Low-Cost Adhesives for Temporary Substrate Support

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Daetec, LLC

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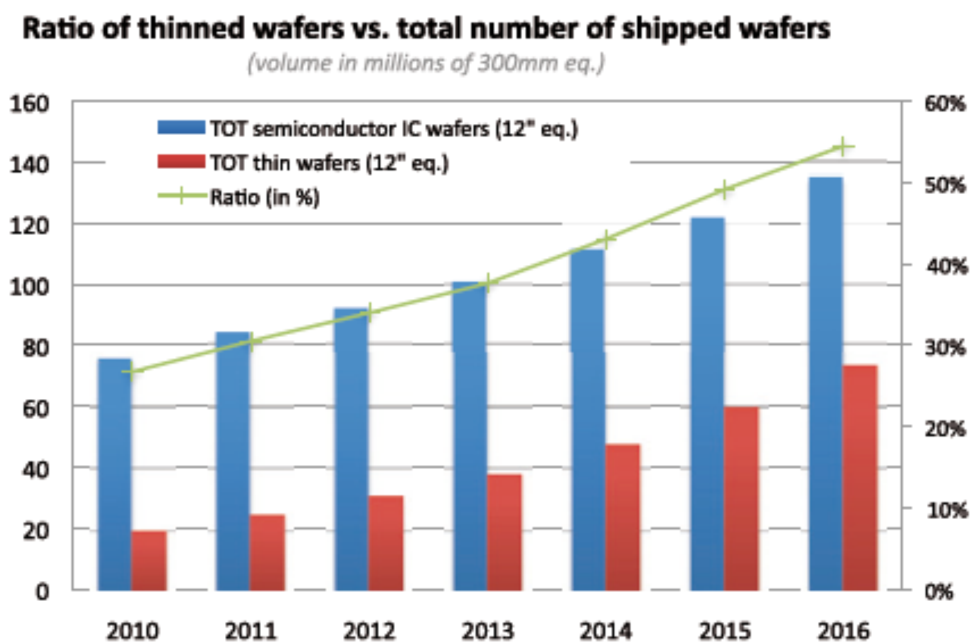
Trending to Thin Substrates

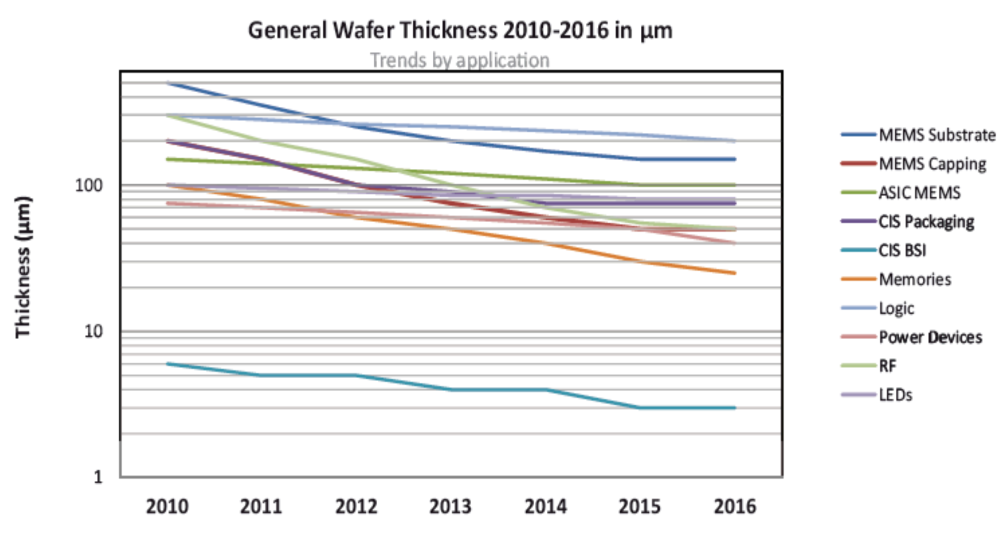
- 2011 - 25% of all wafers are thinned
- ~2yrs, this is expected to double – nearly half of all wafers will be thinned

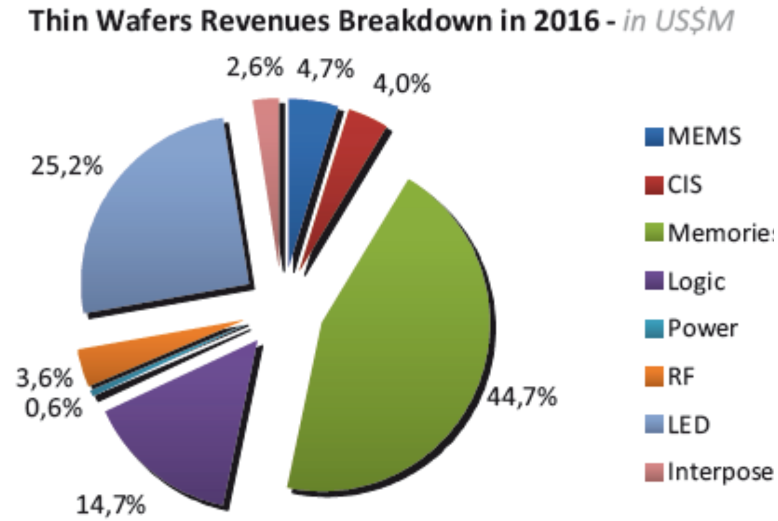


Courtesy: Yole Developpement

Thinning below 100um

- 2011, 80-100um
- ~2yrs, 50um
- ~5yrs, 20-30um





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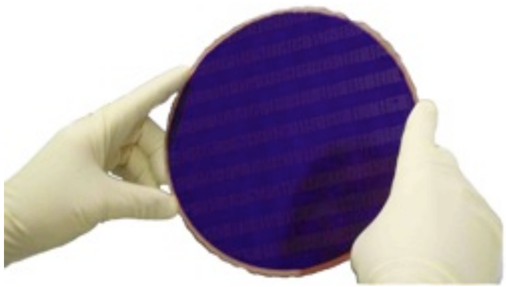
Daetec's Business



Semiconductor: Daetec's major business surrounds the manufacturing of semiconductor devices. Coatings and cleaners for improving yield and reducing costs.

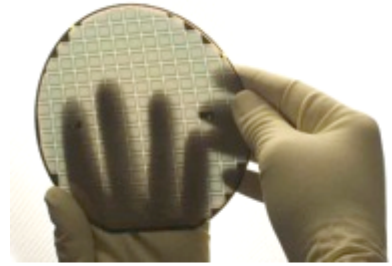
Aerospace: Thermal resistant systems & washable temporary systems.

Panel making: Daetec's newest markets include TFTLCD and OLED panel making practices. Coatings based upon silicone, UV cure acrylics, washable and peelable, and thermal resistant systems to >450C.

Daetec's Customers

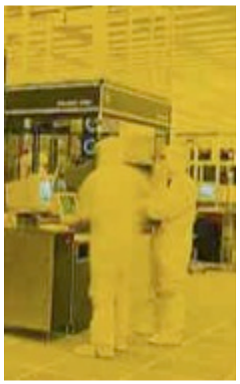
- Daetec has developed products, patents, written papers, and presented work with a wide number of leaders in many industries. Our work spans many technologies enabling growth and market capture with our customers.

Product Development

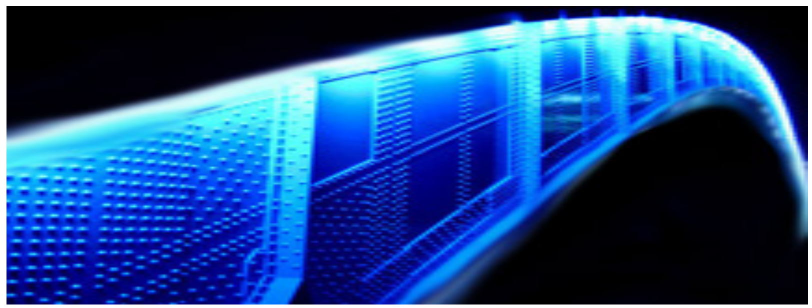


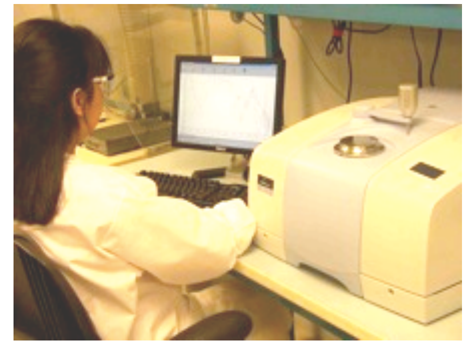
Substrate Handling

Fab Mfg. Support



DAETEC



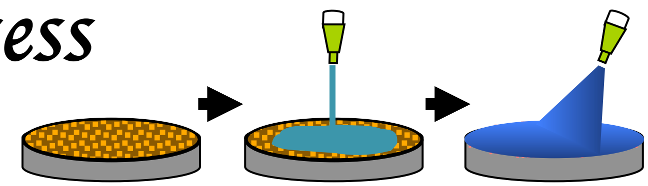


Analytical Testing

Bridging Your Success

Intellectual Property

Toll Support



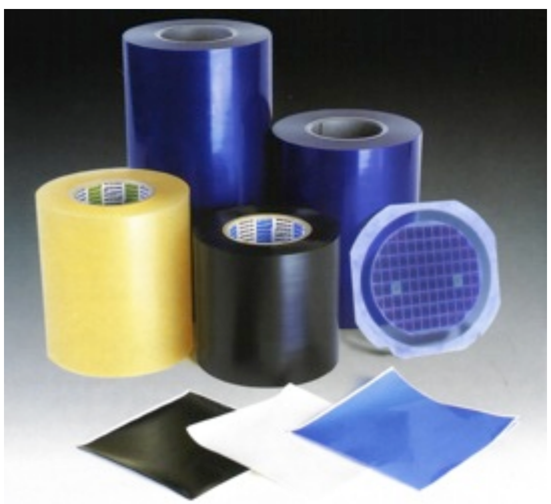
Process Development

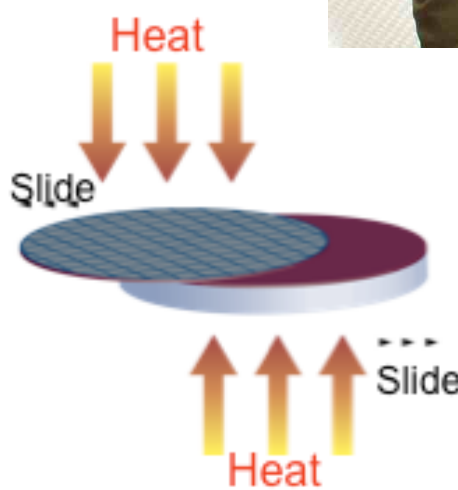
Temporary Adhesive & Backside Processing

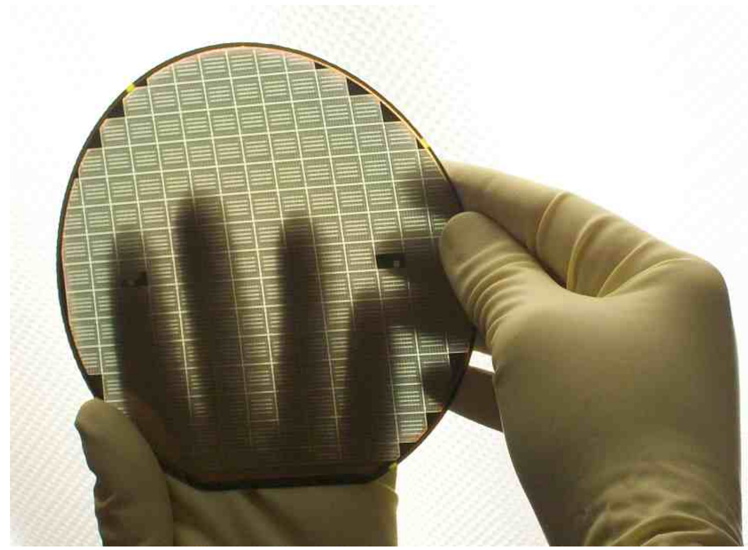
- Adhesive: Mount product wafer to carrier
- Carrier: Silicon or glass, sapphire
- Temporary: Apply to meet mechanical and chemical properties, seal front side, removal when complete
- Backside processing: Achieve connectivity (lithography, etch, metallization)
- Removal: Cleaning complete, no residue

Typical Thin Wafer 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

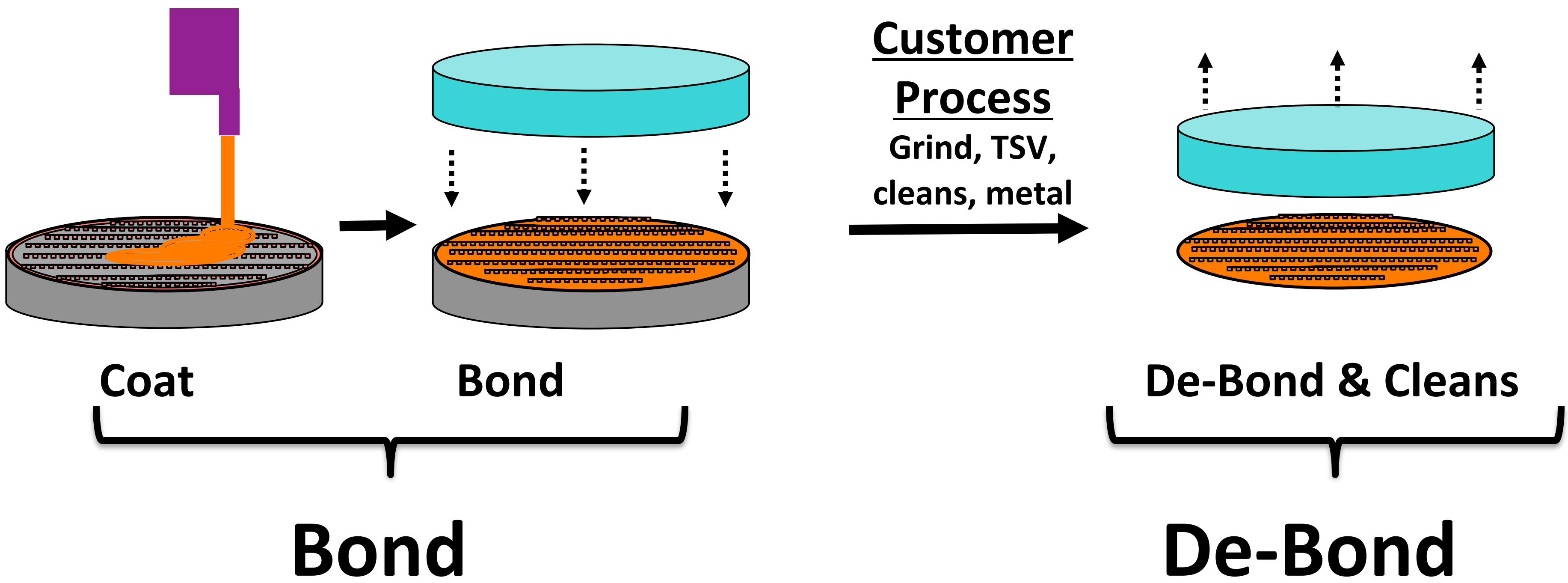
Thinner is Better

Must be Resistant

Versatility Is Best

Must do Backside Processing

Temporary Bonding Process



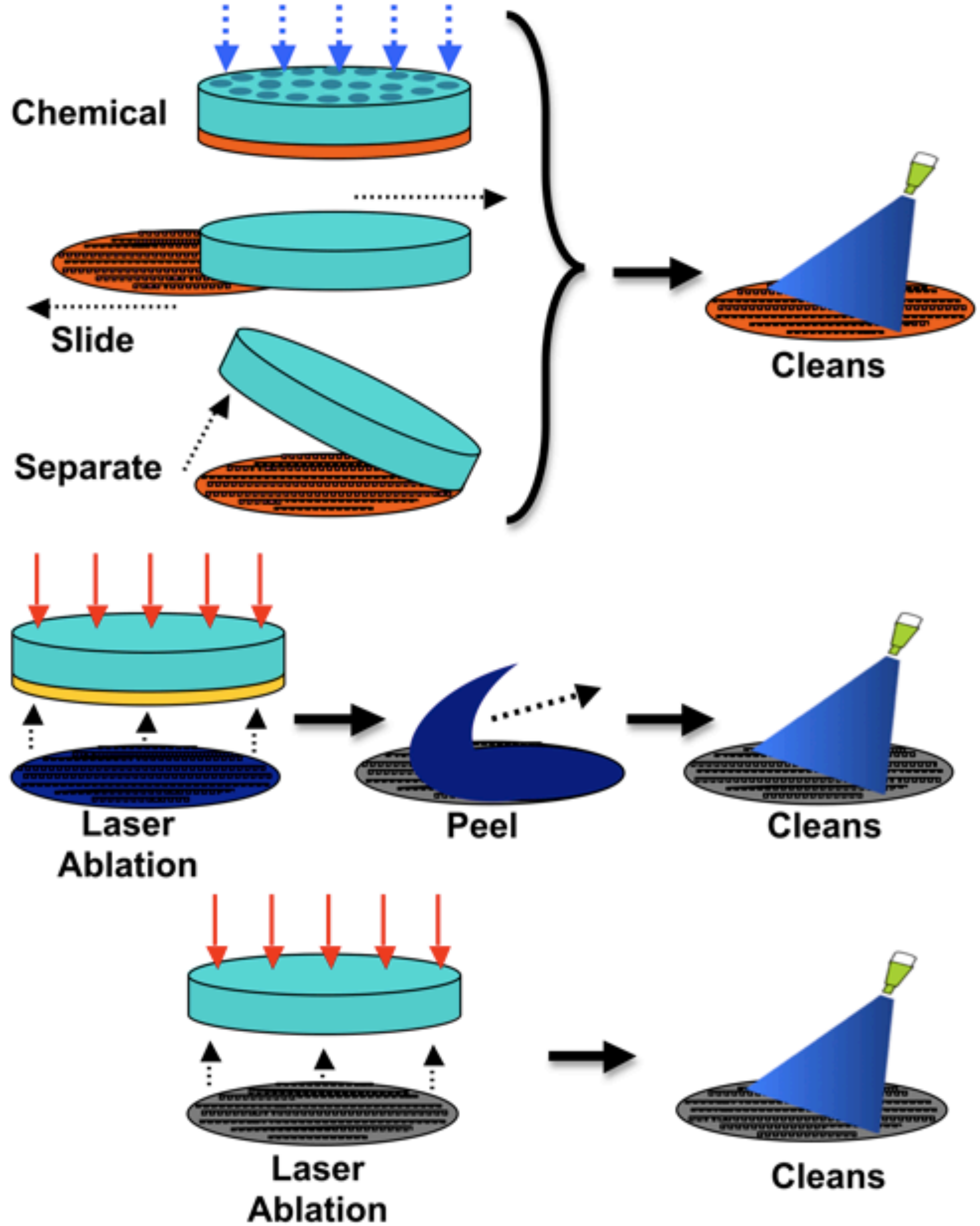
Two ACTIVE steps occur with Temporary Bonding Technologies.
The "BOND" step appears similar between popular practices.
Primary differences occur during "DE-BOND".

De-Bonding

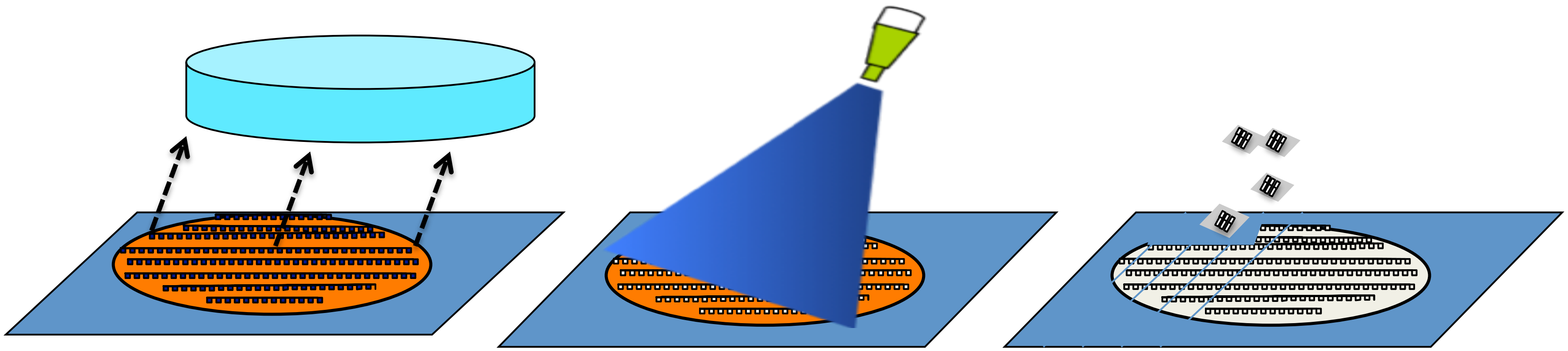
Rubber, olefinic & high MW hydrocarbon polymers, blends

Acrylic, styrenic, and blends

Polyimide & silicone



Roadmap to Dicing



Film Attachment
Carrier Demount

Wafer Cleans
Safe for Tape

Dicing

Evaluation underway for Adhesive 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

Special Properties

- Thermal resistance: Minimum 200 °C
- Low-pressure safe: Supports etch and deposition processes
- Low-stress: Reduced deflection and bow to product wafer

Thermal Resistant Systems

Chemistry	Cure Method	Thickness	Thermal Resistance	Moisture Resistance
Epoxy	UV	<20um	>275C	Yes
Rubber	Evap	<15um	>250C	Yes
Poly-phenylene	Evap	<10um	>330C	Yes
Imidazole	Evap.	<5um	>450C	Yes
Biphenyl Sulfonate + Polyester	Evap.	<10um	>300C	No
Acrylic	UV	<20um	<250C	Yes
Silicone	Catalytic	<10um	>300C	Yes
PEI	Evap	<10um	>400C	Yes
Hybrid system	Evap	>50um	>500C	Yes

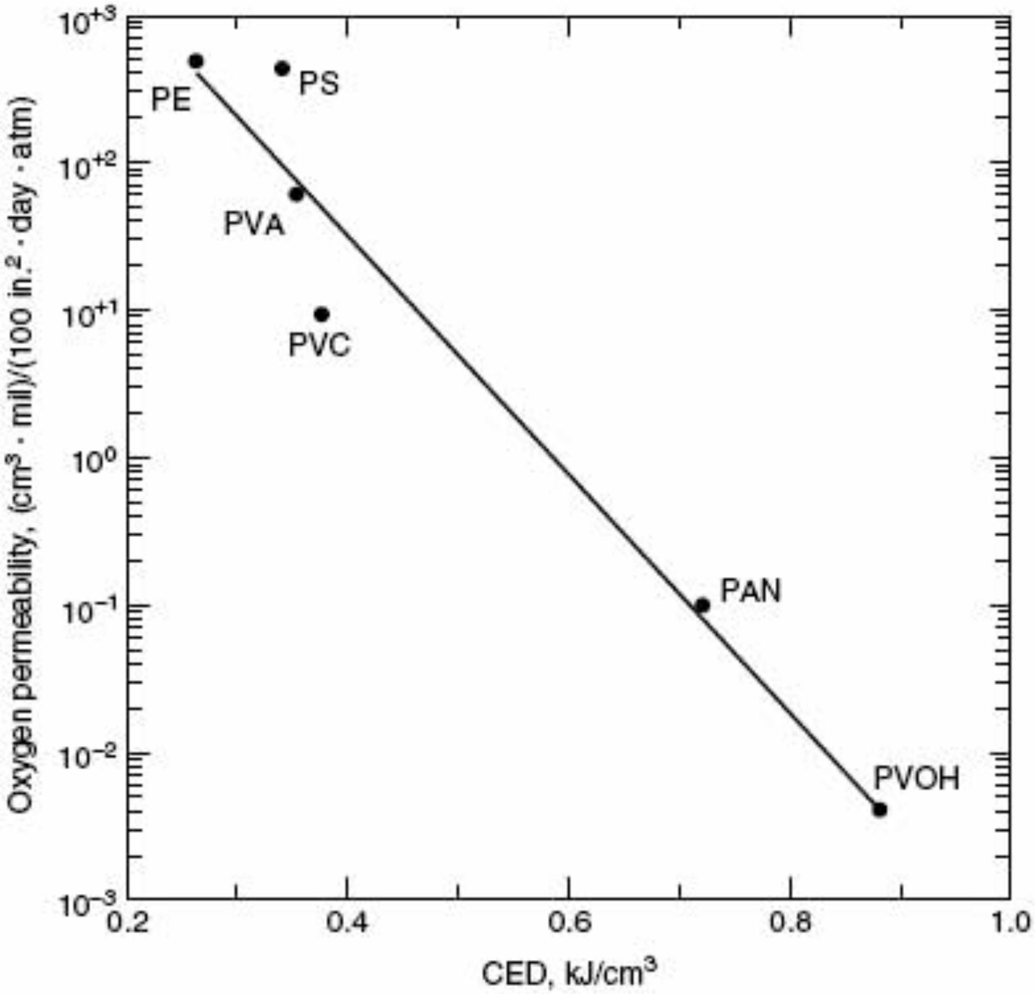
Polymer Gas Permeability

Gas permeability: cm3-mm/m2-day

Polymer	N_2	O_2	CO_2	H_2	H_2O
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

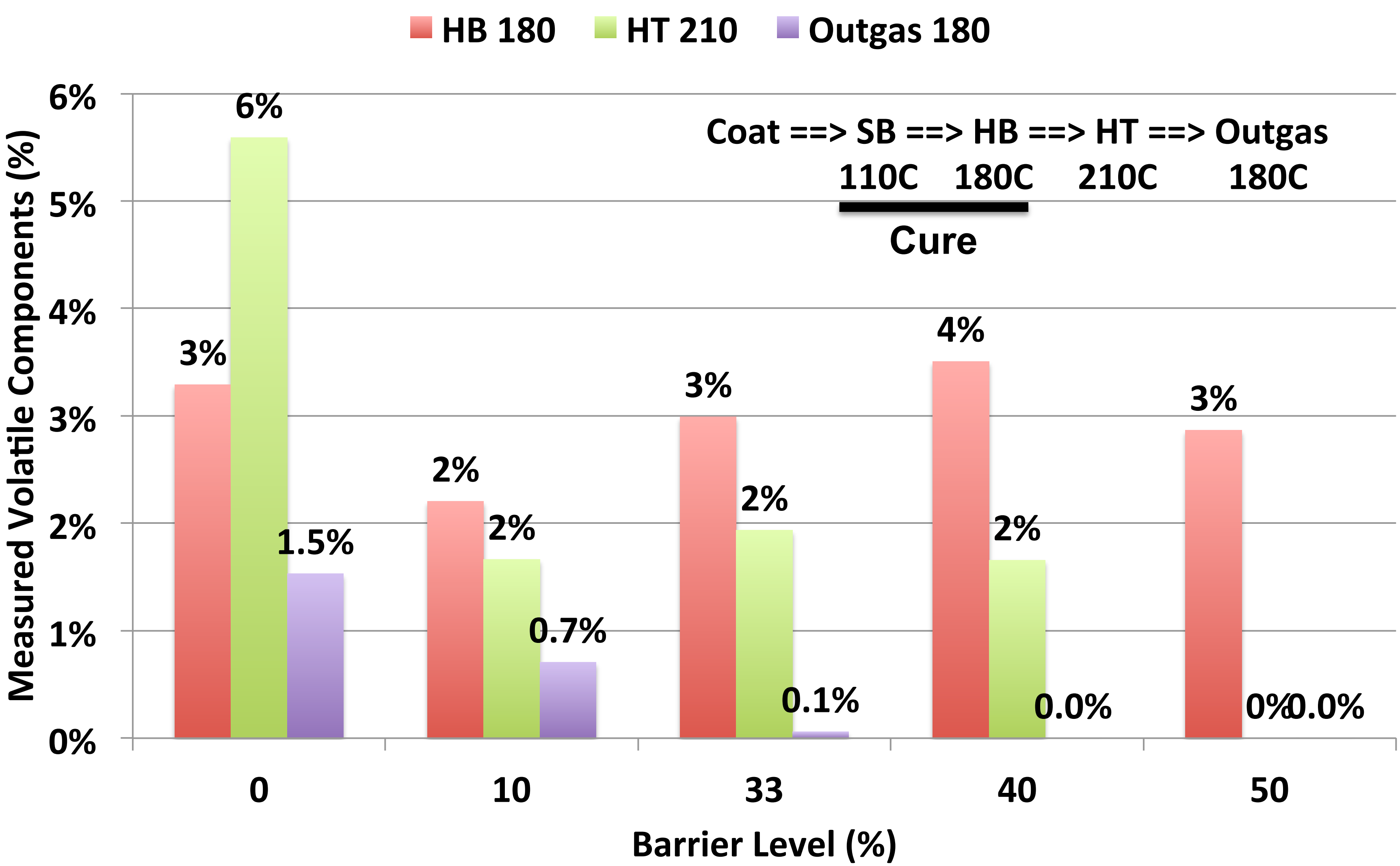
Barrier Usage for Reduced Outgas



Gas Barrier Properties

Assist with formulating low outgas coatings

Volatile Component vs. Temperature Exposure

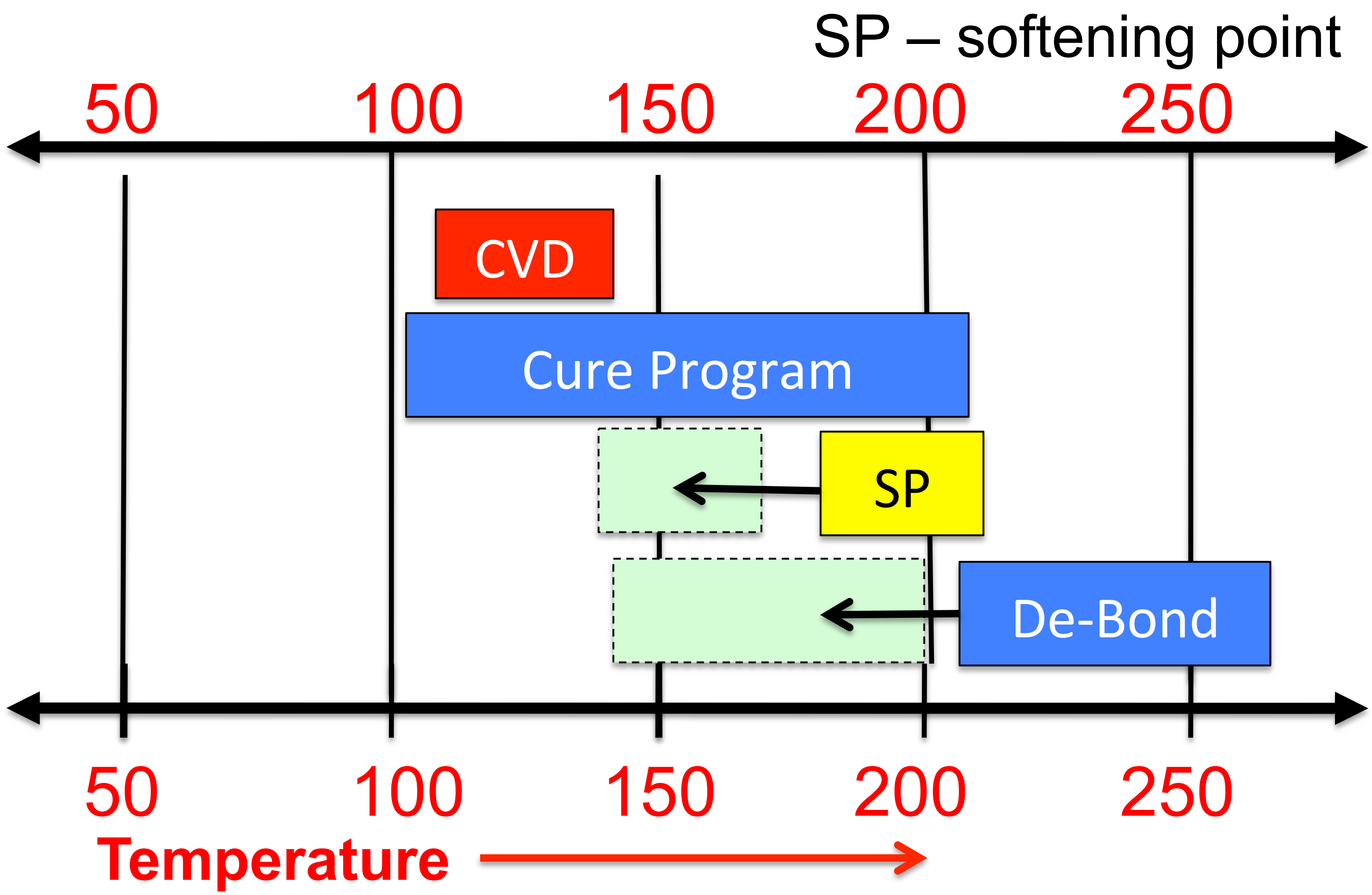


Low Outgas Product for CVD

Targets for successful CVD processing:

- Low permeability coating
- High Tg
- If amorphous, high softening/melting point
- Softening/melt pt is > process temp
- Design cure program as > process temp

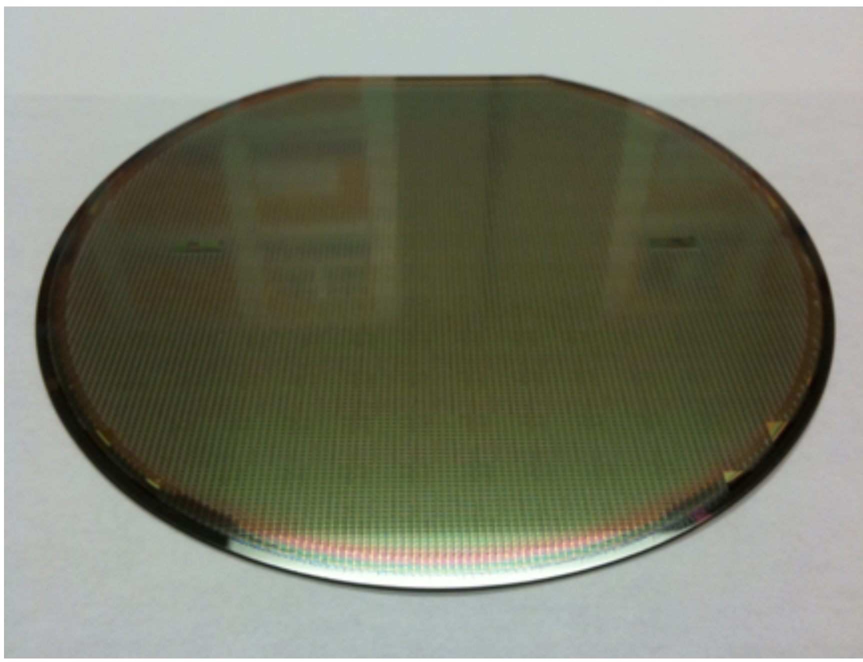
Process Overlay



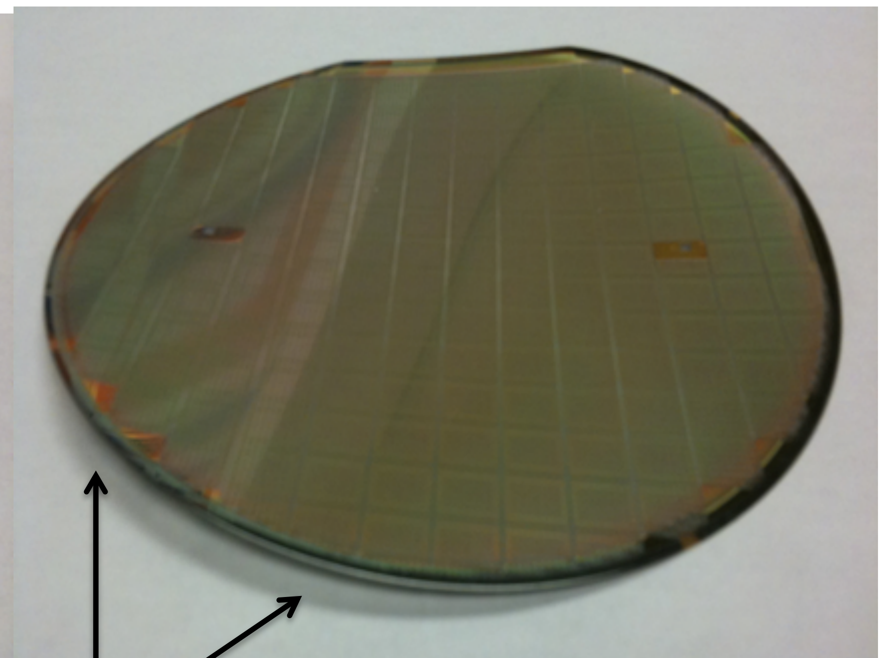
Stress Introduction

Bowing is observed from internal stress of microelectronic layers

Full thickness ~ 700um

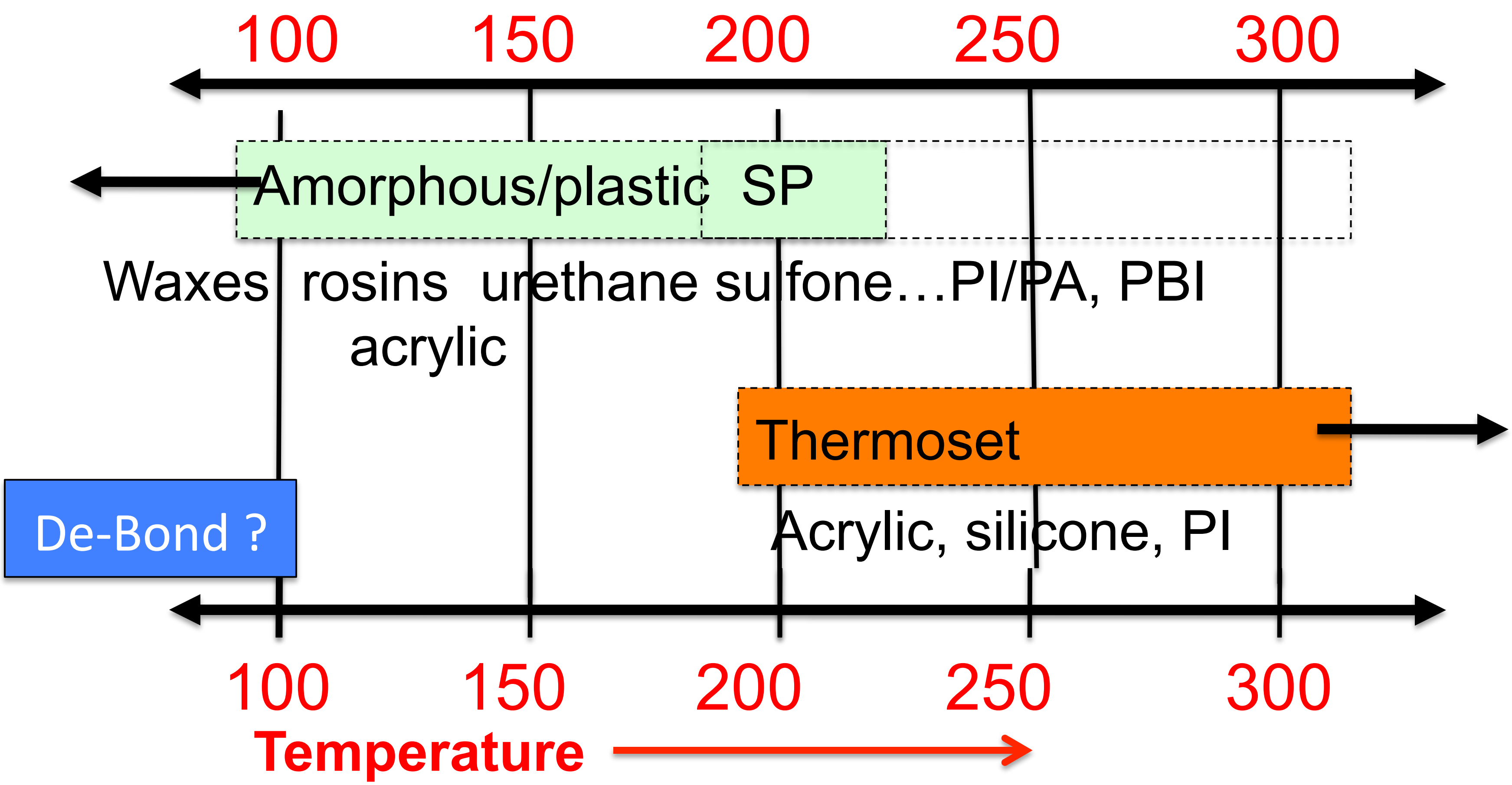


Thinned ~ 100um



Wafer Bow

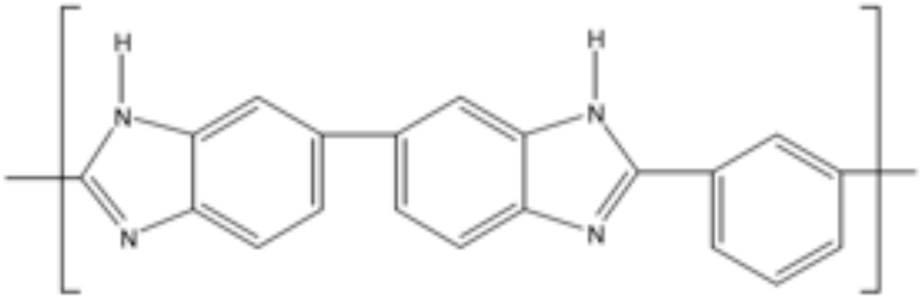
Materials Overlay

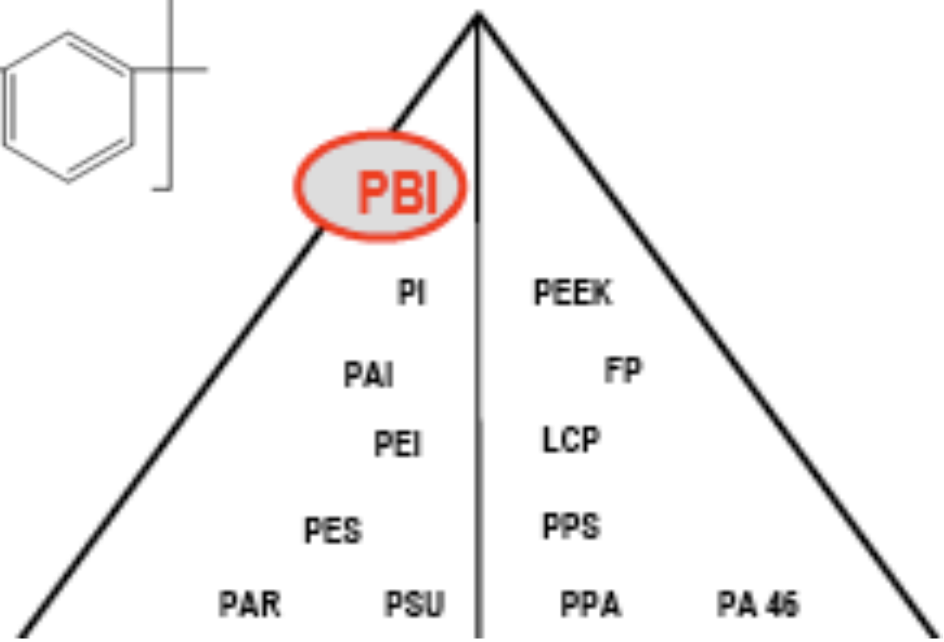


PBI UV Cure System

- Thermal resistant (tunable) >300C
- Applied by spin-coating, spray, roll-coat, pipet
- Low temp cure, <150C in minutes
- Low outgas at high temps (300C)
- Debond and cleans (chemical)

PBI – High Temp Thermoplastic



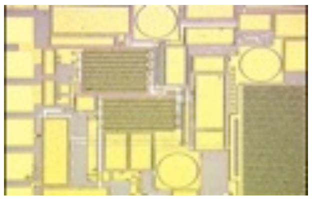


Tg	**= 427 °C**
CTE (ppm)	**= 23**
Modulus (Gpa)	**= 5.9**
Elongation (%)	**= 3**
Moisture abs (%)	**= 0.4**
Breakdown (v/mil)	**= 580**

Fire Fighting & Protection

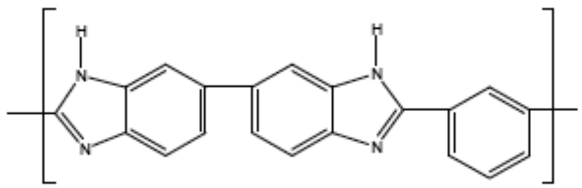
Automotive

Injection Molding



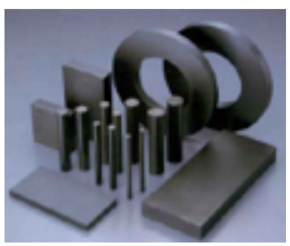
Electronics & Semiconductor

Polybenzimidazole (PBI)



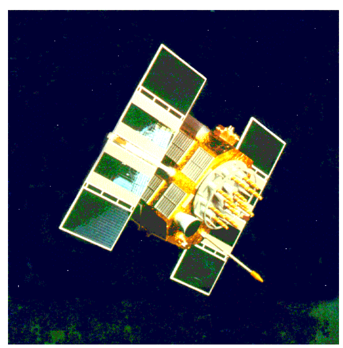
Aviation

Thermal Resistance
for Multiple Applications

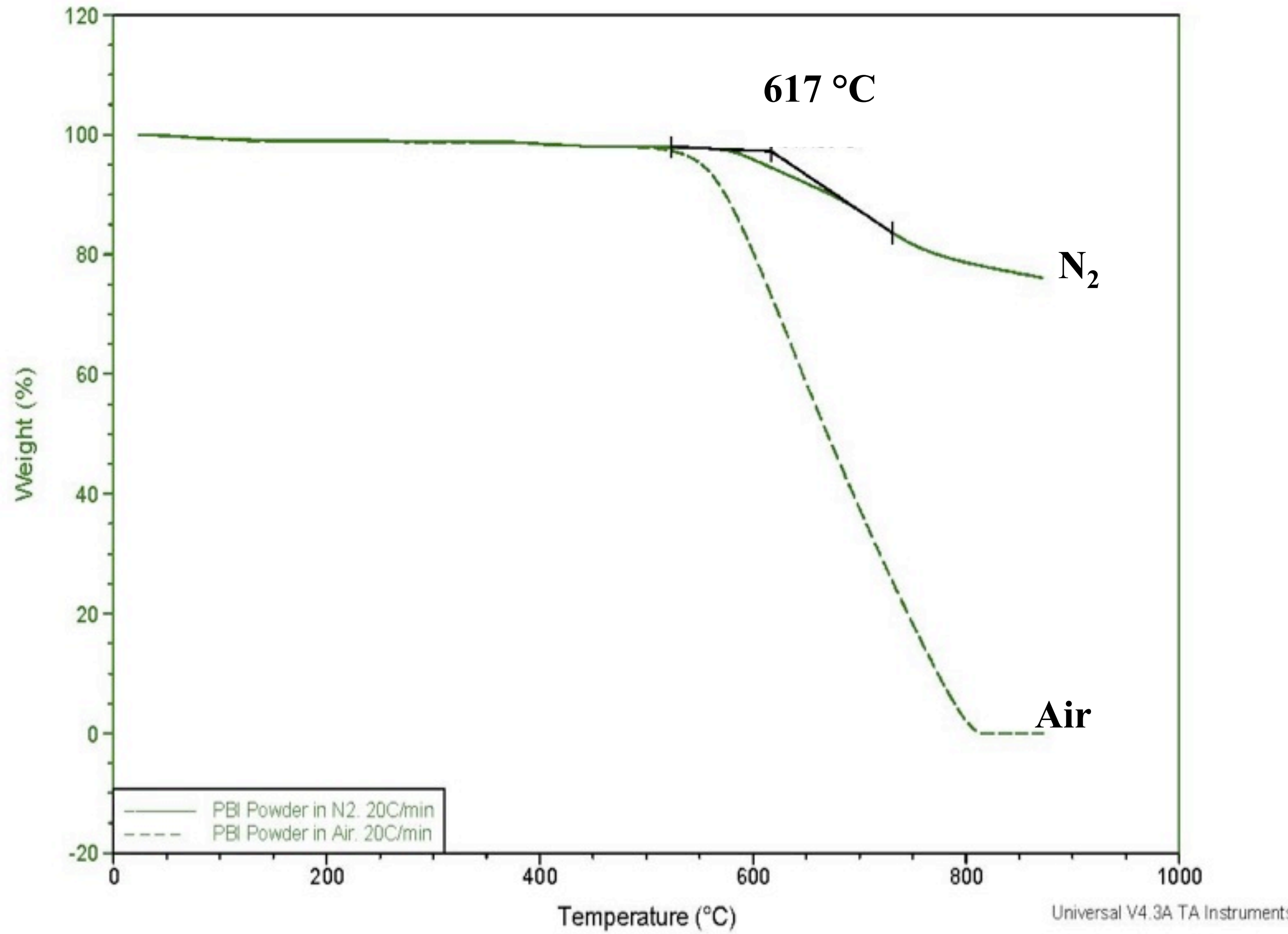


Compression Molding

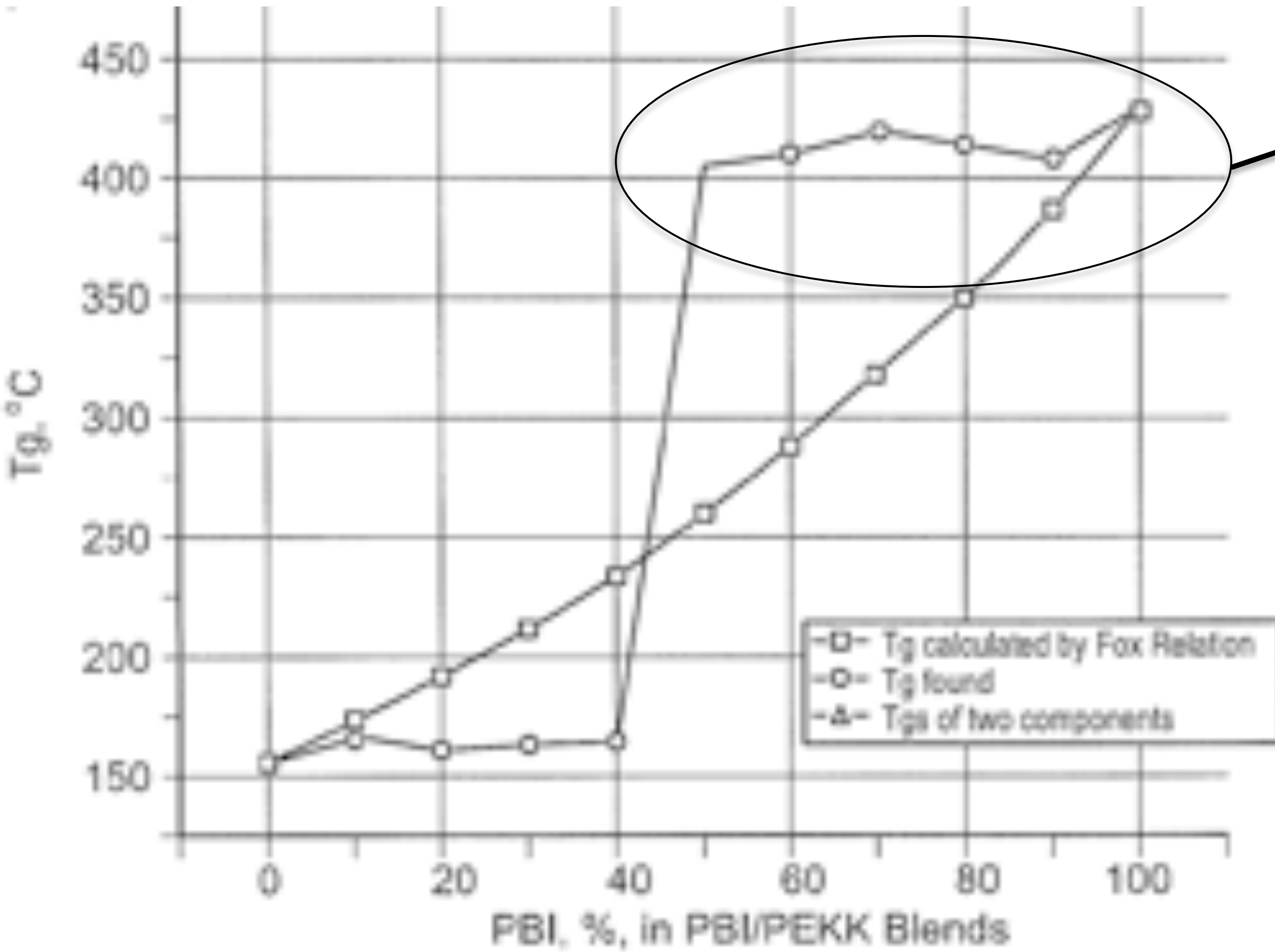
Metal Working



Aerospace


617 °C
N_2
Air
120
100
80
60
40
20
0
-20
Weight (%)
0
200
400
600
800
1000
Temperature (°C)
PBI Powder in N2. 20C/min
PBI Powder in Air. 20C/min
Universal V4.3A TA Instruments

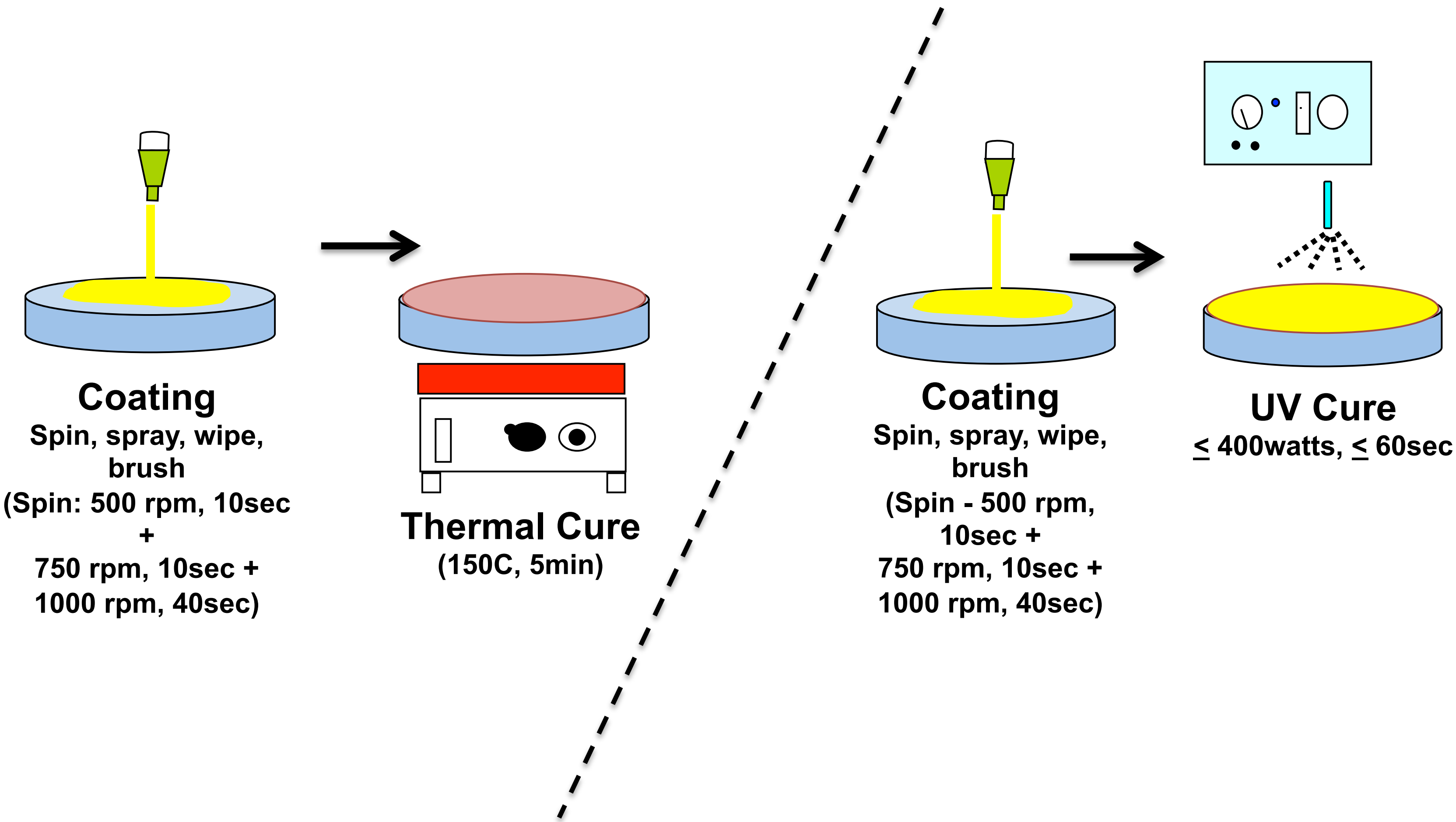
PBI Polymer Blends



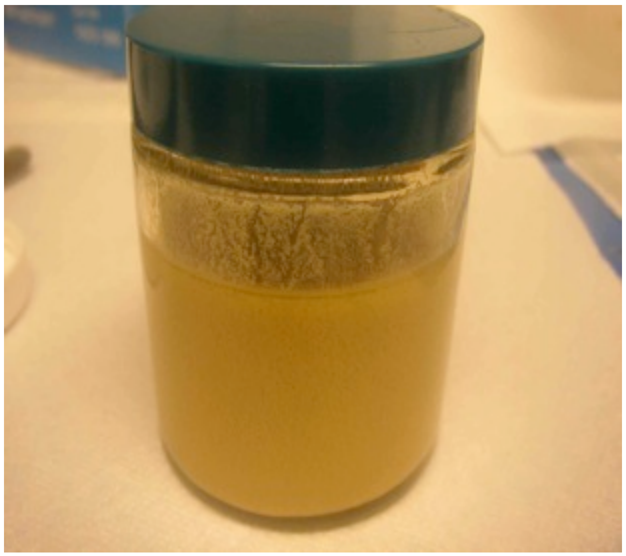
Blends of PBI/PEKK* represent PBI (i.e. Tg >400C) when >50% PBI

***polyetherketoneketone**

Evaporative vs UV

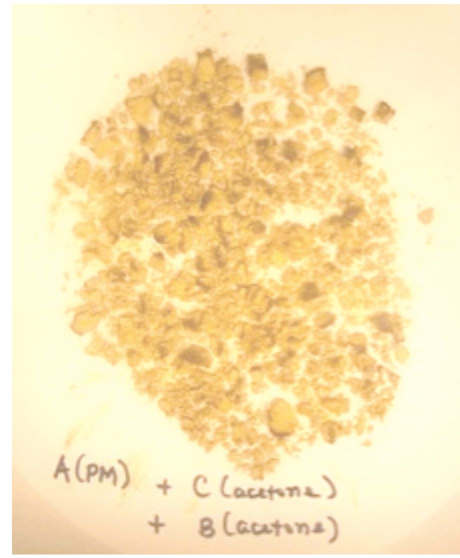


PBI "Recon"



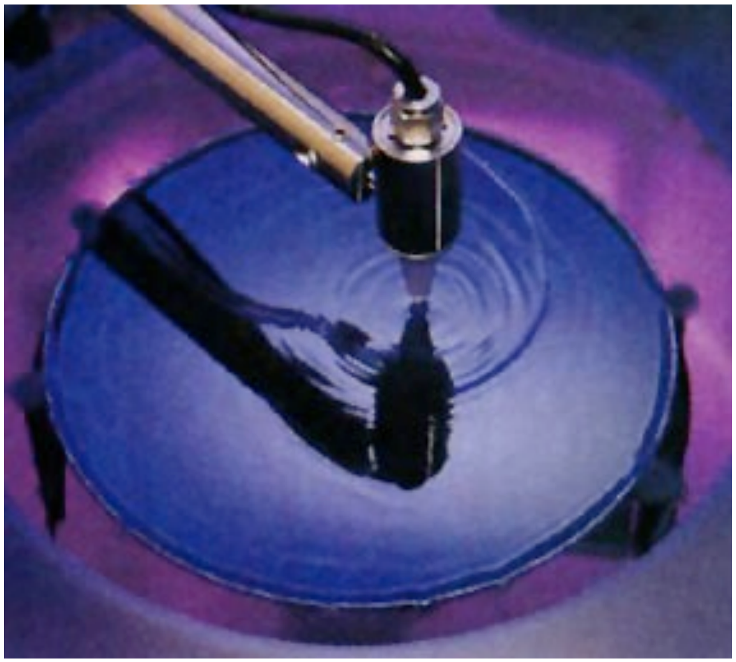
PBI ppt

Filter

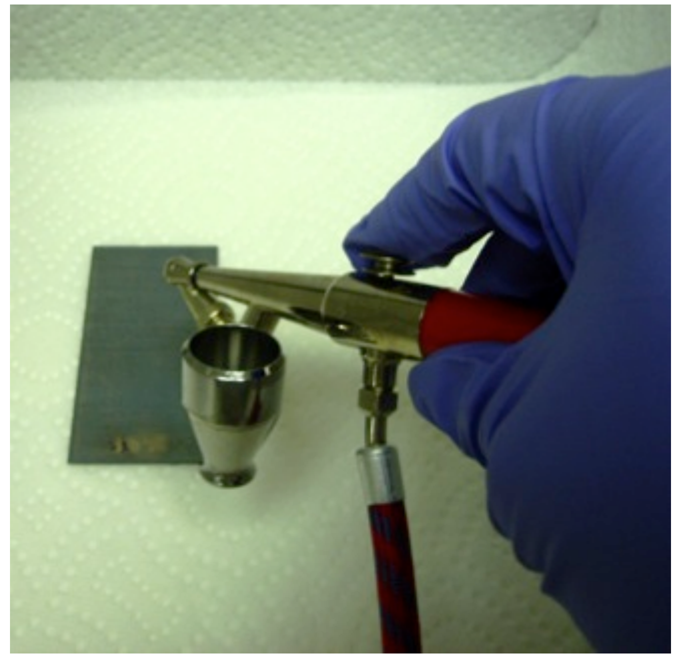


Dry

Coating Application Options

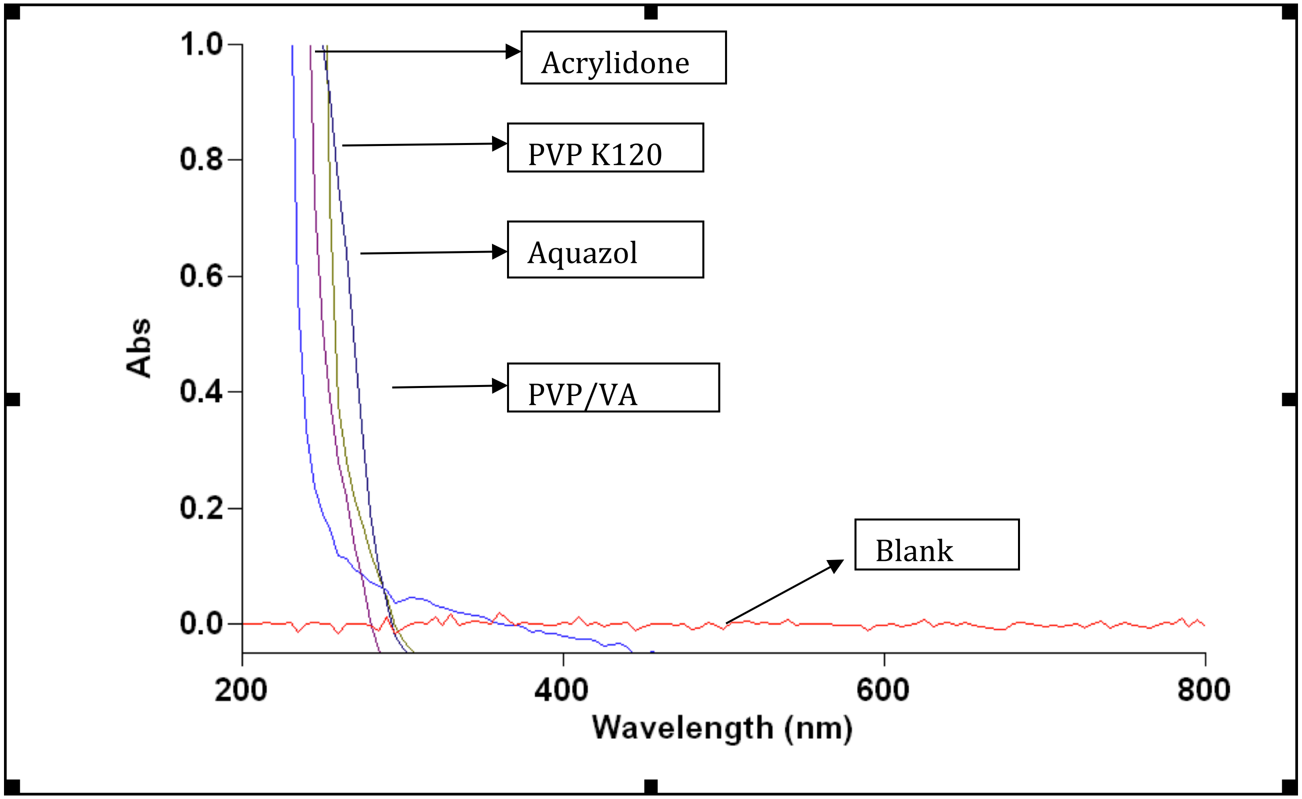


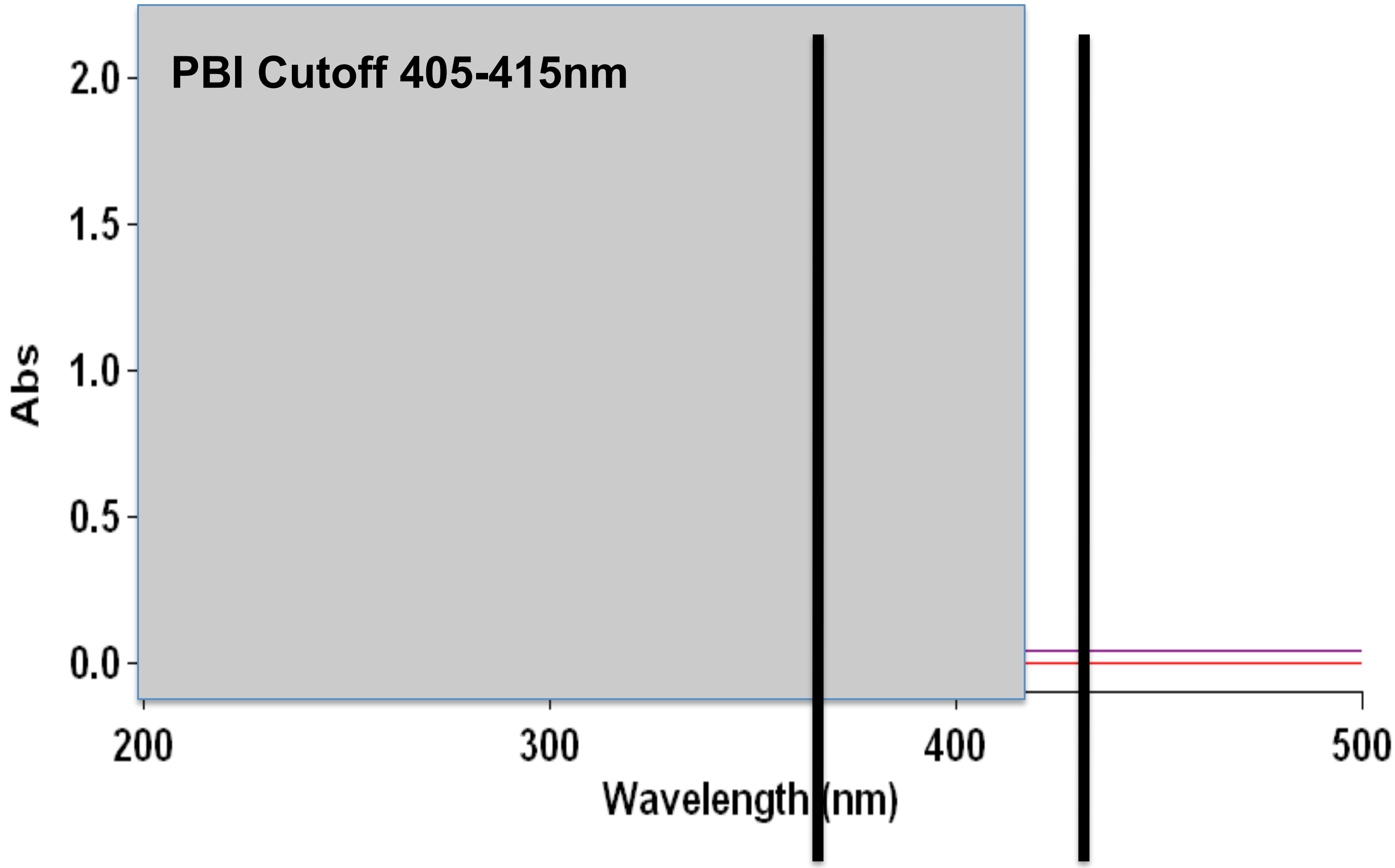
Spin-Coating



Spray-Coating

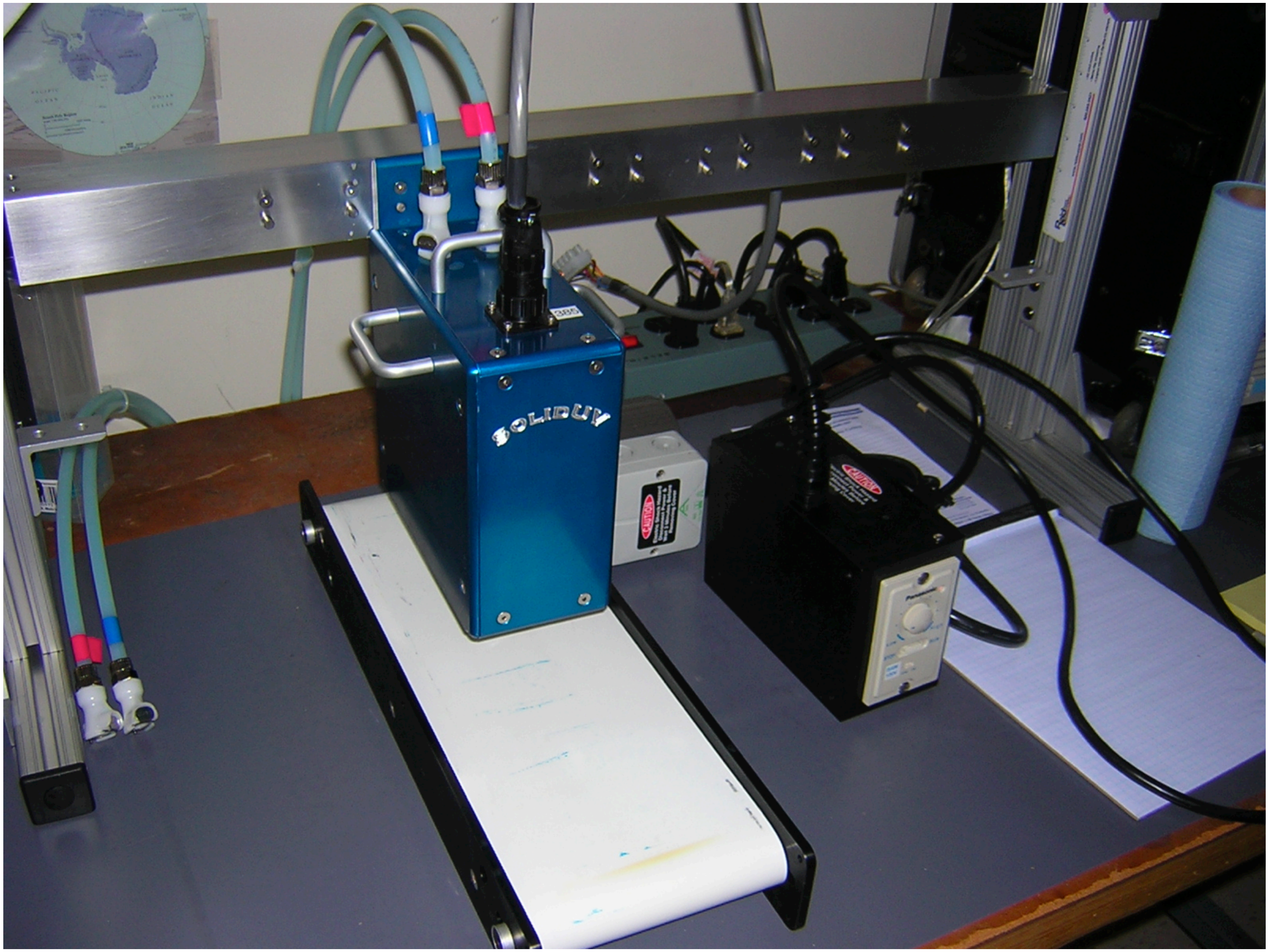
Transparency for UV Applications





I-line 365nm

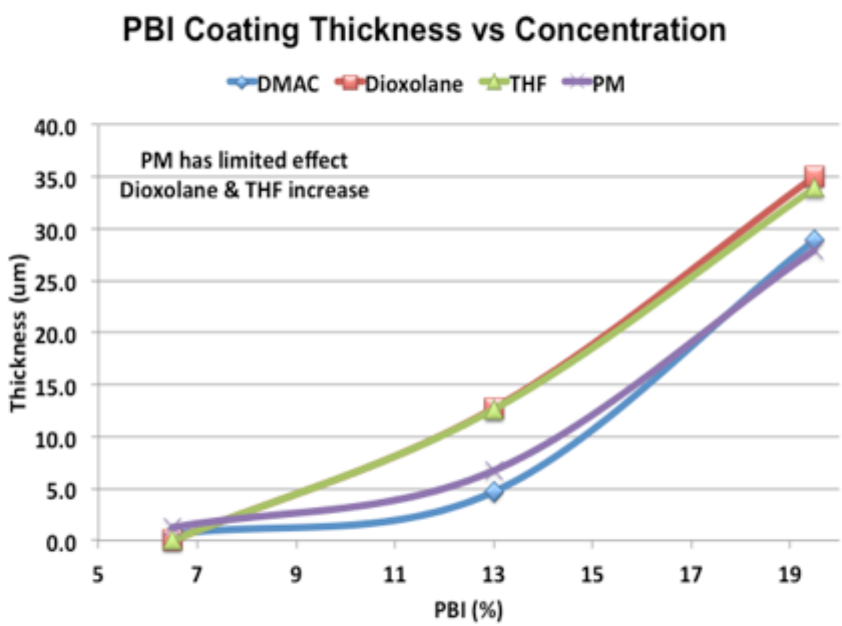
G-line 436nm


SOLIDUV

Hg Lamp Unit (Fusion)

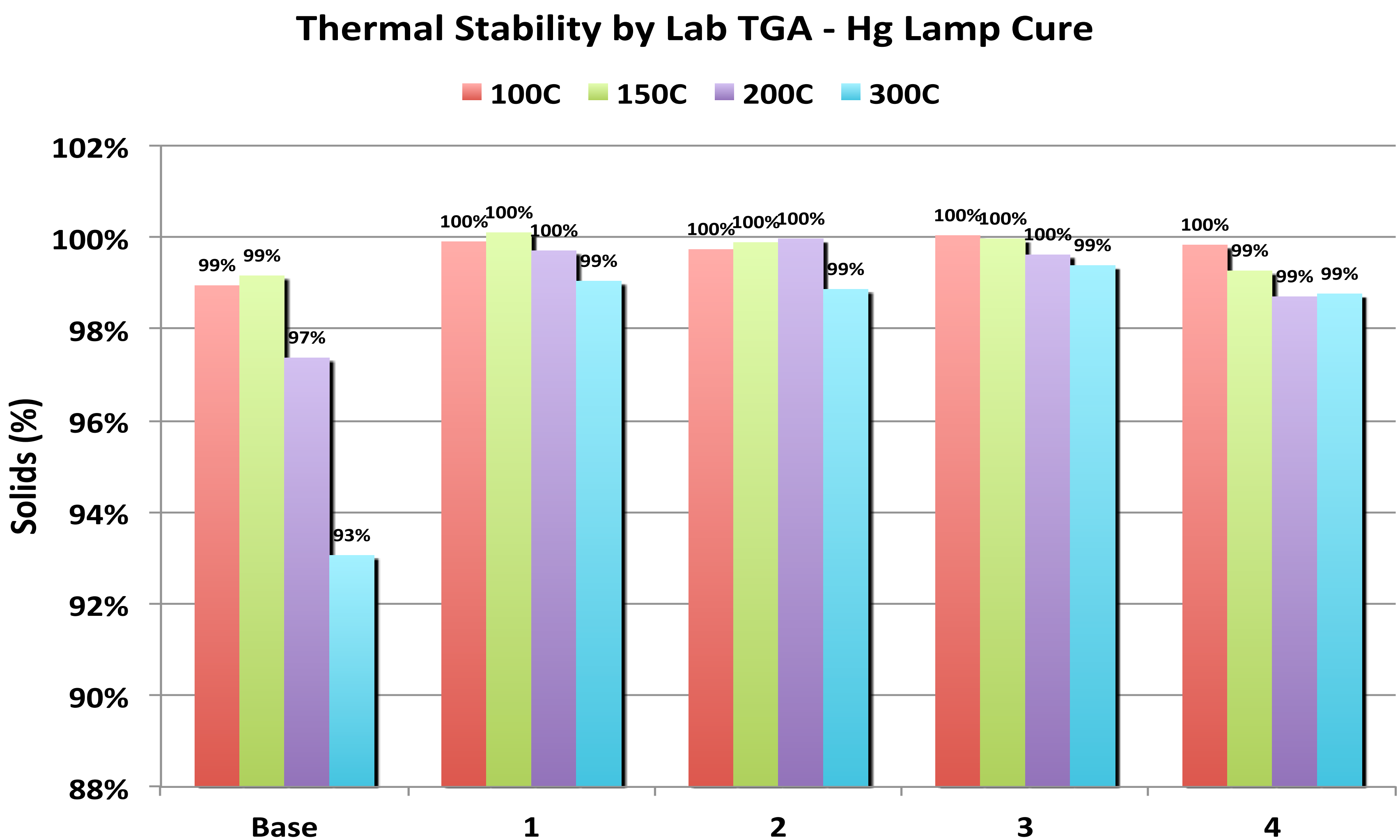
PBI/Acrylic UV Cure System

Evaporative PBI System



PBI/Acrylic System

Item #	Thickness (µm)	Appearance
Base (no UV)	50	Irregular, peeling up
#1 UV	221	Smooth
#2 UV	203	Smooth
#3 UV	230	Smooth
#4 UV	288	Smooth
#5 UV	253	Smooth
#6 UV	280	Smooth
#7 UV	268	Smooth
#8 UV	176	Smooth


Thermal Stability by Lab TGA - Hg Lamp Cure
100C
150C
200C
300C
102%
100%
98%
96%
94%
92%
90%
88%
Solids (%)
Base
1
2
3
4
99%
99%
97%
93%
100%
100%
100%
99%
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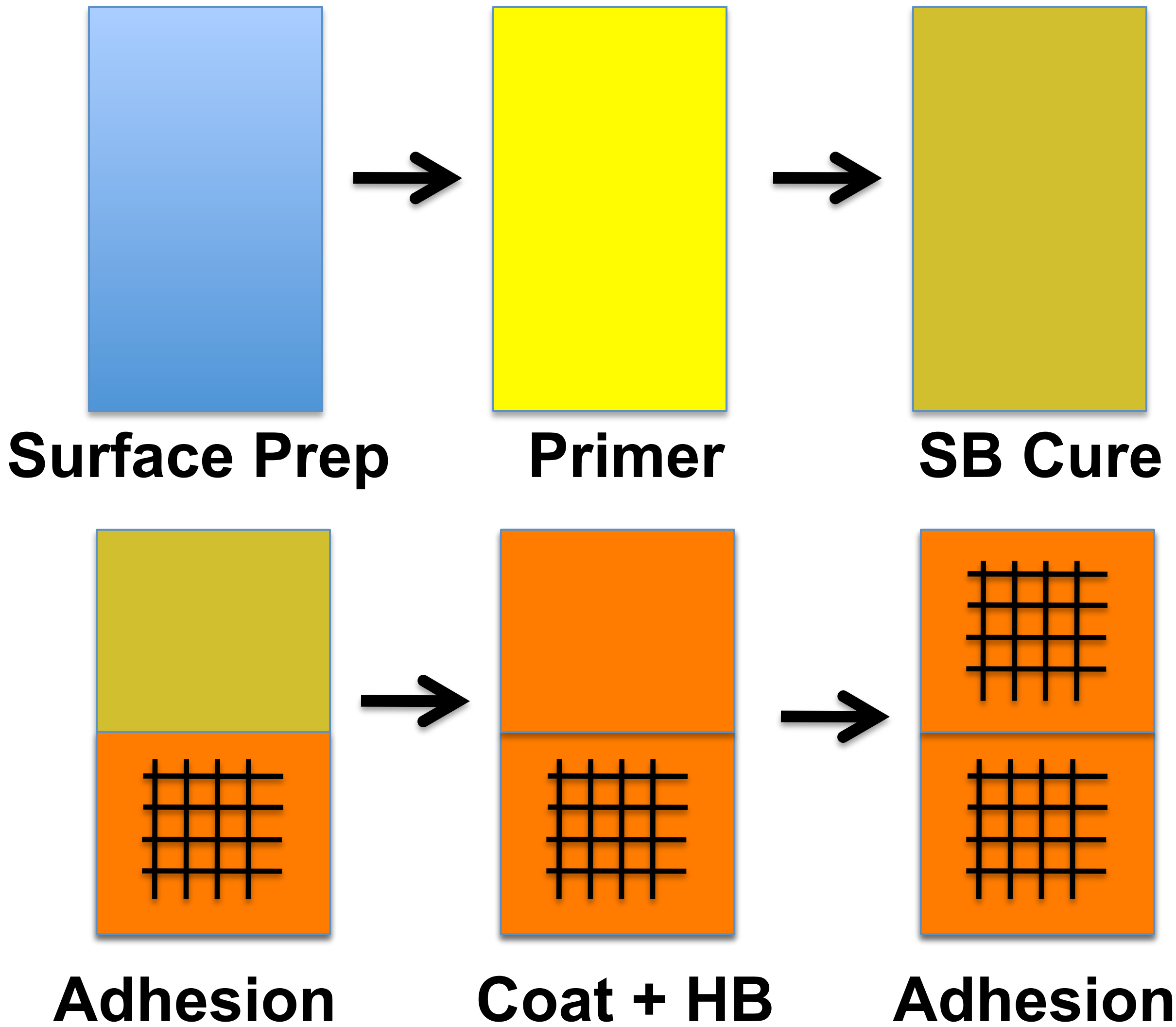
99%

PBI UV Cured Coatings

- Use of PBI-R (reconstituted, pwdr)
- Dissolve in UV cure agent w/sensitizer
- Cures in seconds
- Very high adhesion
- Uniform and smooth coatings
- Thickness >300um
- Thermal resistance >300C

Adhesion Testing (ASTM D3359)



ASTM 3359
- **Crosshatch**
- **Tape-pull**
- **Observed result**

Adhesion Testing

Following Cure & TGA (300C)

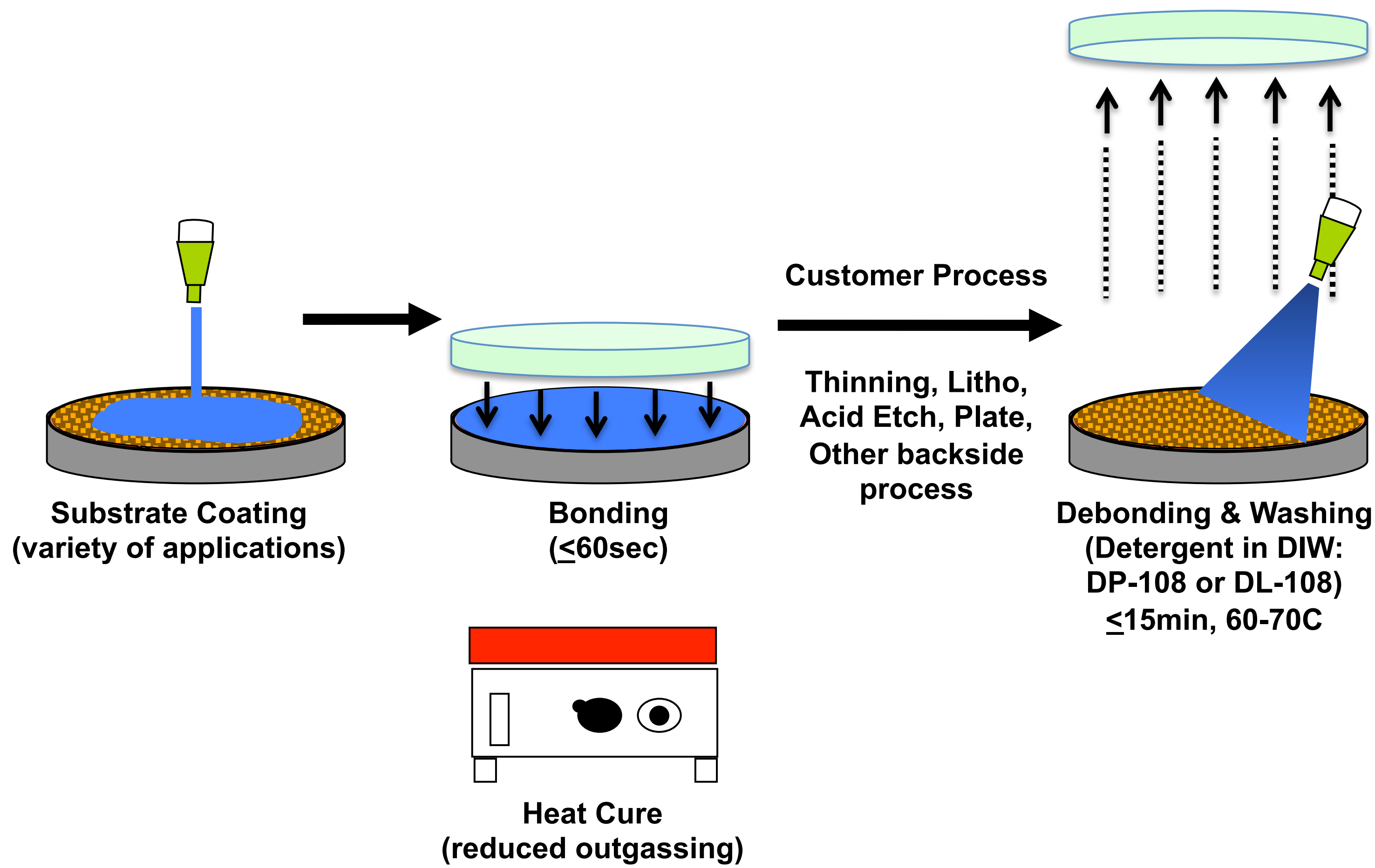
<u>Base PBI (DMAC cure)</u>
Loss of adhesion, PBI peels And lifts off substrate without Stimulus (i.e. spontaneous Lift-off)

<u>PBI in DMAA – Photo cure</u>
Adhesion very strong, not Brittle, durable, flexible. Material has noticeably strong adhesion

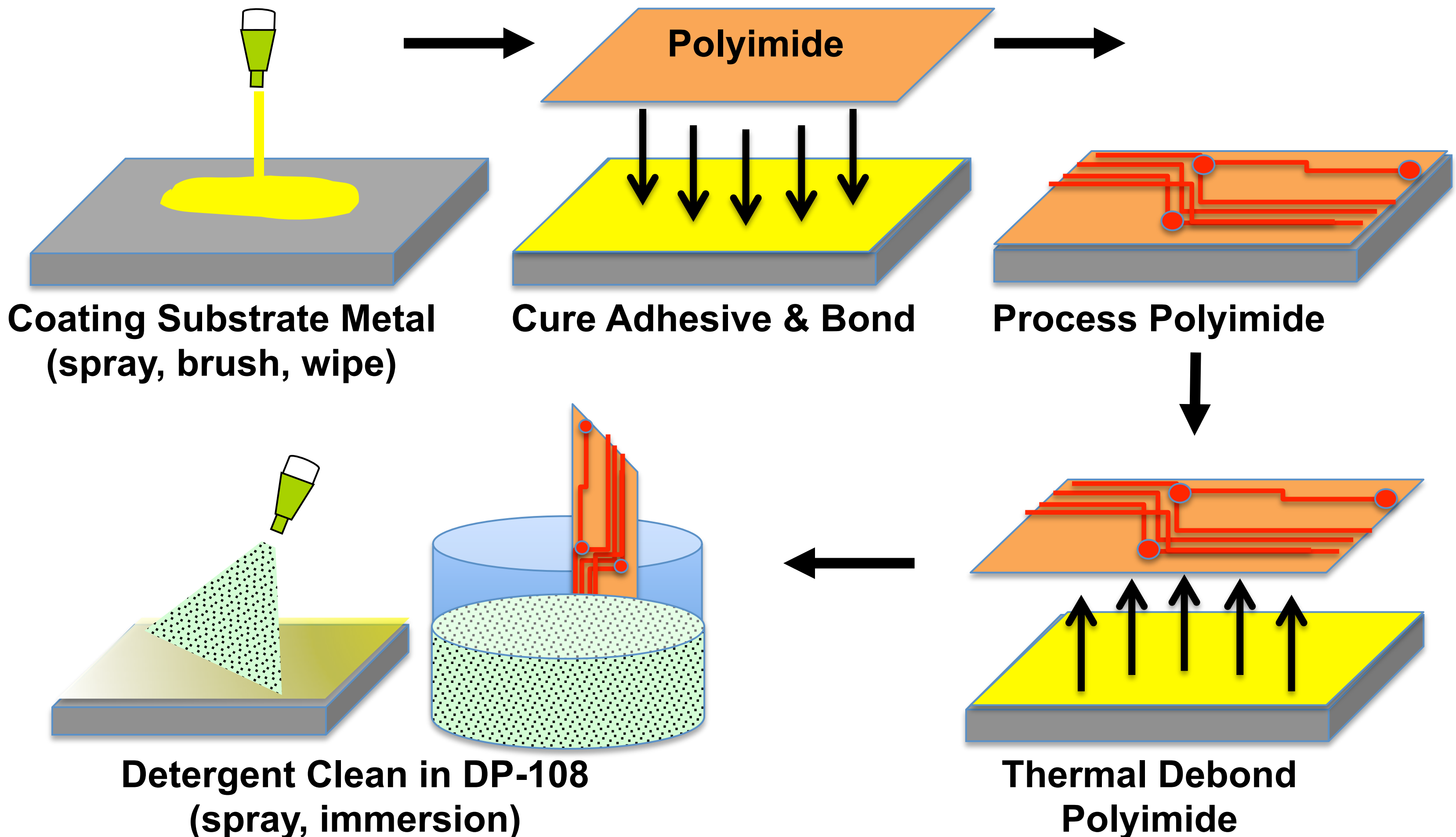
Other Systems

- Aqueous cleans for panel making
- Peel systems – thin flexible substrates

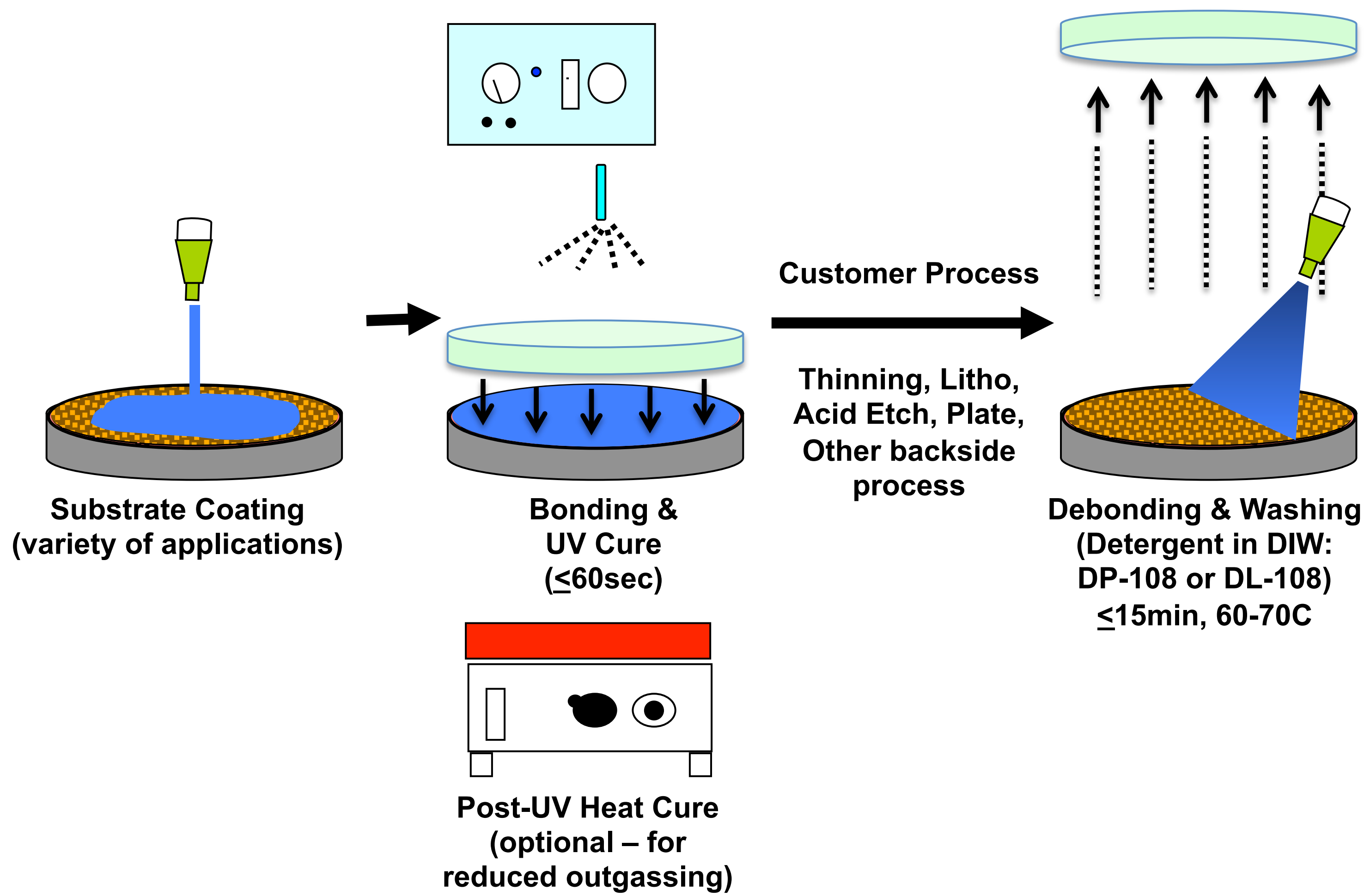
Thermal Adhesive Bond and Debond



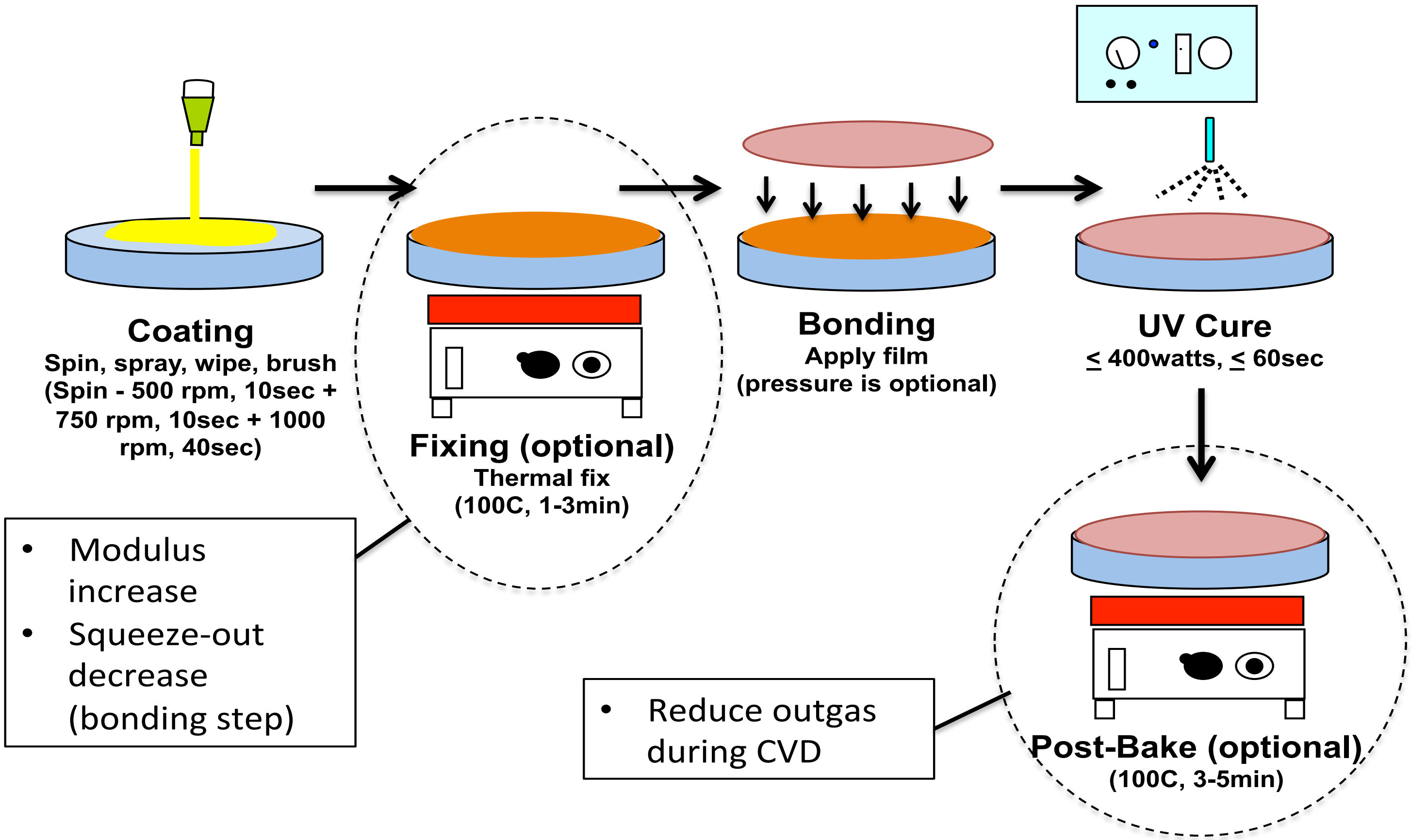
Polyimide Film Temporary Adhesive

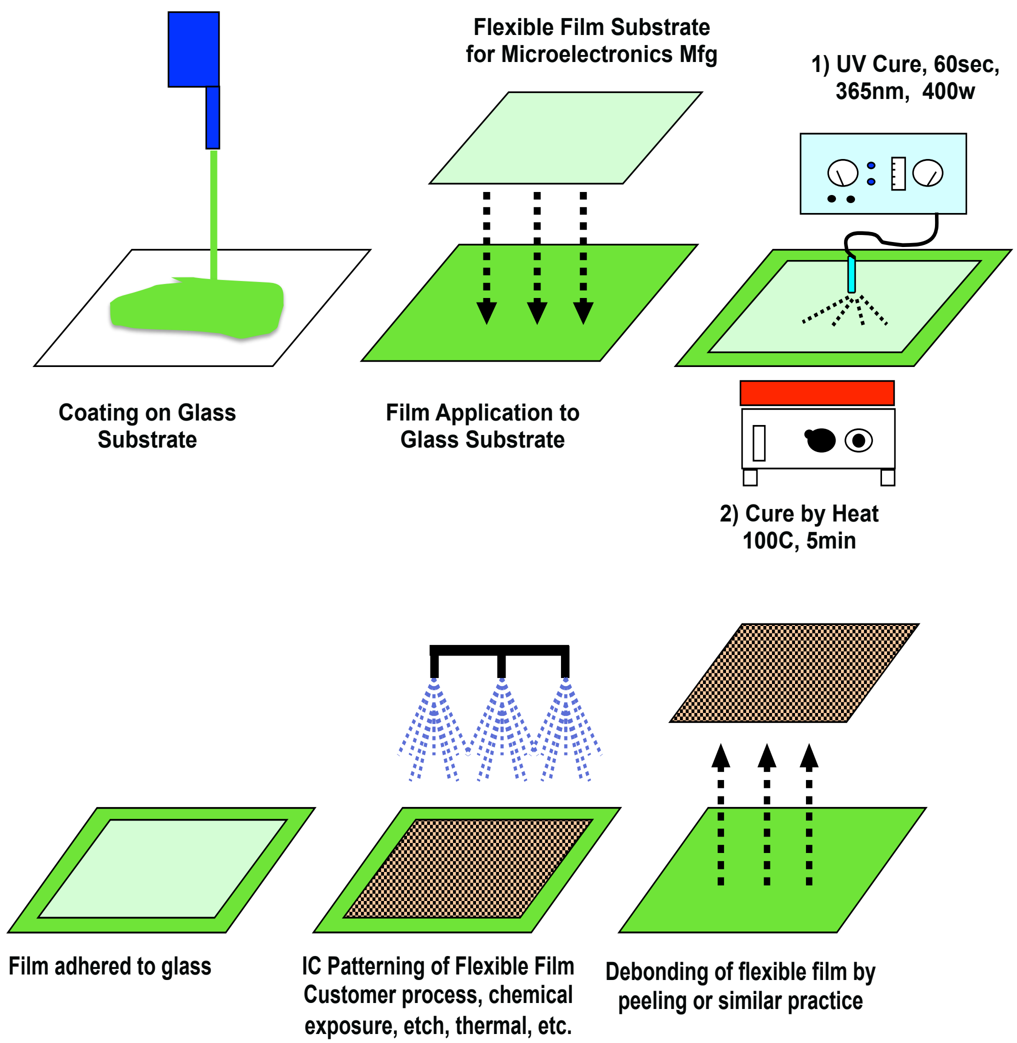


UV Temporary Adhesive Application



UV Cured System – Peel Debond



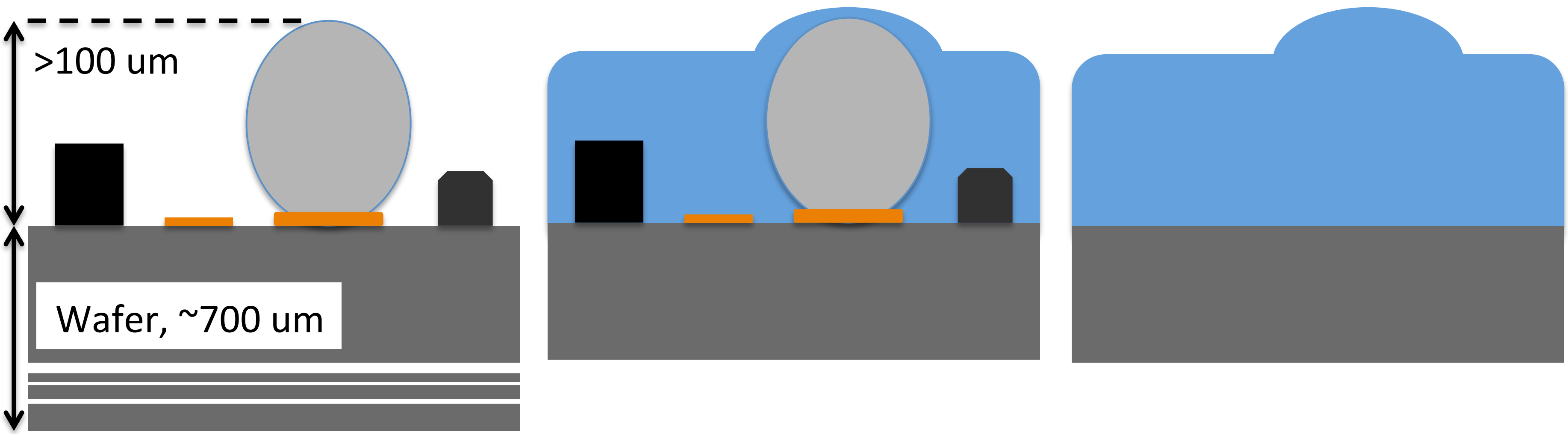


Flexible Film Substrate
for Microelectronics Mfg
1) UV Cure, 60sec,
365nm, 400w
Coating on Glass
Substrate
Film Application to
Glass Substrate
2) Cure by Heat
100C, 5min
Film adhered to glass
IC Patterning of Flexible Film
Customer process, chemical
exposure, etch, thermal, etc.
Debonding of flexible film by
peeling or similar practice

Debond Using Porous Carriers

- Under development
- Rigid support
- High fluid contact
- Enables batch processing
- Simple tank-type debond & cleans
- High Throughput (potential >400 wph)

Aq Soluble Planarization Layer

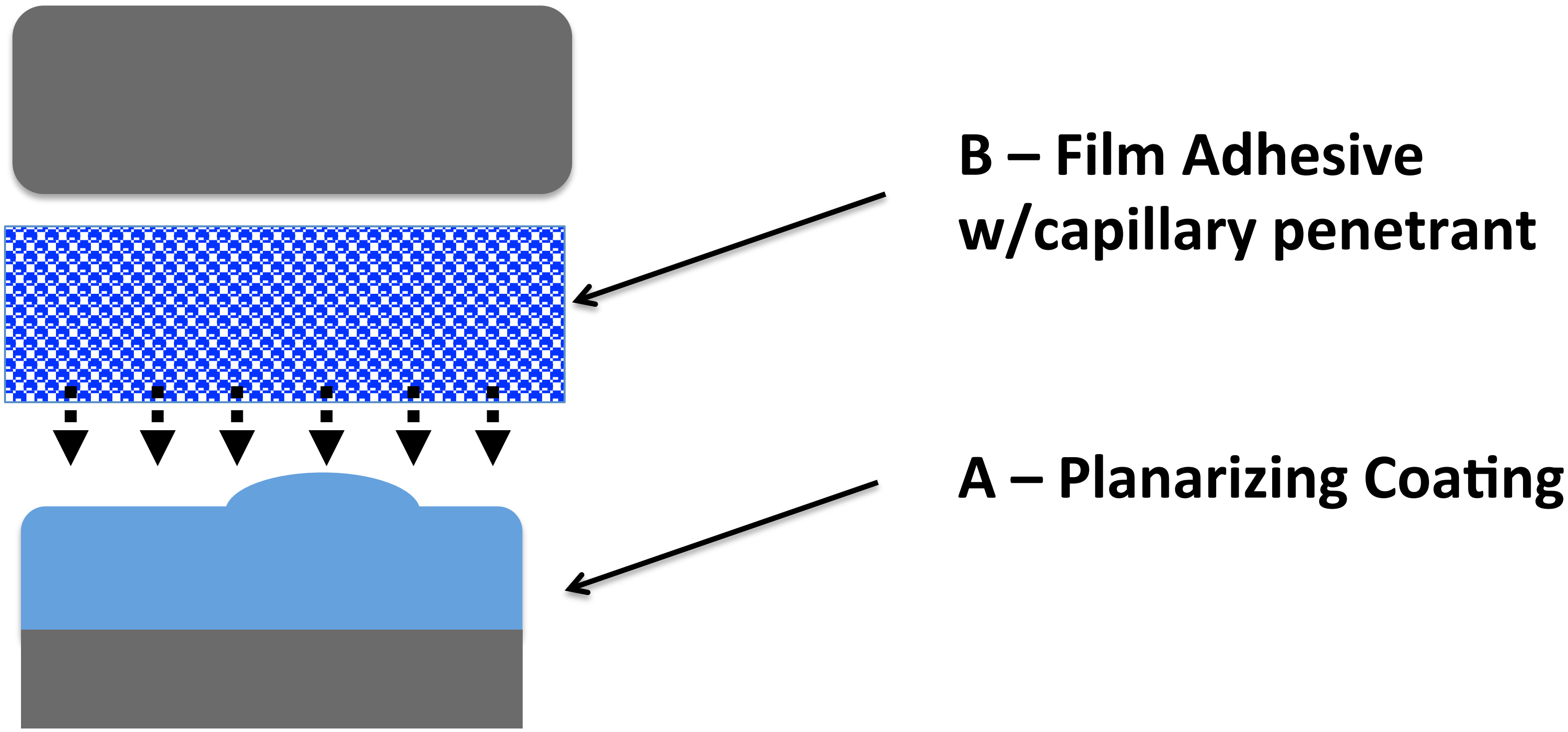


Wafer with Topography (able to planarize >100um)

Planarization Coating

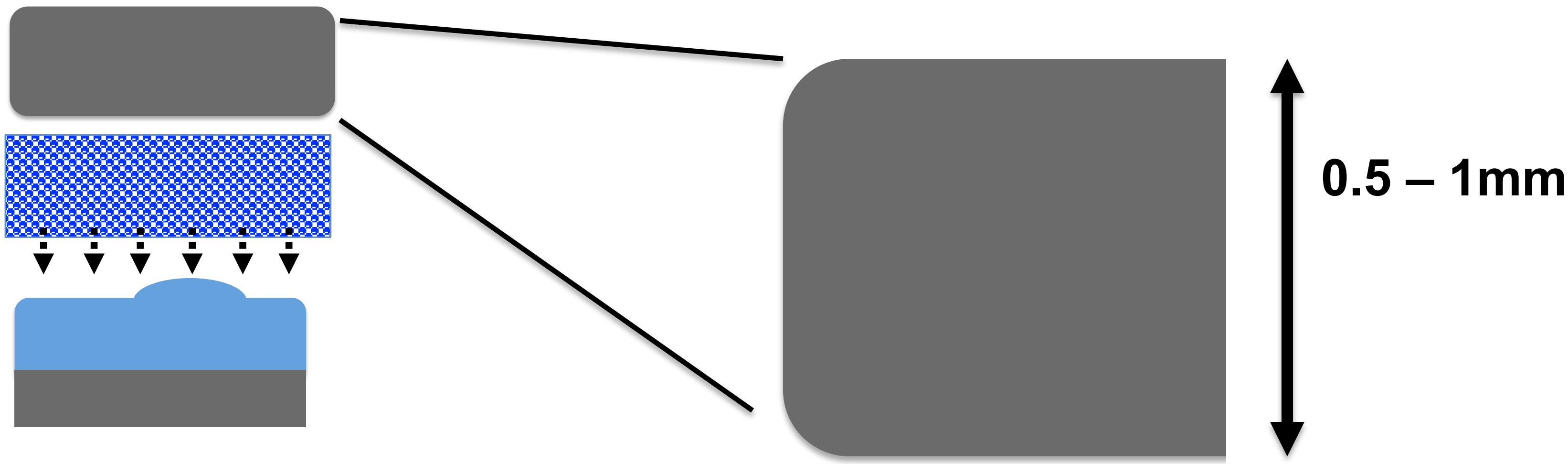
Film Attachment

Adhesive Film Attachment



Film Attachment

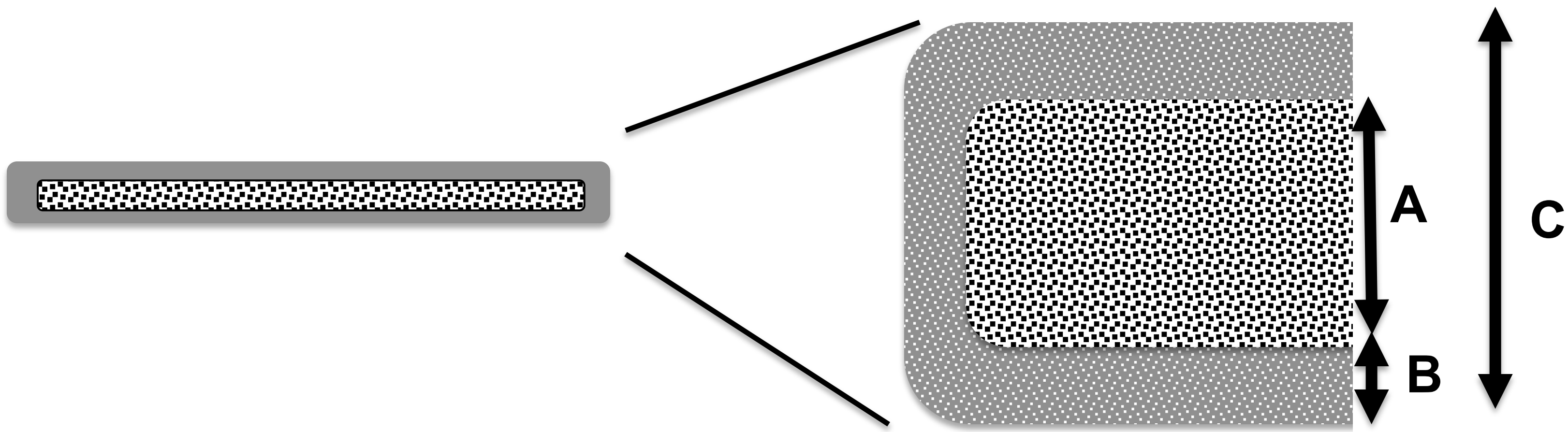
“Reference” – Glass & Silicon



Closed substrate, allowing no communication of chemistry into the stack. The only opportunity for chemical penetration is through the adhesive bondline. This does not occur

Debonding must occur by thermal sliding or other complex method. Slide or other complex de-bond methods damage the device wafer and drive throughput down.

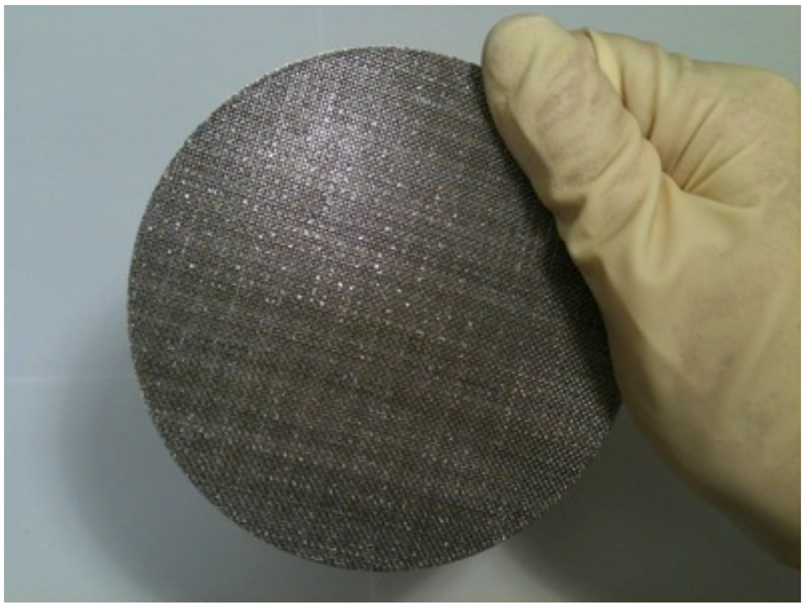
Porous Design Example



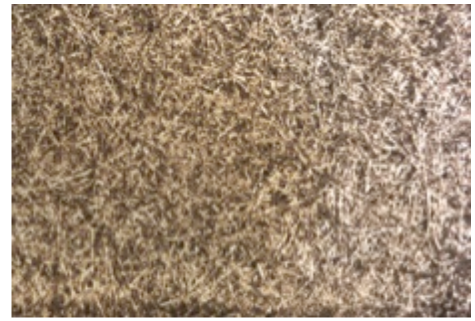
A = 0.5 – 0.8mm
B = 0.1 - 0.25mm
C = 0.5 – 1mm

Porosity higher for inside material (A). Outer coating (B) is lower porosity, more uniform, less voids.

Porous Carrier

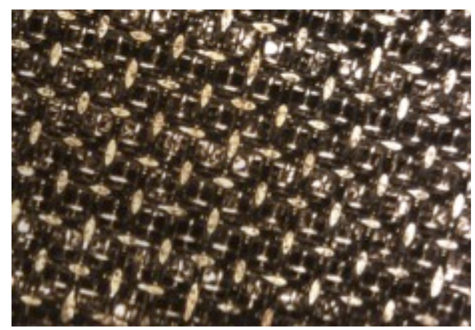


Example Porous Carrier



Type A (fine)

Type B (Med. fine)



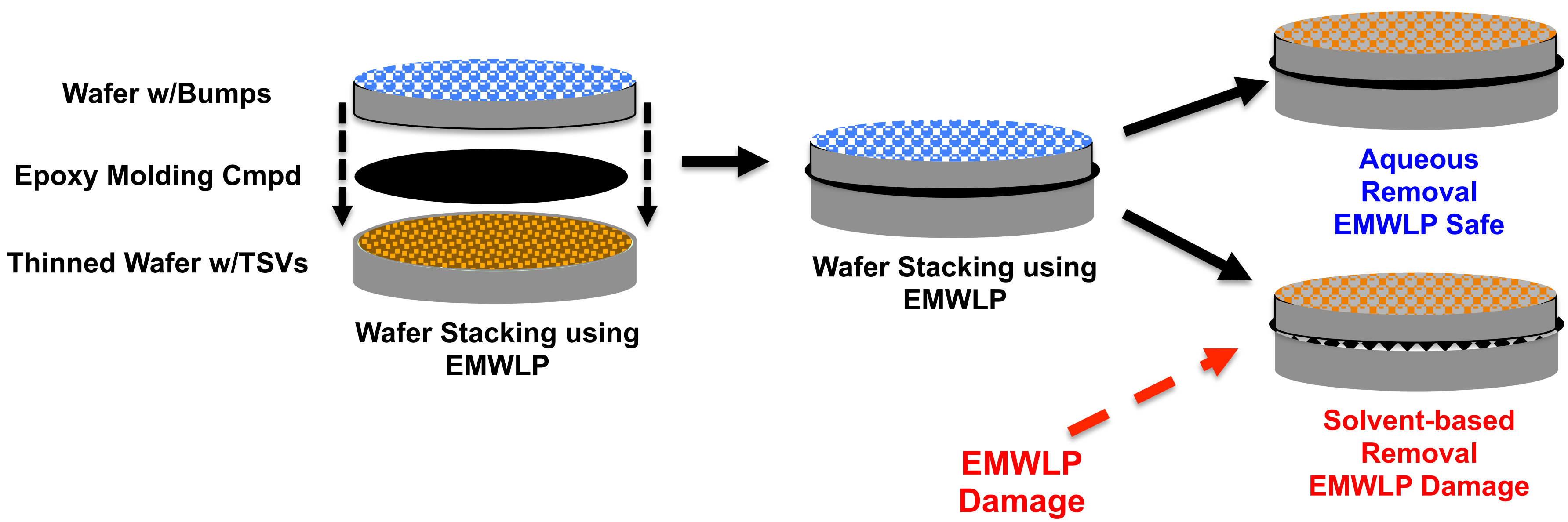
Type C (Coarse)

Benefits & Cost

- Product costs 10-75% of commercial
- COO <10% due to batch processing

ENABLES NEW TECHNOLOGIES

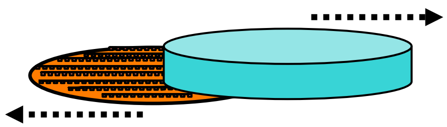
- 3D wafer level stacking using epoxy molding
- Embedded Micro Wafer Level Pkg (EMWLP)



Process – Debond/Cleans

Process flow after moulding differs: 1) rubber and 2) AQ

1) Rubber

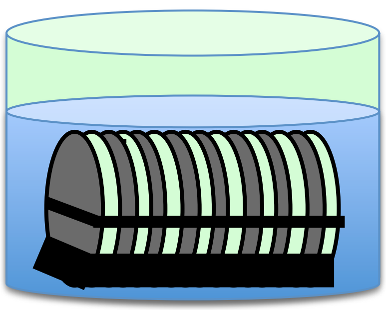


Slide/Debond + Clean

~12 wph

SW Debond & Cleans

2) AQ



Batch Demount & Cleans

100-400 wph

Batch Debond & Cleans (Wet Bench)

COO Defined (SEMI E35)

$$COO = \frac{F\$+R\$+Y\$}{L \times T \times Y \times U} = \frac{Costs}{Product}$$

Item	Definition
F$	Fixed Costs
R$	Recurring Costs
Y$	Yield Cost (scrap)
L	Equipment Life
T	Throughput
Y	Composite Yield
U	Utilization

$$\frac{COO_2}{COO_1} = \frac{\text{AQ DB/Cleans}}{\text{Rubber DB/Cleans}}$$

COO Value Calculation Example

$$\frac{COO_2}{COO_1} = \frac{\text{AQ DB/Cleans}}{\text{Rubber DB/Cleans}}$$

Item	Definition	COO_2 vs. COO_1	Explanation
F$	Fixed Costs	$F\$_1 = 5.1 \times R\$_1$ $F\$_2 = $ -0- or $1.2 \times R\$_2$	SW tool as Materials Cost Use onsite tool or batch
R$	Recurring Costs	$R\$_2 = 0.75 \times R\$_1$	Materials Cost #2 (AQ) = 0.75 X #1 (current)
Y$	Yield Cost (scrap)	$Y\$_2 = Y\$_1 = 0$	No loss for each tech.
L	Equipment Life	$L_2 = L_1$	Same life
T	Throughput	$T_2 = 8.3 \times T_1$	batch vs SW = 8.3 X T_1
Y	Composite Yield	$Y_2 = Y_1$	Same yield
U	Utilization	$U_2 = U_1$	Same maintenance

COO_2/COO_1 Comparison Results

Comparison of COO Technologies	Use Existing Wet Bench (Batch)	New Wet Bench (Batch)
COO_2/COO_1	1.5%	3.2%

Summary: The COO of the new technology (AQ adhesive) is projected to be between 1.5 – 3.3% of the COO of the current (rubber) technology.

PP of New and Existing Lines

Payback Period Method	Use Existing Wet Bench (Batch)	New Wet Bench (Batch)
Throughput considered	**<1mo**	**~1mo.**
Remove Throughput	**4mos**	**10mos**

Summary

- Demand for alternative adhesives
- Extreme properties as thermal, low outgas, and stress-free in adhesives for temporary applications are achievable
- Thick materials and unique carriers are suggested
- Low-cost is required for scaling, comparative COO of <50% is common, <10% is a target
- As designs change, so must the materials and process to achieve them

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)

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