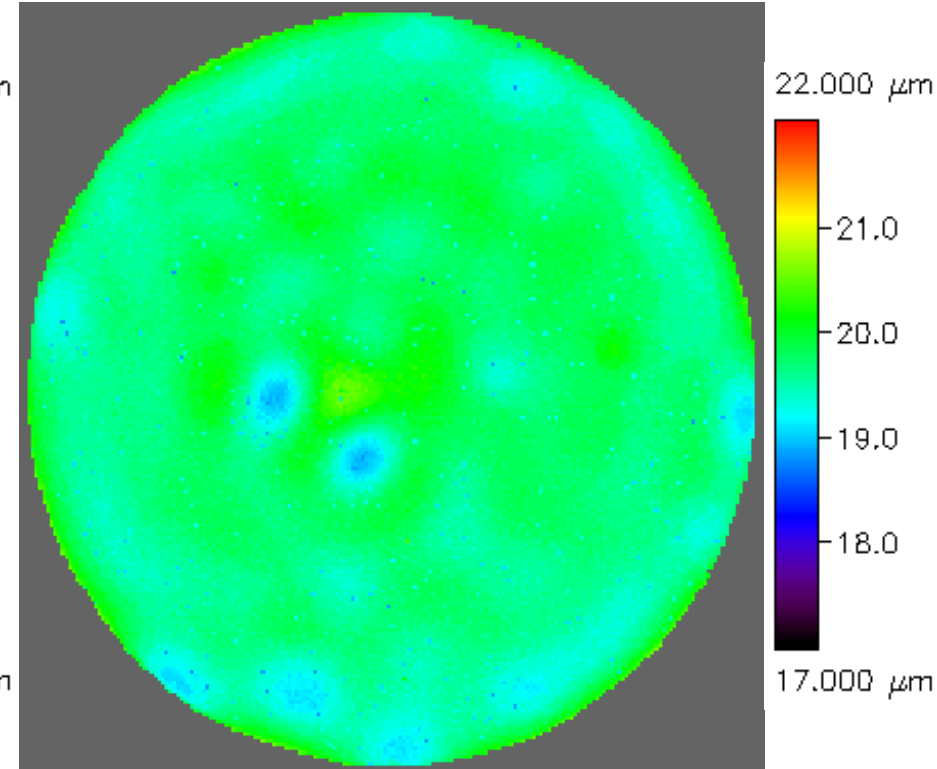
No bond line defects appear during full processing

Thermoset Material System – Results

Before Cure and Heat Treatment



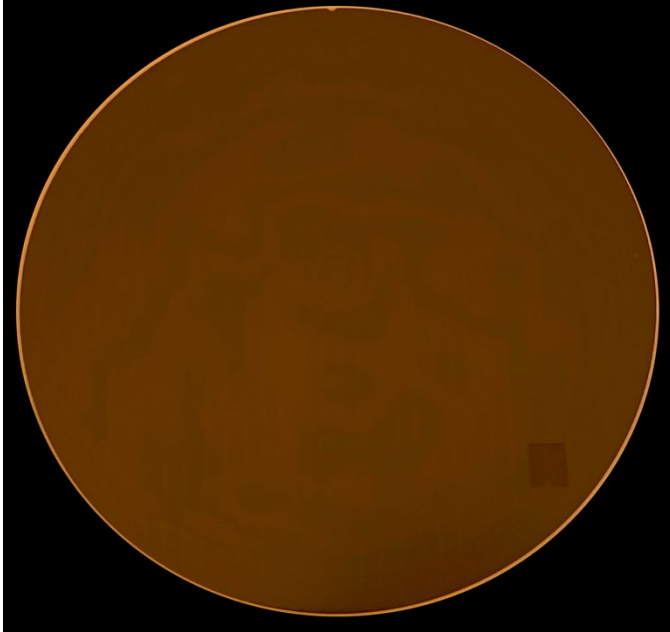
After Cure and Heat Treatment



Minimal material flow occurs before and after heat treatment.

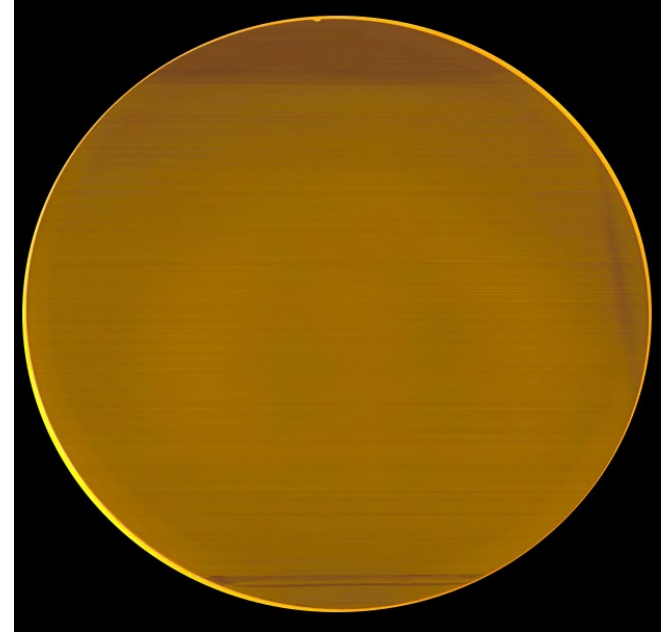
Thermoset Material System – Results

Post-308 nm Laser Debond



Debond Fluence: 275 mJ/cm²

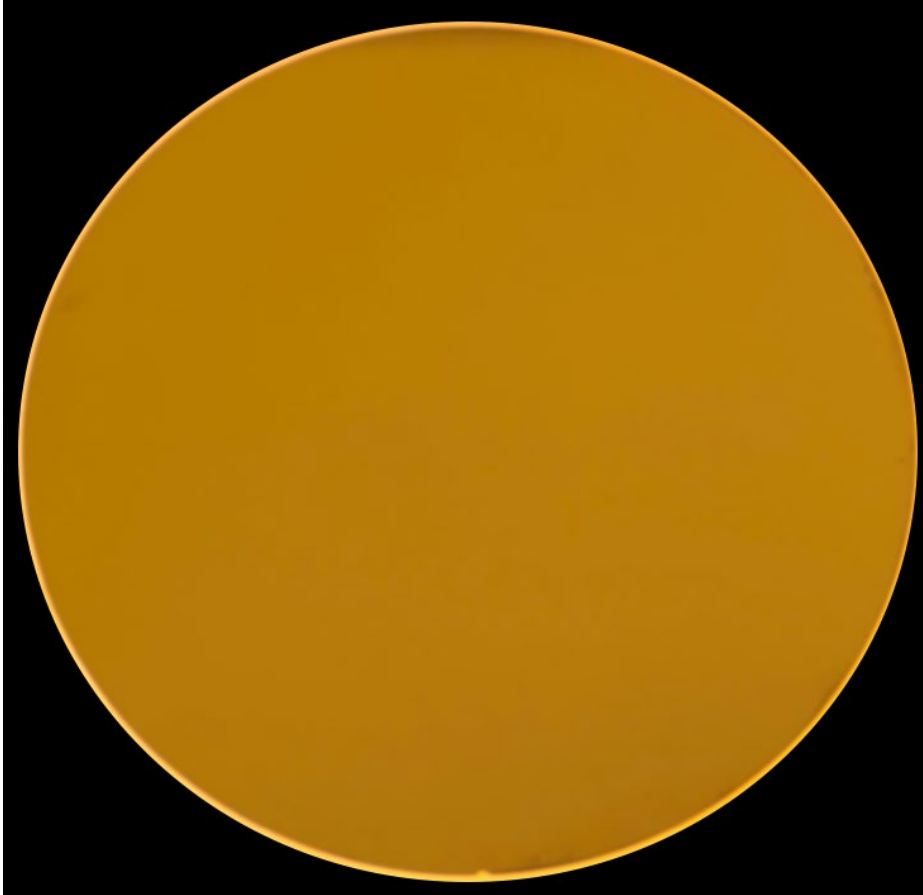
Post-355 nm Laser Debond



Debond Power: 4 W
Debond Time: 71 s

Thermoset Material System – Results

Post-Processed Cleaned Wafer



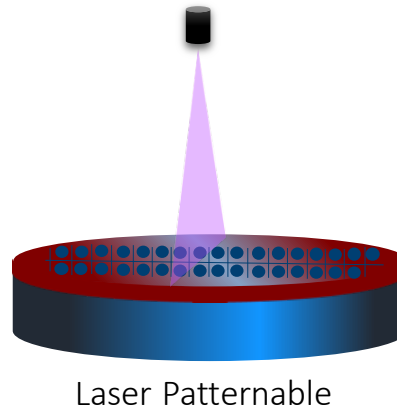
Curable layer can be cleaned
using non-harsh chemical
solvent-based systems

LASER ETCHING AND PATTERNING MATERIAL SYSTEM

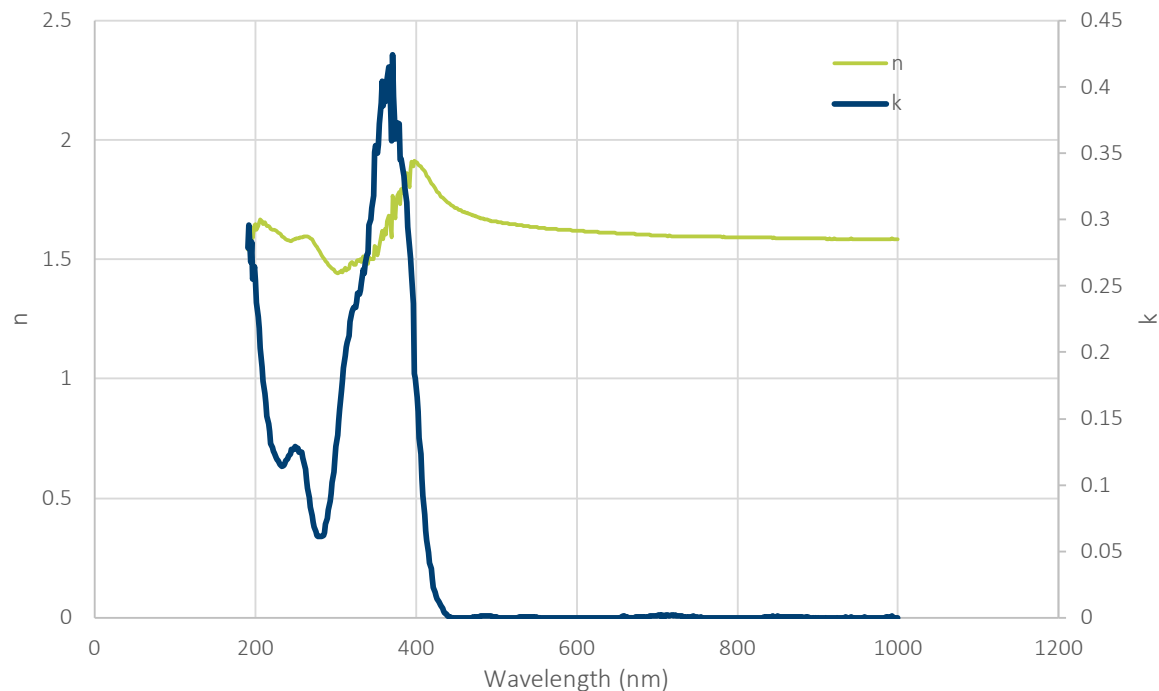
Material E

Overview of Laser Etching and Patterning Material System

- Laser Etching and Patterning Materials
 - Sensitive to wavelengths at the target laser source
 - Materials can withstand thermal process of up to 250°C
 - Glass transition temperature is above 50°C
 - Minimizes residue produced during the laser etching process



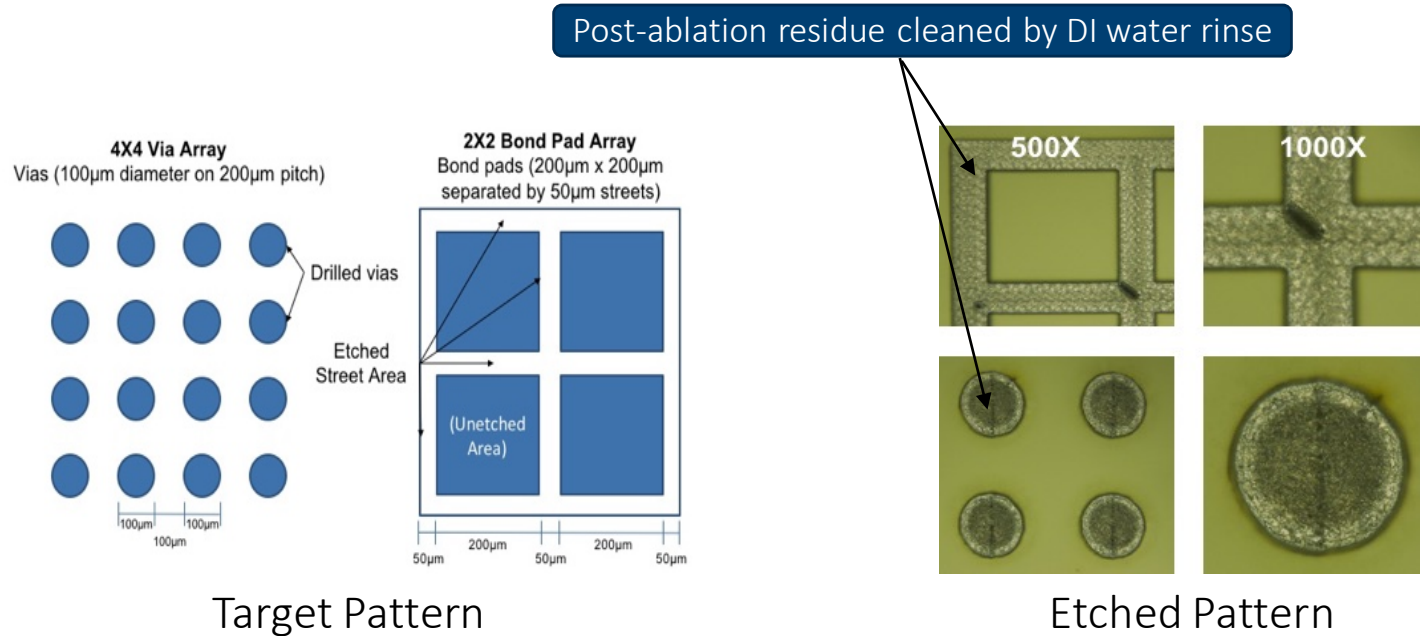
Laser Etching Material System – Material Characterization



Wavelength(nm)	N	K
308	1.45	0.18
355	1.56	0.37
365	1.68	0.42

	Thermal Decomposition Under N ₂ (°C)	Glass Transition Temperature (°C)	Thickness (μm)
Material E	325	82.4	7.7

Laser Etching Material System – Results



Little residue remains after etching of vias and streets

CONCLUSIONS

Conclusions

Two Layer System

1

- High thermal stability
- Good UV absorbance
- Flexibility in materials
- Wet cleanable after full processing

Single Layer Thermoplastic

2

- Combines bonding layer and release layer
- Wet cleanable after laser debond
- Lowest amount of processing

Single Layer Thermoset

3

- Thermal curable
- Good UV absorbance
- Good thermal/mechanical stability
- Wet cleanable after curing

Laser Etching And Patterning

4

- UV curable
- Good thermal and mechanical stability
- Laser Etchable
- Ability to be used as a flexible material



THANK YOU!

Follow Us On
Social Media

