Optical Profilometry of Substrate Bow Reduction Using Temporary Adhesives

[a]Paul Flynn, FRT of America LLC

[b]John Moore, DAETEC LLC

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[a]Fries Research & Technology (pflynn@frtofamerica.com)

[b]Diversified Applications Engineering Technologies (jmoore@daetec.com)

Agenda

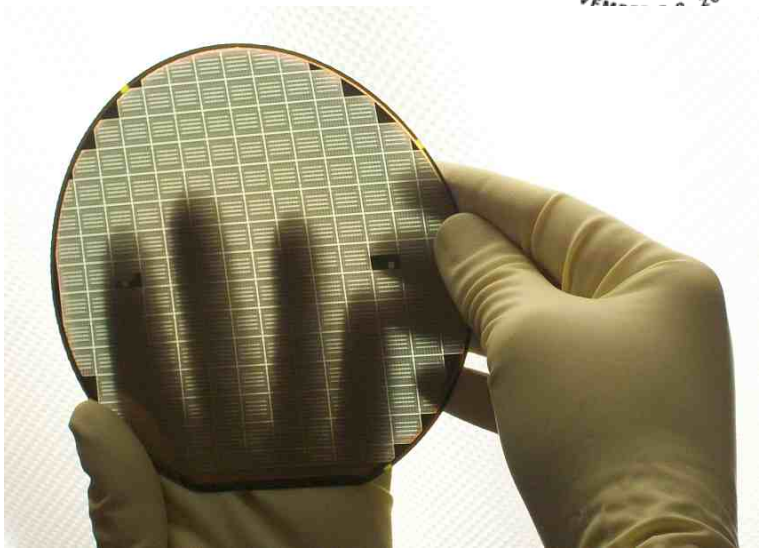
- Background
- Equipment
- TSI Baseline
- Application
- Results
- Summary

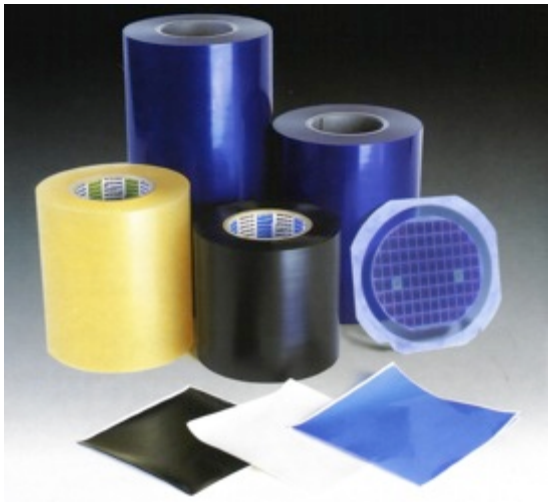
Background
Thin Substrate Support

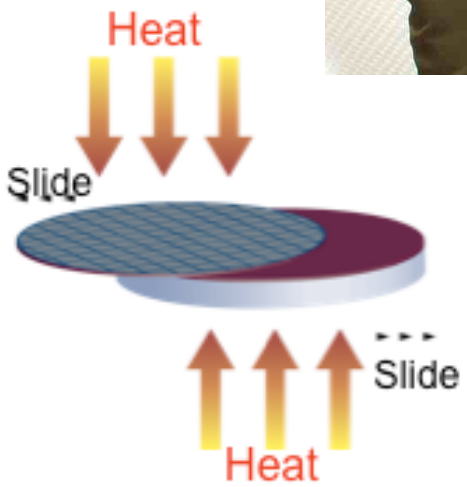
- Adhesive: Mount product wafer to carrier
- Carrier: Silicon or glass, sapphire
- Temporary: Apply to meet mechanical and chemical properties, seal front side, removal when complete
- Backside processing: Achieve connectivity (lithography, etch, metallization)
- Removal: Cleaning complete, no residue

Typical Thin Substrate Support

- Tape
- Vacuum Chuck
- Carrier & Adhesive



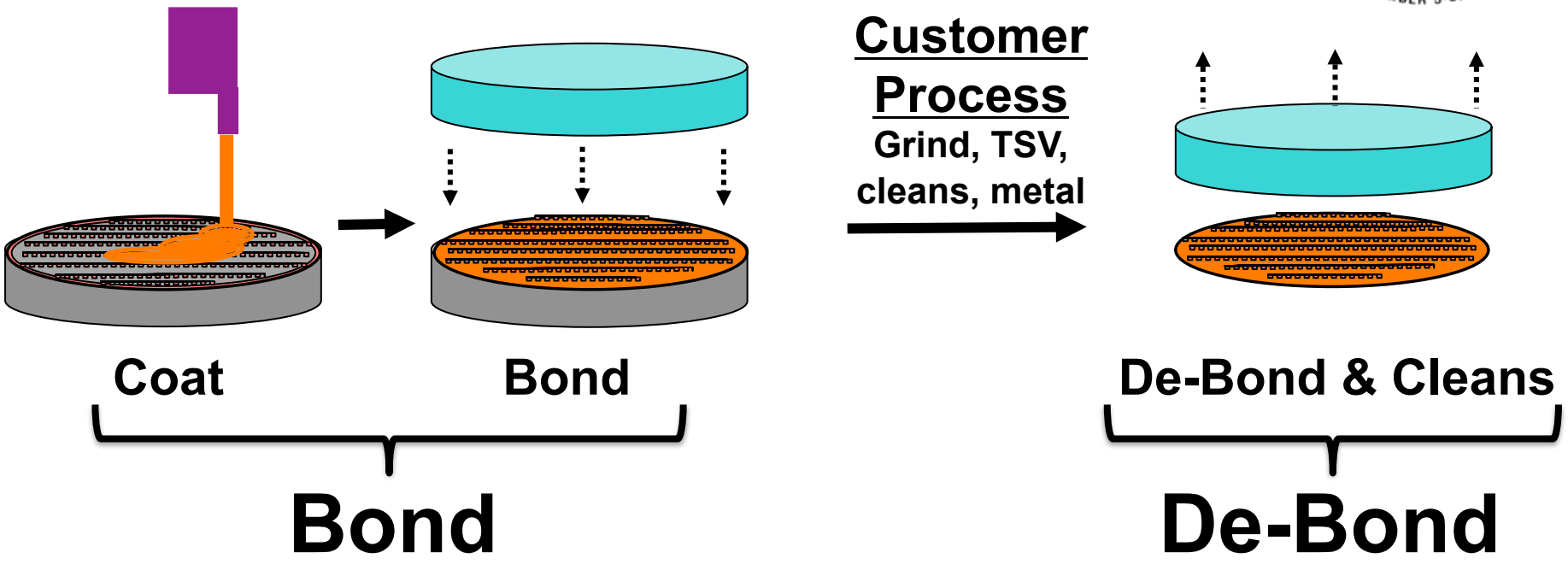




Thin Wafer support

Thin Wafer Handling	Thickness Min (um)	Chem & Therm Resistant	Single Wafer or Batch	Backside Processing Support
Tape	>50	No	Both	No
Vacuum Chuck	>50	No	Single	No
Adhesive Bonded Carrier	<25	Yes	Both	Yes
	Thinner is Better	Must be Resistant	Versatility Is Best	Must do Backside Processing

Temporary Bonding Process



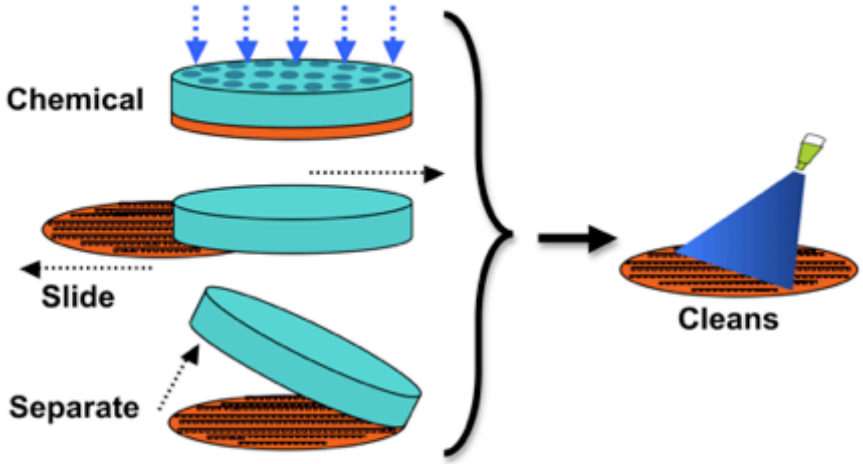
Two ACTIVE steps occur with Temporary Bonding Technologies.
The "BOND" step is similar between popular practices.
Primary differences occur during "DE-BOND".

Wafer Bonding Chemistries

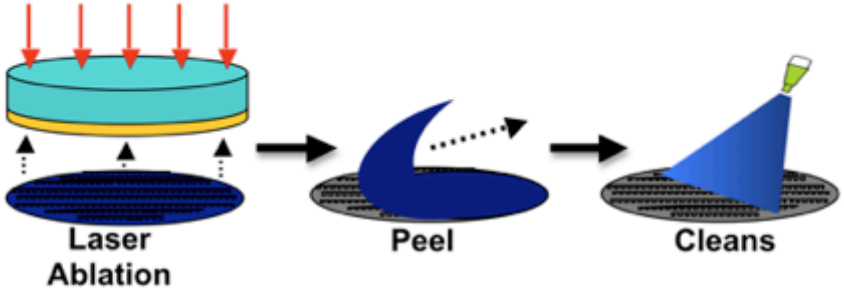
Firm	Chemistry	DeBond Method	Batch or SW	Cleans
BSI	Rubber	Chemical, slide, peel	SW	Non-polar solvent
3M	Acrylic	Ablate/peel	SW	Polar solvent
TMAT & Dow Corning	Silicone	Peel	SW	Non-polar solvent
DuPont	Polyimide	Ablate/peel	SW	Polar solvent
TOK	Urethane	Chemical	Batch	Polar solvent
Daetec	Rosin Acid	Chemical	Batch	Detergent

De-Bonding

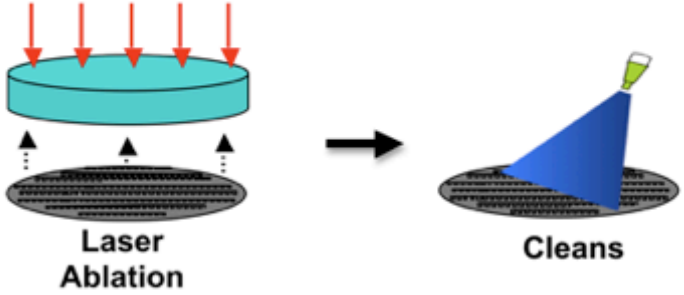
Rubber, olefinic & high MW hydrocarbon polymers, blends



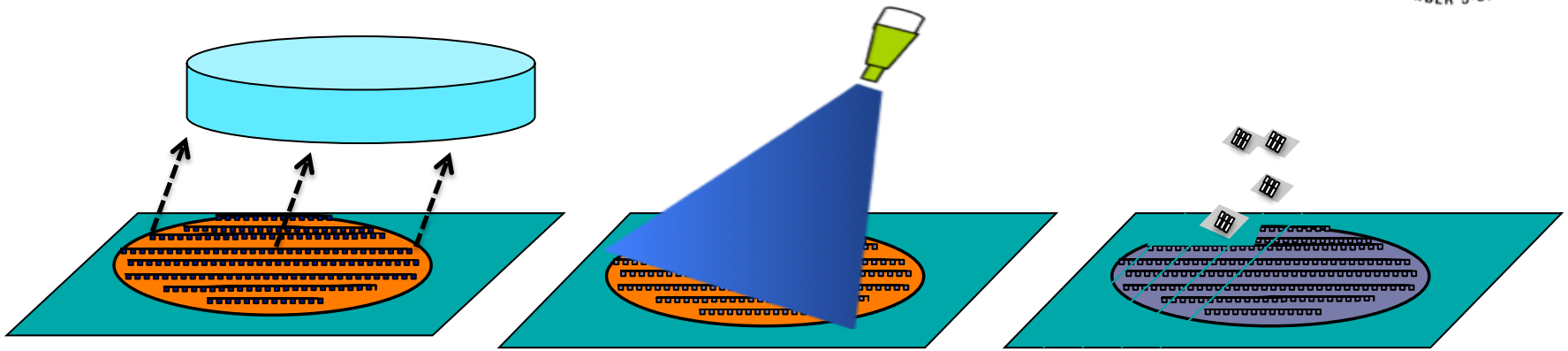
Acrylic, styrenic, and blends



Polyimide & silicone



Roadmap to Dicing



Film Attachment Carrier Demount

Wafer Cleans Safe for Tape

Dicing

cleans compatible to tape or vice-versa

Adhesive Governs the Process

- Final properties & processing capacity
- Choice in bond & de-bond tool, time, yield
- Cleaning chemistry
- Tape/film compatibility
- Need for tuning for each process & customer

Polymer Gas Permeability

Gas permeability: cm3-mm/m2-day

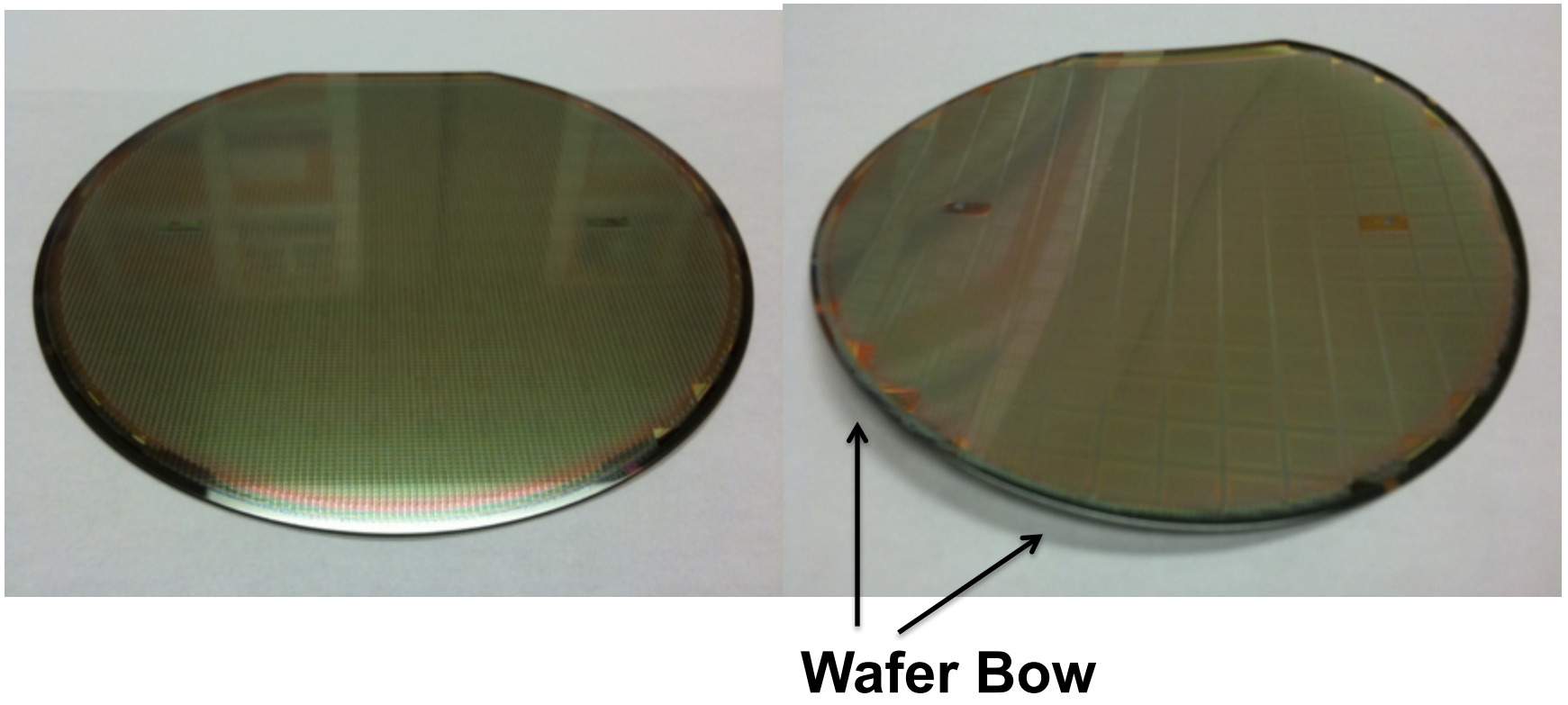
Polymer	N2	O2	CO2	H2	H2O
Parylene N	1.7	39	214	540	1.5
Parylene C	1	7.2	7.7	110	0.2
Parylene D	4.5	32	13	240	0.2
Epoxies	4	5-10	8	110	1.8-2.4
Silicones	- -	50,000	300,000	45,000	4.4-7.9
Urethanes	80	200	3,000	- -	2.4-8.7

Parylene conformal coating systems, www.scscookson.com

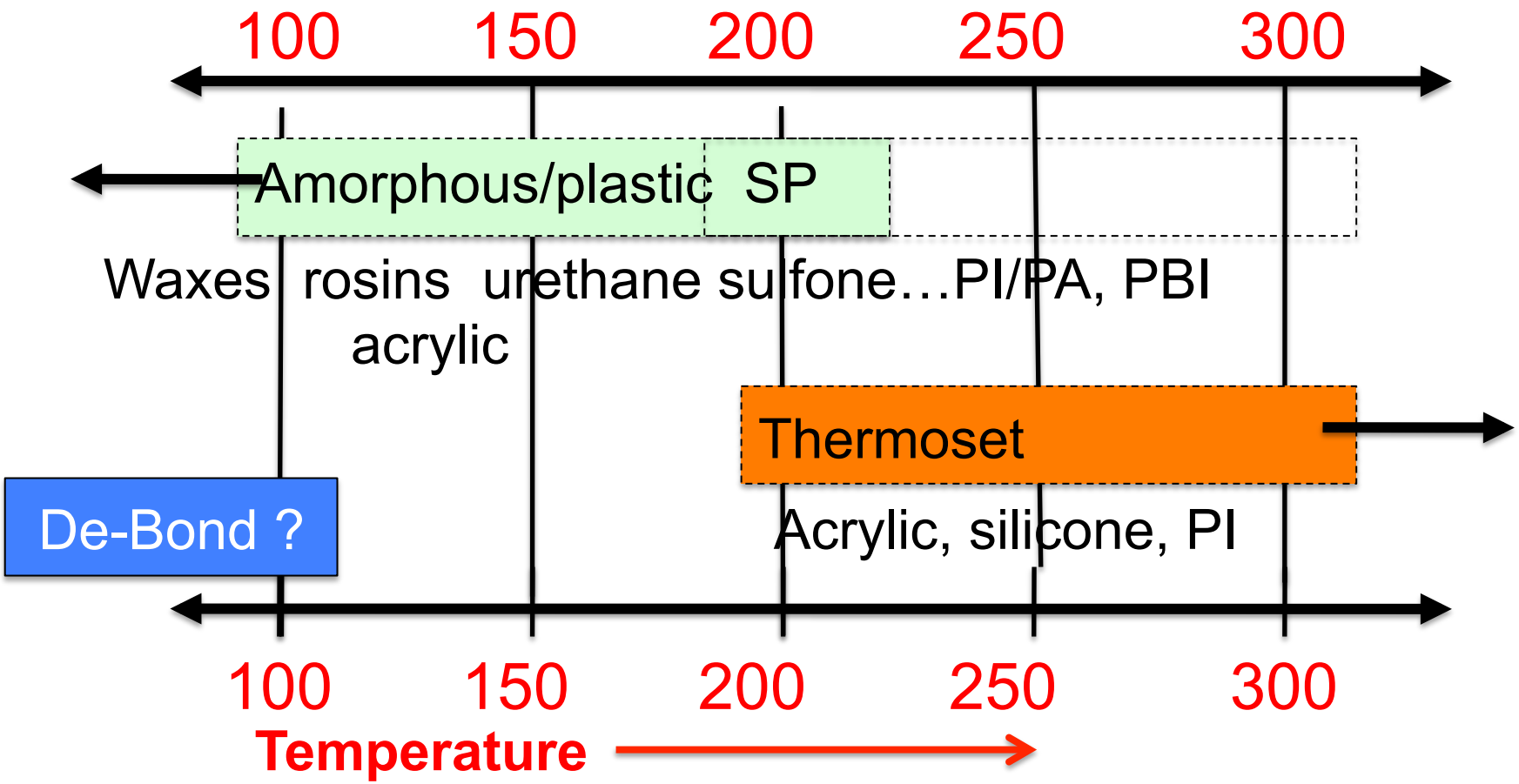
Stress Introduction

Bowing – observed internal stress, metal layers

Full thickness ~ 700um **Thinned ~ 100um**



Materials Overlay

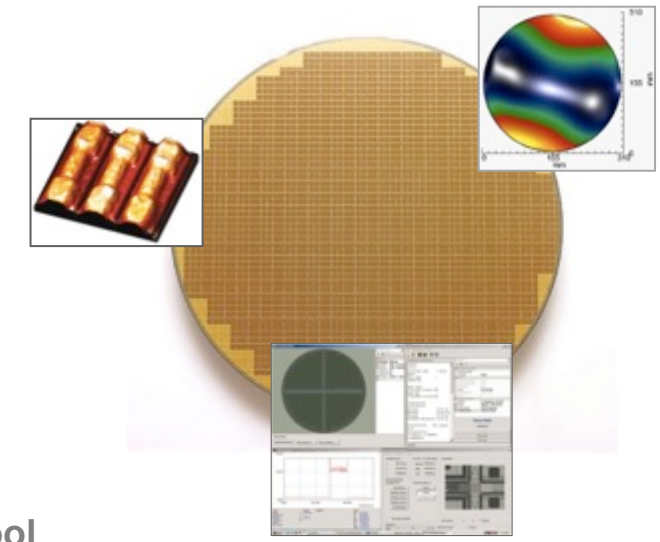


Equipment

- Entire substrate/wafer needs to be mapped
- Optical profilometry is preferred choice
- Bow, warp, TTV, flatness
- High resolution, speed, reliability

FRT MicroProf®

Wafer Metrology Tools



semi

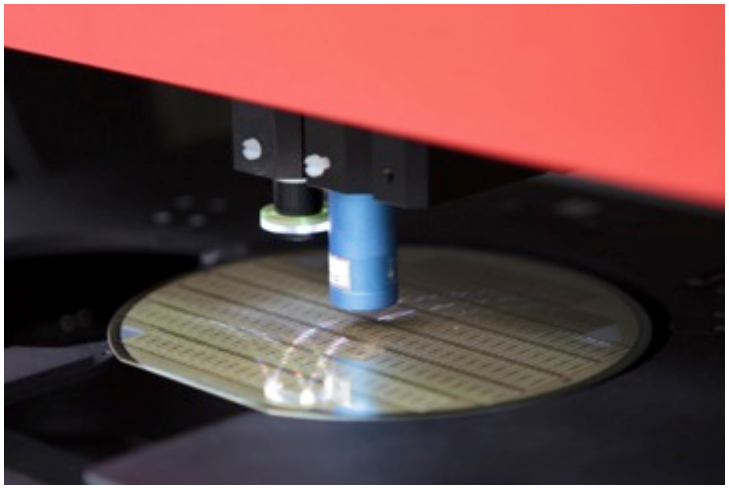
SEMI Compliant
TTV Measurement

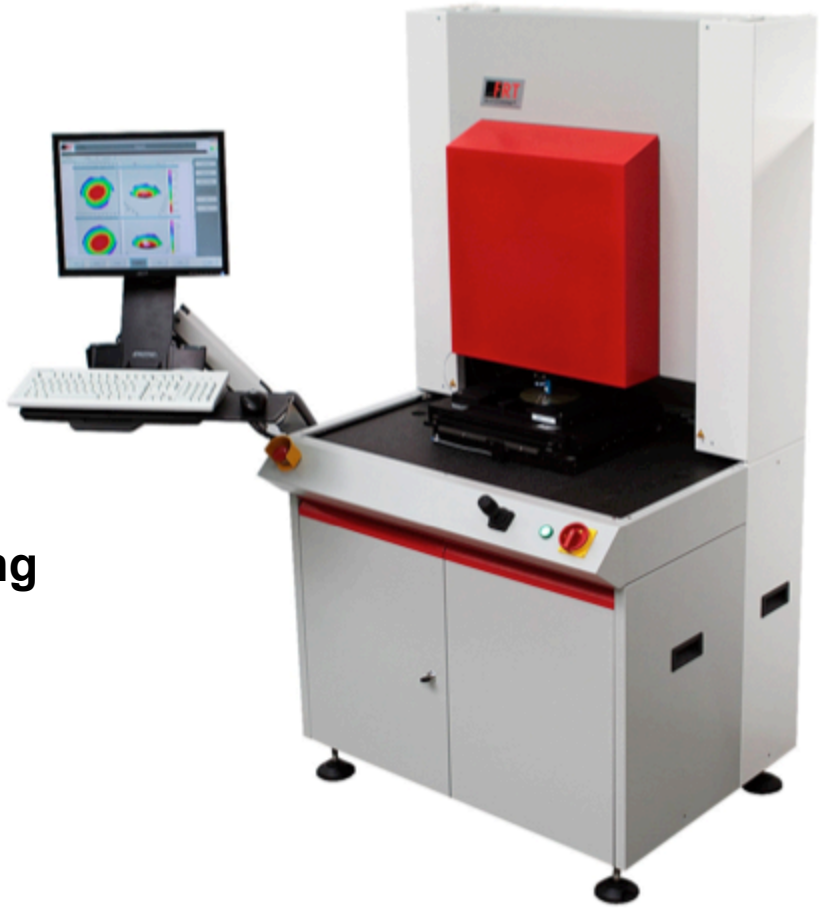
MicroProf® 300
Multi Sensor metrology tool with 300 mm stage and optional housing

FRT MFE - Metrology for Frontend
Fully automated Multi Sensor metrology tool with 300 mm stage, bridge tool, class 1 EFEM, SECS/GEM interface

MicroProf® 300 TTV MHU
Multi Sensor metrology tool with 300 mm stage, sensor setup for wafer thickness measurement (TTV), fully automated

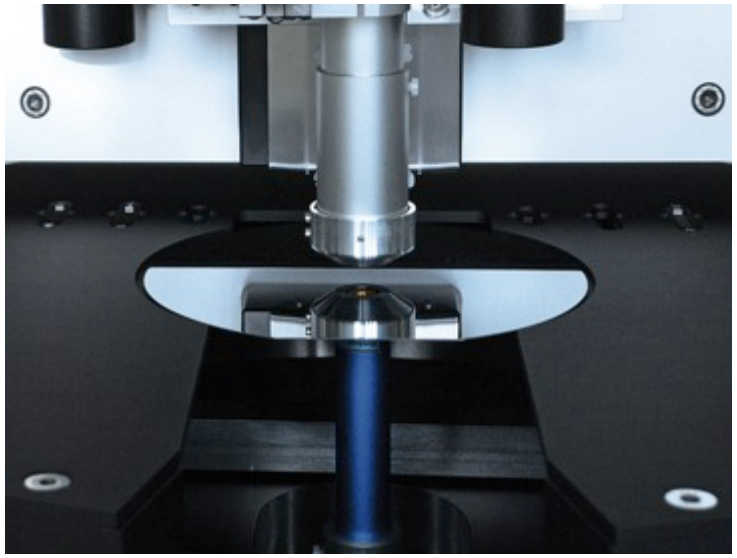
FRT MicroProf®
Semi Automated Metrology Tools

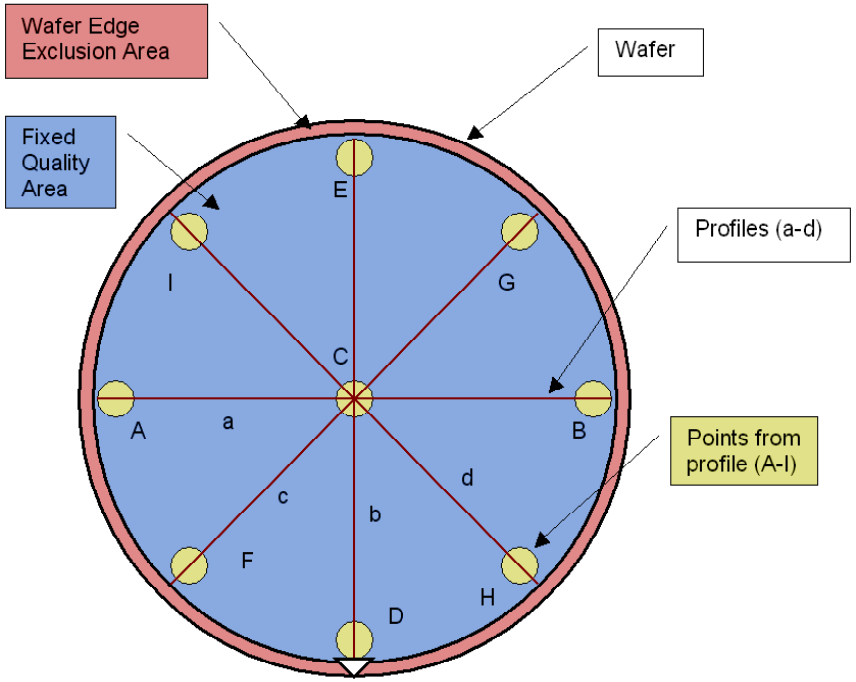




- Manual Operation
- Optical sensor acts as an OM
- 2D profile and 3D raster scanning
- Z working distance to 5mm
- Z-resolution can be set to 3nm
- IR and film thickness sensors
- TSV depth measurements

FRT MicroProf® TTV
Measurements According to Semi Standards





- **fully Semi compliant**
- **sawn, ground, polished wafers**
- **material independent (Si, sapphire, glass,..)**
- **recipe driven Semi compliant software**

FRT MicroProf® TTV
Measuring Parameters

Roughness:

- Ra
- Rmax
- Rz
- Rp
- Rt
- Rv
- Rq
- Wt

Profile:

- Wafer Thickness
- Center Thickness
- Wafer TTV
- BowBF
- Wafer Warp
- Sori
- TIR
- TIR95
- Sag X
- Sag Y
- Profile Warp
- Profile Sori
- NTD
- NTV
- Profile
- Profile TTV
- TV5 / TV9
- 3D map

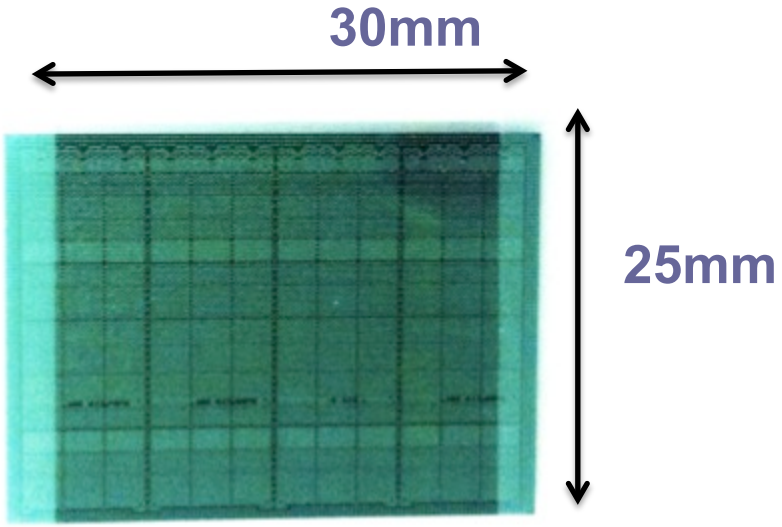
3D Map:

- Thickness
- Center Thickness
- Wafer TTV
- Bow BF
- Wafer Warp
- Sori
- TIR
- TIR95
- GBID
- GF3D
- GF3R
- NTV
- NTD
- Sag X
- Sag Y
- SBID
- SF3D
- SF3R
- SFLD
- SFQR
- Wafer FPD

TSI Baseline

- Substrate ~100um thickness
- Underlying bumps ~100um height

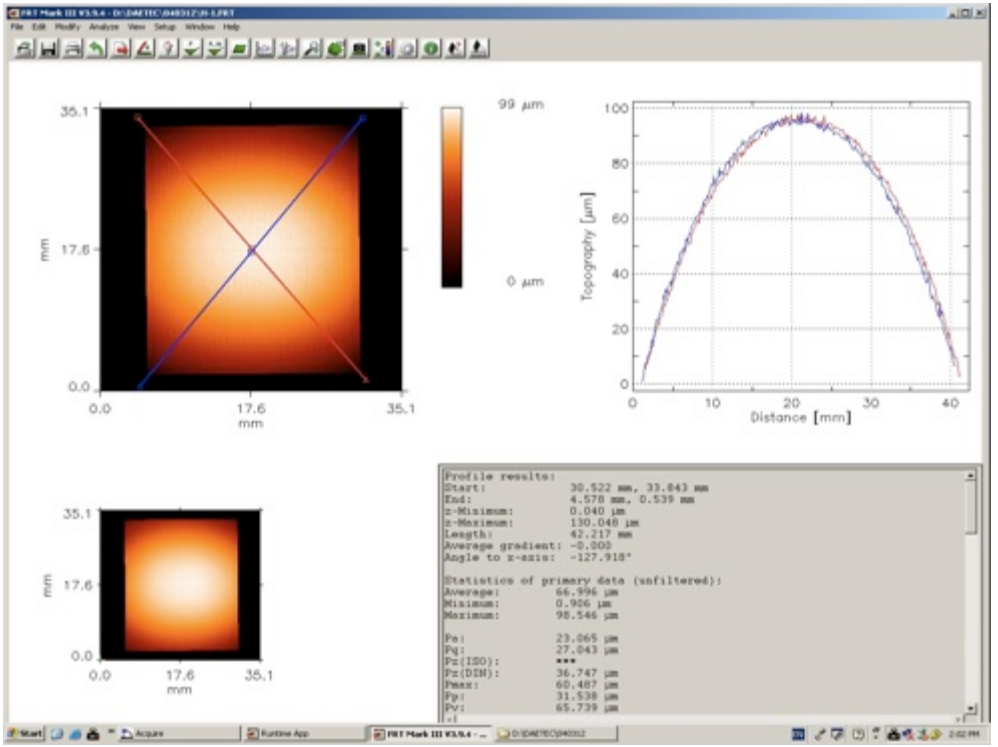
Top side



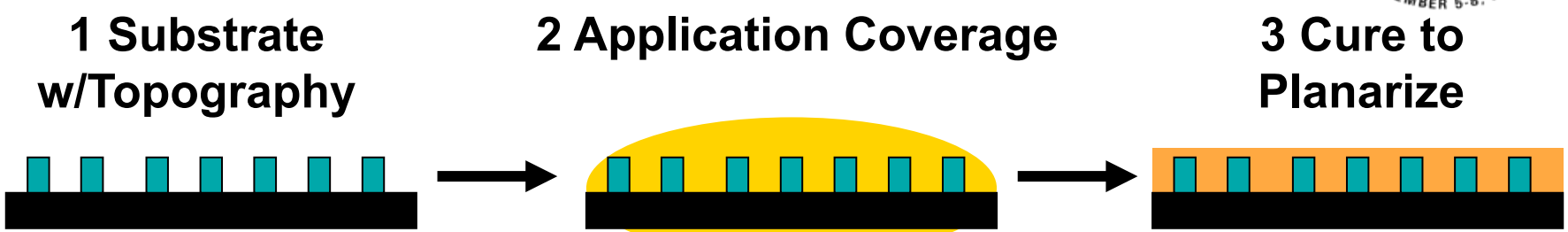
Bottom side
(contains solder bumps)

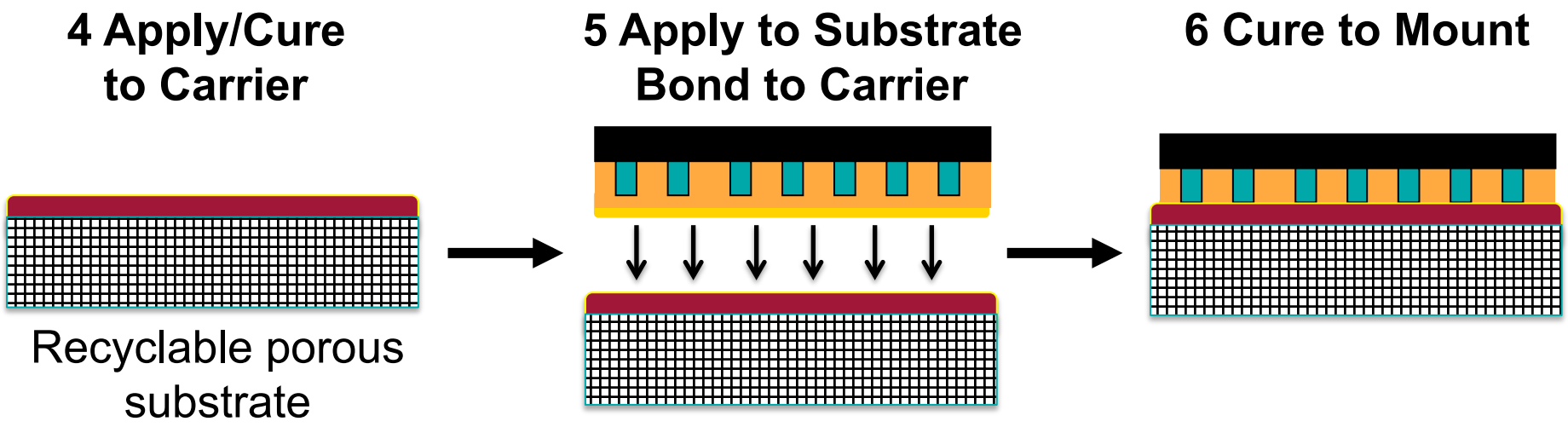
Interposer Initial Bow/Warp

- Bow, measured by optical profilometry
- Beginning bow varies from 100-120um
- Convex shape
- Must reduce to <40um



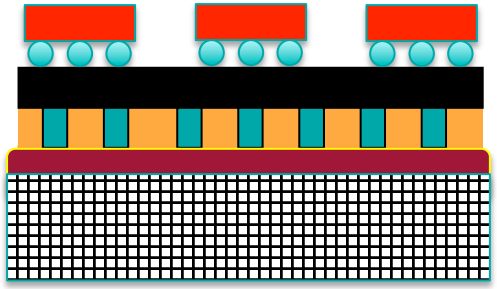
Application





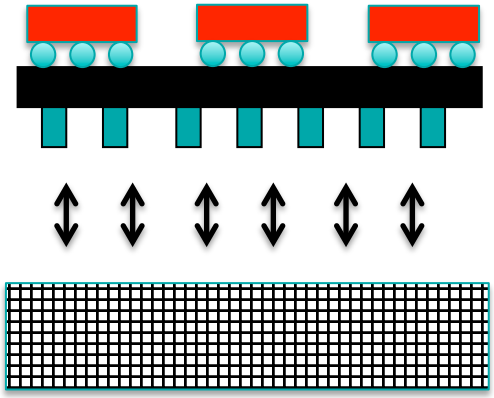
Post-Bonding Process

7 Customer Process



Bonded interposer attach chips to interposer Reflow 250-300C

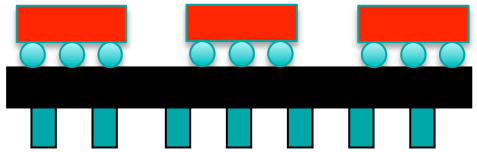
8 Debond & Cleans



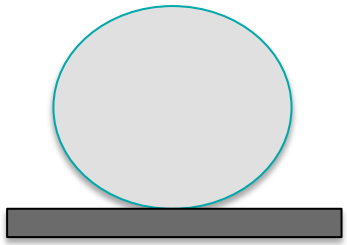
Debond and Cleans rinse, dry

Recycle carrier

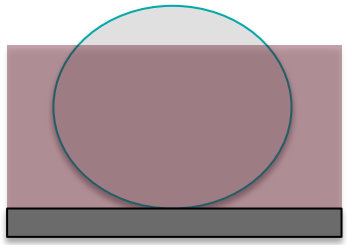
9 Acquire Final Product



Adhesive Planarization



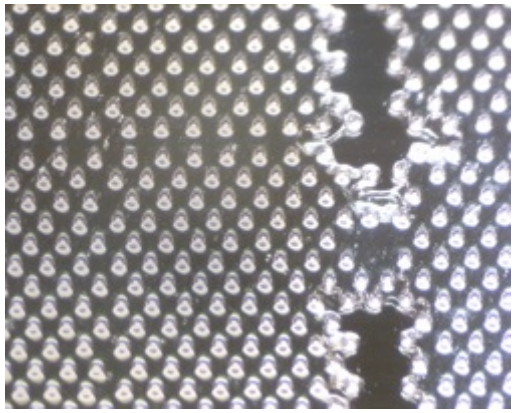
No adhesive



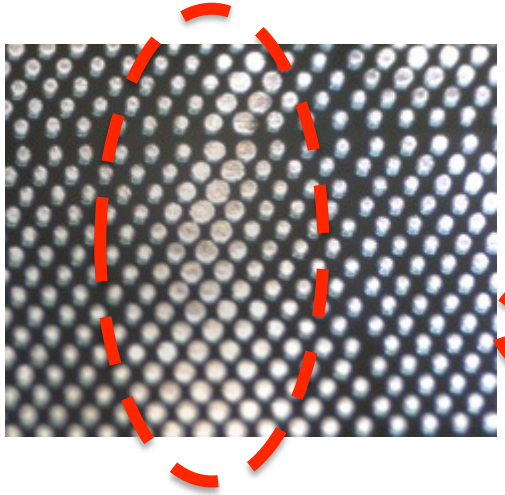
~75% Bump height

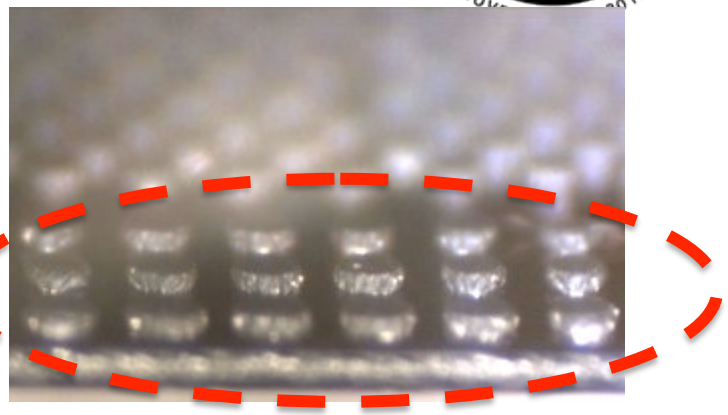
Adhesive

Planarization and Thermal

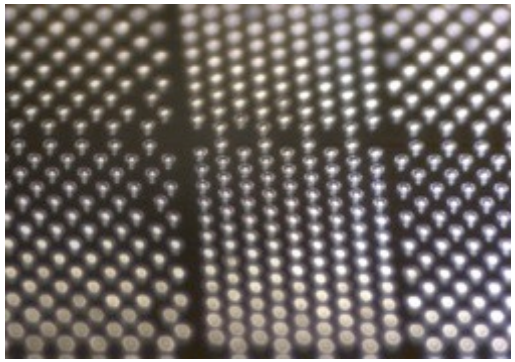


- Voids -

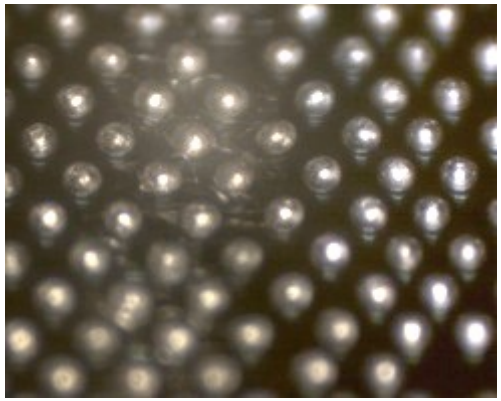


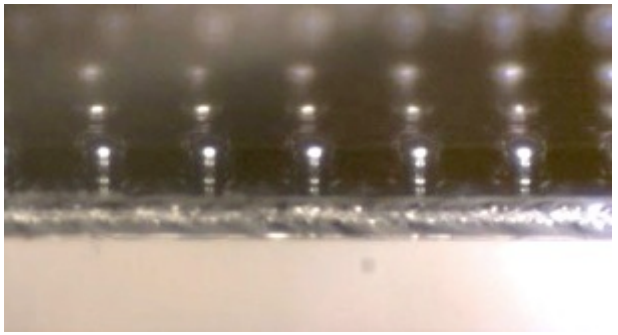


Serious Damage



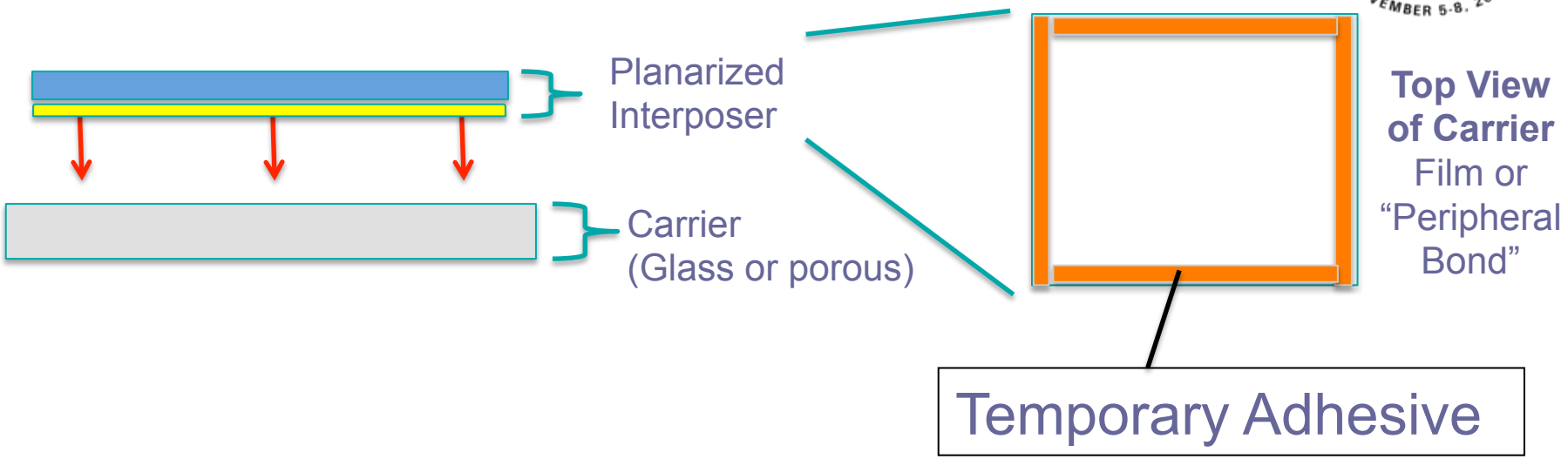
No Voids





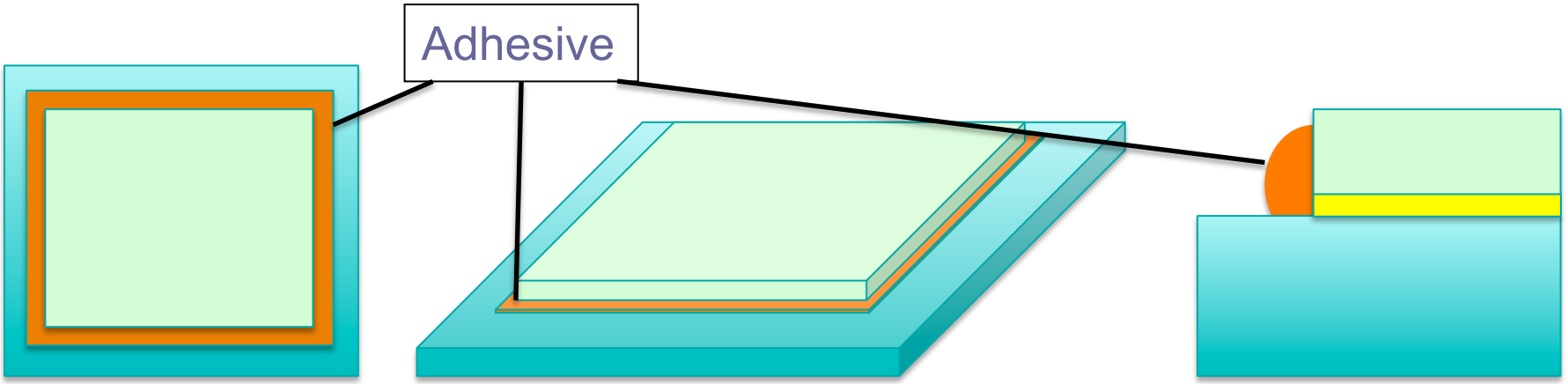
No Damage

Peripheral Bond



- The adhesive is applied on the edges of the carrier – known as *peripheral bond*
- Thin substrate is bonded onto carrier
- Adhesive is cured

Peripheral Bond



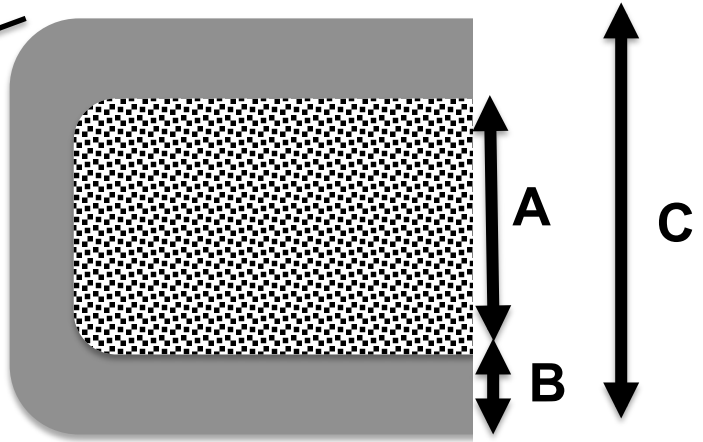
Top View
Film Adhesive

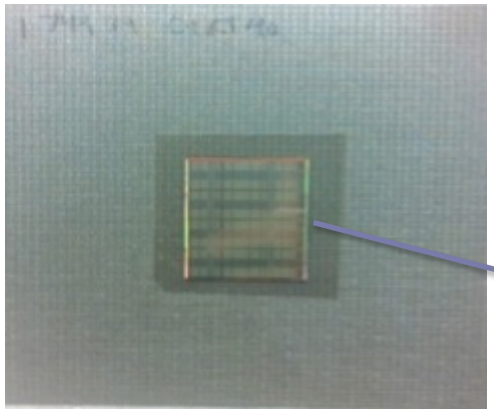
Horizontal View
Film Adhesive

Side View
Peripheral Bond

Porous Carrier

Porosity higher for inside material (A). Outer coating (B) is lower porosity



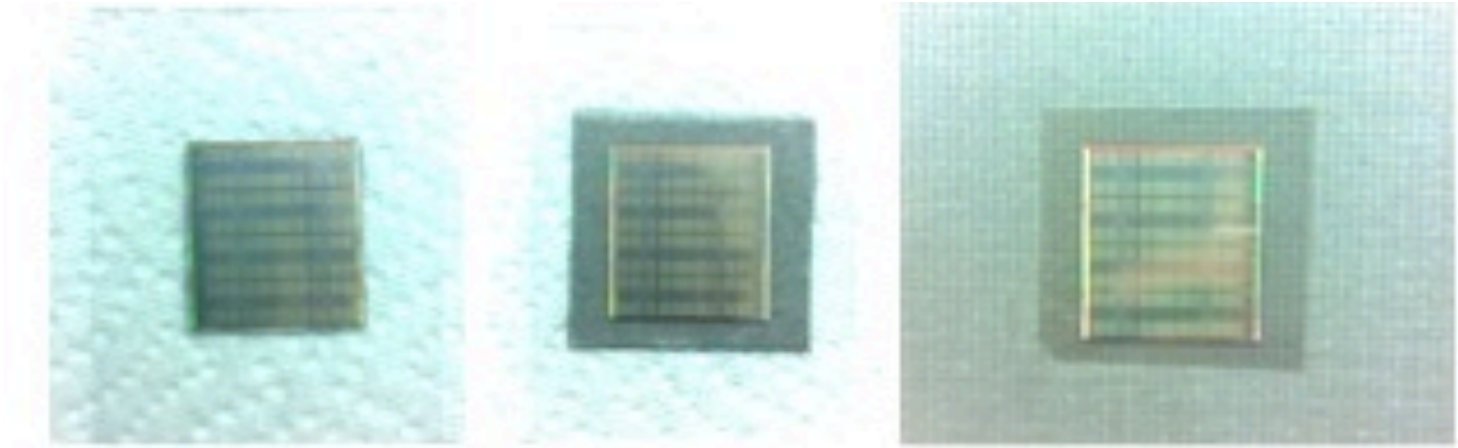


Porous Carrier

TSI on adhesive

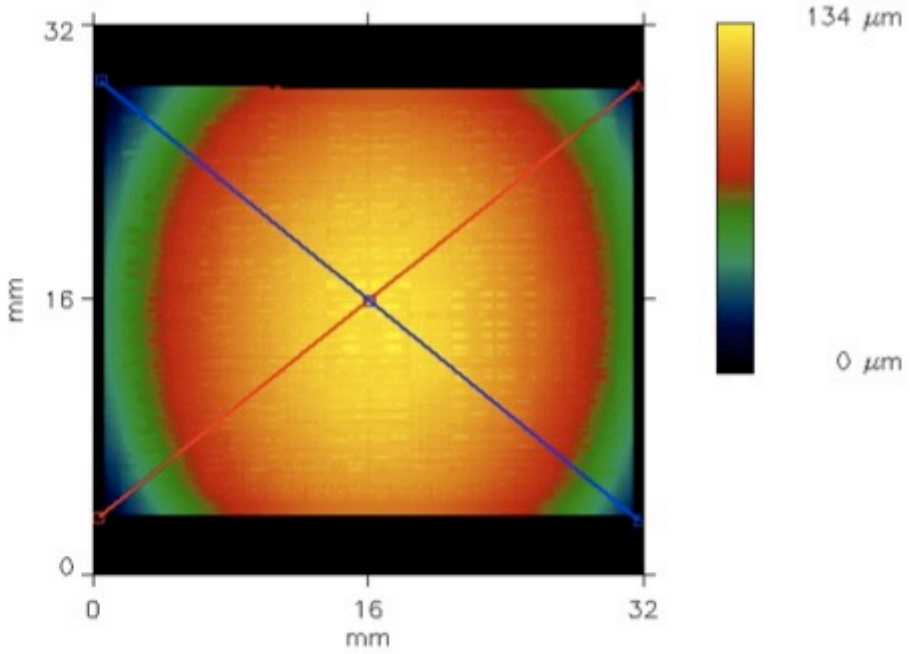
A = 0.5 – 0.8mm
B = 0.1 - 0.25mm
C = 0.5 – 1mm

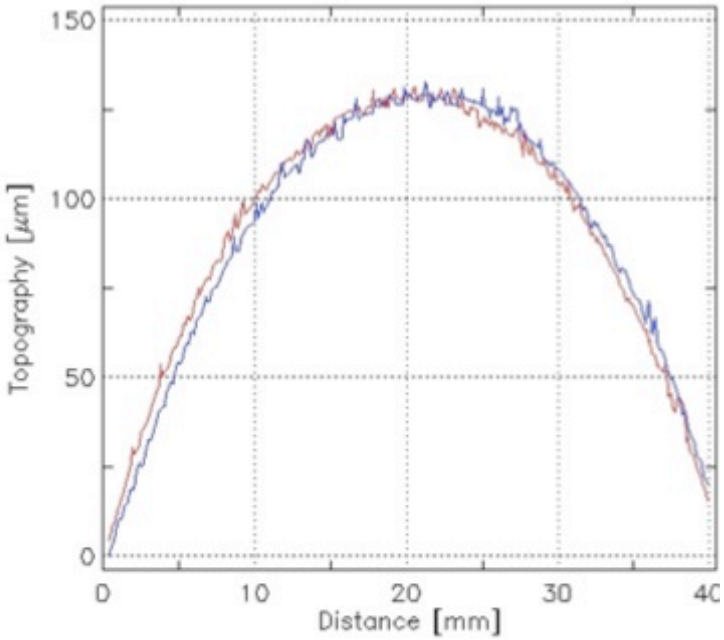
Planarized & Bonded

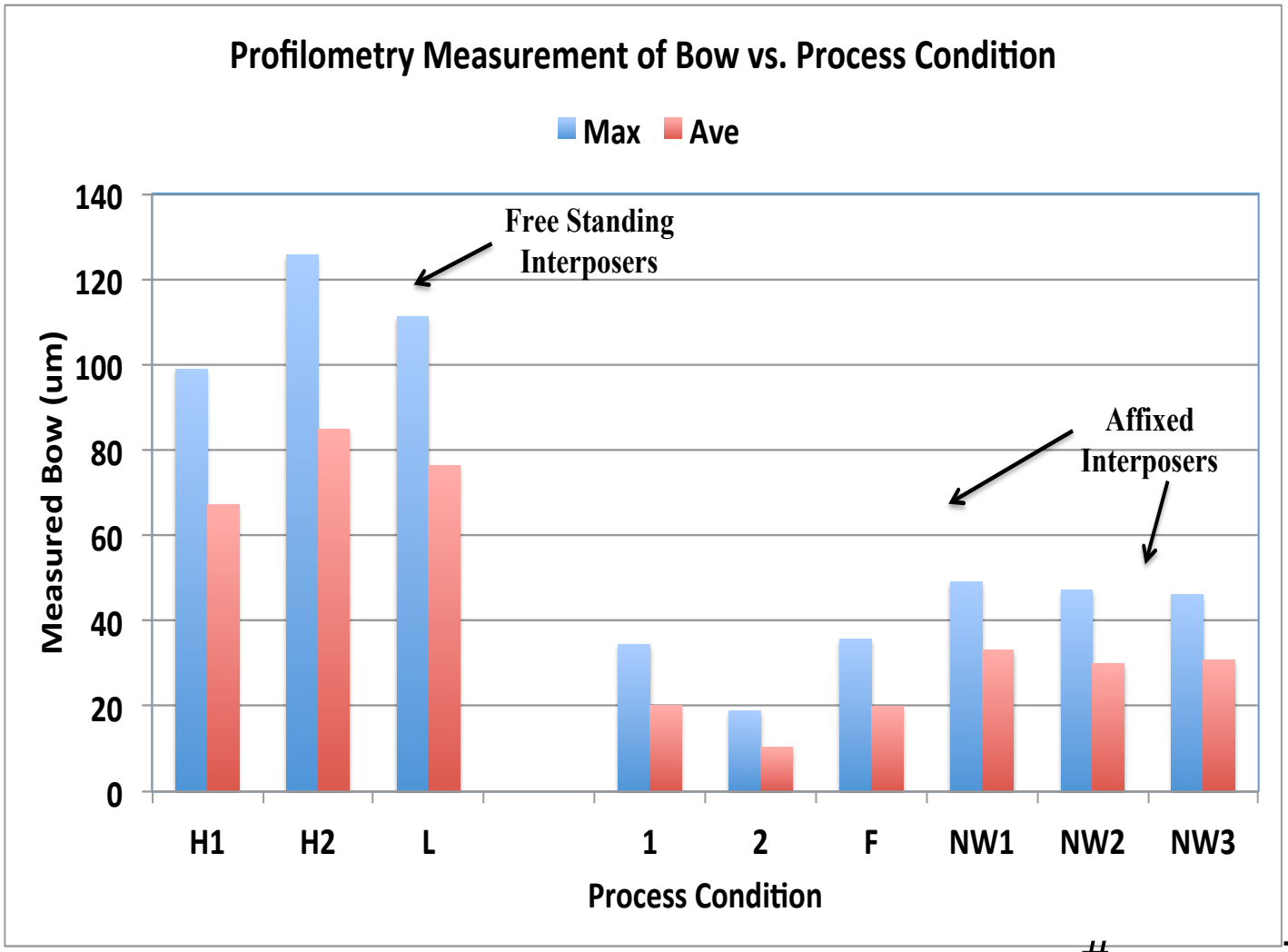


Glass Semi-porous Porous

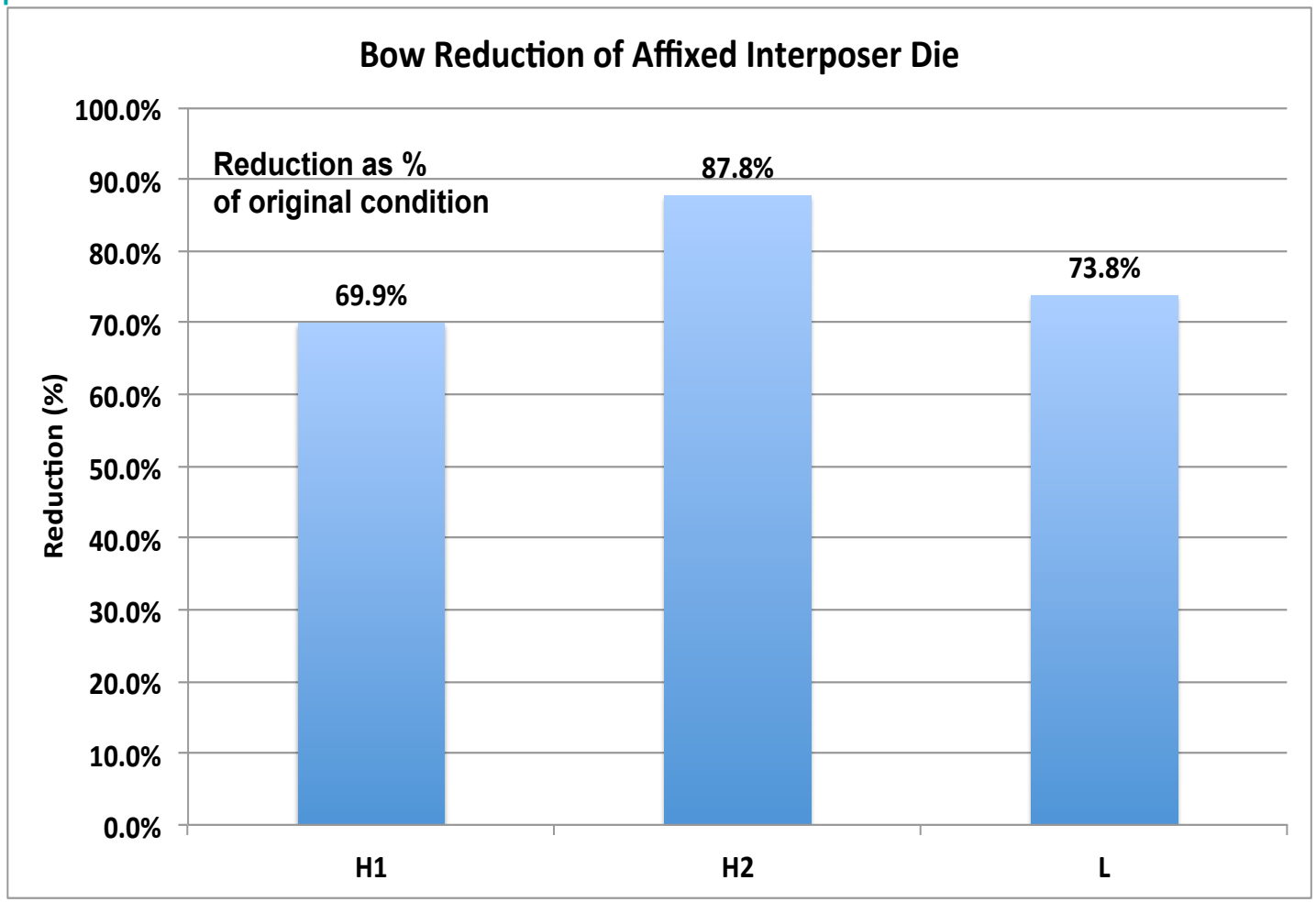
Results – baseline TSI



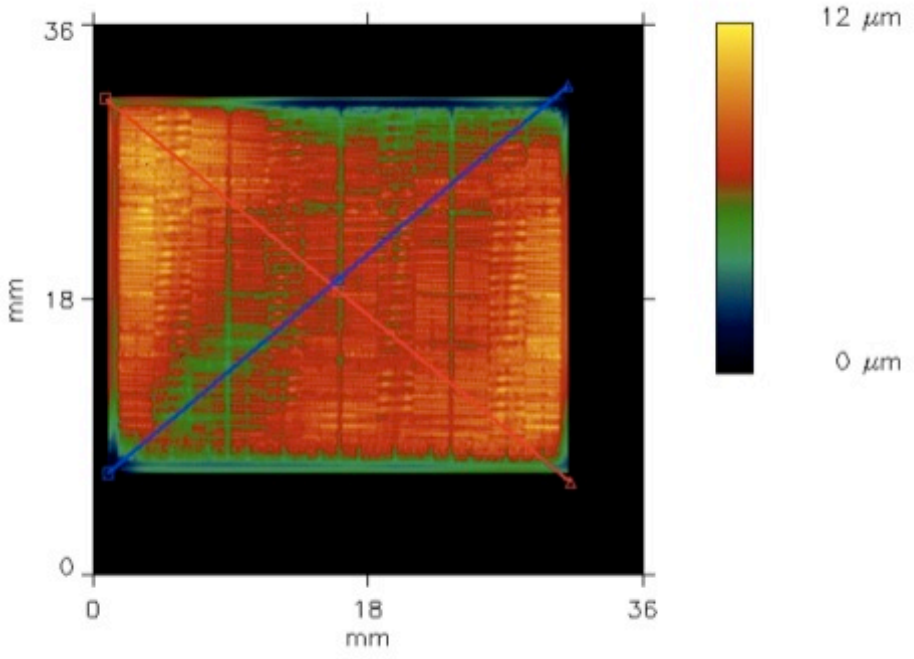


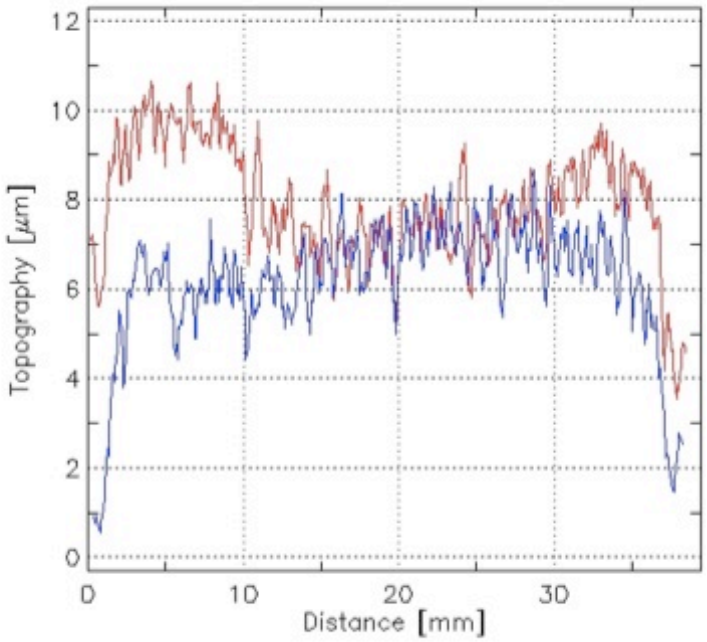


#	Type
1, 2, F	Peripheral
NW	Porous Subst


Bow Reduction of Affixed Interposer Die
Reduction as %
of original condition
Reduction (%)
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
69.9%
87.8%
73.8%
H1
H2
L

Results – Bonded TSI



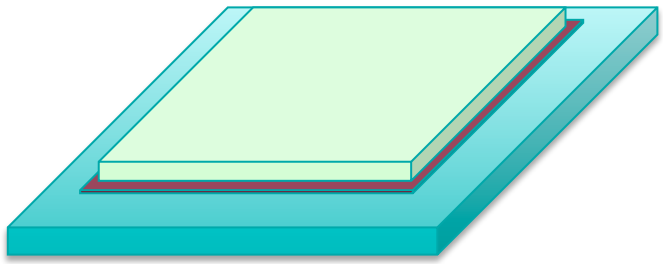


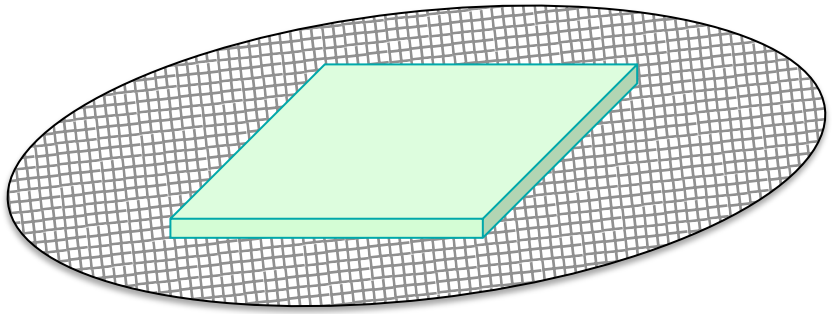
Variation <12um

Results – Adhesives/Cleans

Adhesive	Form	Chemistry	Cleaning
DaeCoat FS300	Film	Silicone	DaeClean SL1750, SL3200
DaeCoat CS300	Liquid/ gel	Silicone	DaeClean SL1750, SL3200
DaeCoat CD170	Liquid	Acrylic	DaeClean DP-108
DaeCoat CD300	Liquid	Acrylic	DaeClean DP-108

Rapid Bond/DeBond Options





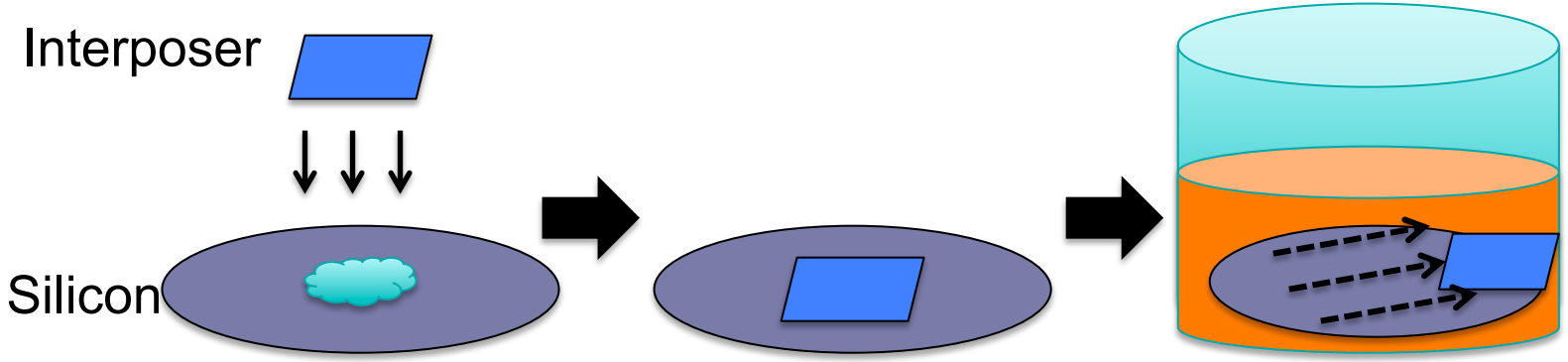
Glass Substrate

- Planarized interposer
- Peripheral bond

Porous Substrate

- Planarized interposer
- Bulk adhesive bond

Results – DeBonding



1	2	3
Prior activity involved applying adhesive to interposer & silicon wafer, holding interposer in place	Bond interposer to silicon wafer, observe flatness and other process details	Debond from silicon in Daetec digesting fluid, observe time

Results - Cleans

- Debond & cleans all occurred <15min, batch
- Cleans chemistry varied with adhesive, solvent to detergent
- Silicone film – solvent cleans
- High temp acrylic – detergent cleans

Summary

- Optical profilometry - critical for measurement
- Bow reduction to 90% is demonstrated using simple tooling, manual practice
- Demonstration of peripheral & porous bond
- Temporary adhesives w/detergent cleans
- Batch debond/cleans <15min

Contact for More Information

- DAETEC provides development, consulting, and technical training/support to solve manufacturing problems and introduce new options of doing business.
- Diversified Applications Engineering Technologies (DAETEC)

  Camarillo, CA (USA) (805) 484-5546

  jmoore@daetec.com; www.DAETEC.com