A Review of Wafer Coating Methods for 3D Packaging

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Asymtek

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Carlsbad, CA 92010

March, 2010 – IMAPS Device Packaging Conference, Scottsdale, Arizona

Nordson ASYMTEK

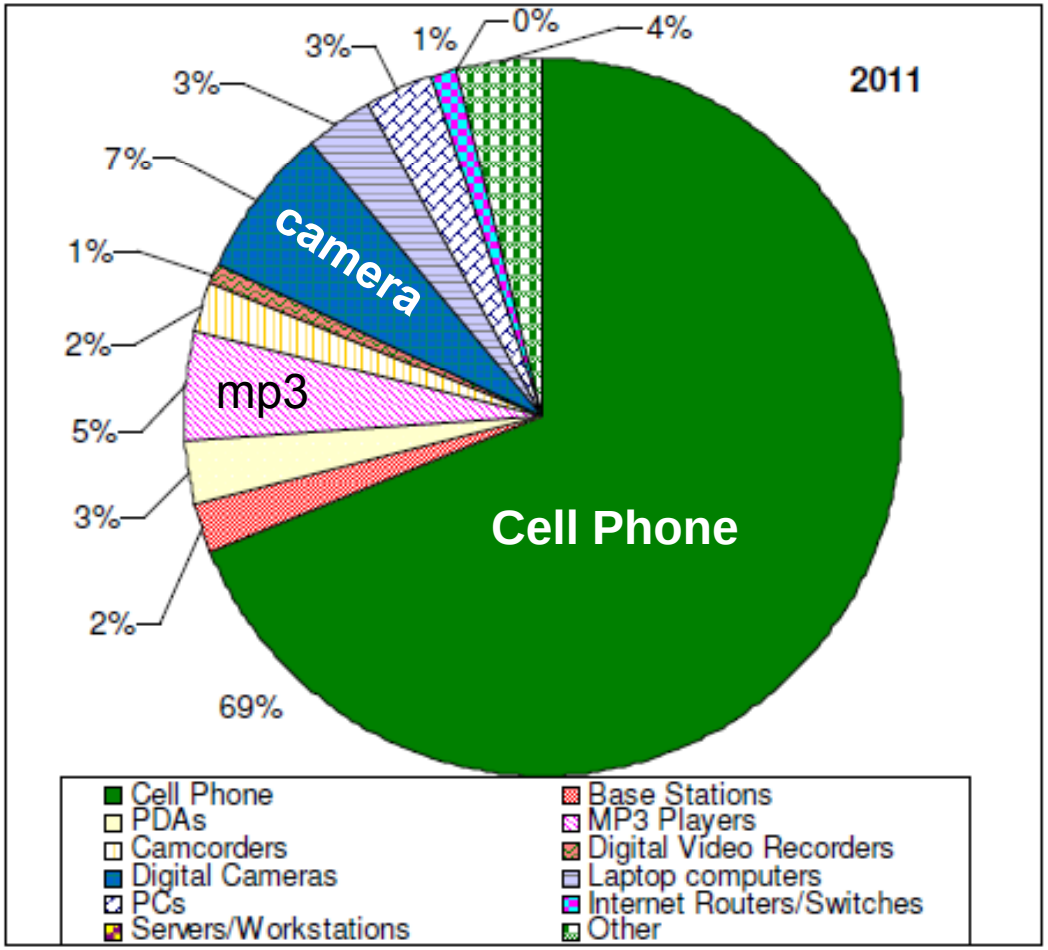
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Agenda

- The drive to thin electronics
- The need for coatings
- Wafer thinning and handling
- Coating Methods
  - Die Attach Films (DAF)
  - Spin Coating
  - Screen Printing
  - Ultrasonic Spray Coating
  - Linear Coating
  - Spin / Spray Coating
- Summary

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Microelectronic Market By Segment



ASTRI

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What do we look for in Cell Phones



Various cell phones from the past 10–15 years.
Legend:
1. NEC Cellstar 500 series (1992)
2. Nokia 2110 series (1994)
3. Nokia 5120 (1998)
4. Kyocera 2135 (2002)
5. Audiovox CDM8300 (2002)
6. Samsung SCH-A650 (2004)

More Features





Pocketnow.com

Stack of Cell Phone

Less weight and thinner

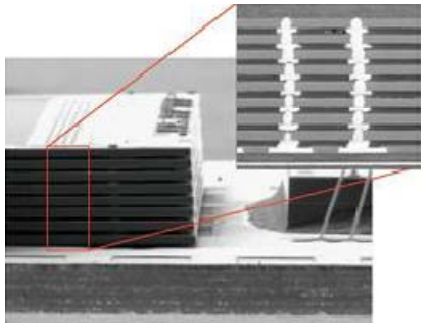
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How do we get put more functions into phones and keep them small and thin – 3D Packaging

Nordson ASYMTEK

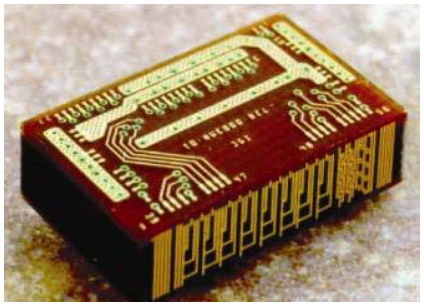
Thin Wafers allow you stack die, enabling more functions in a thinner profile device

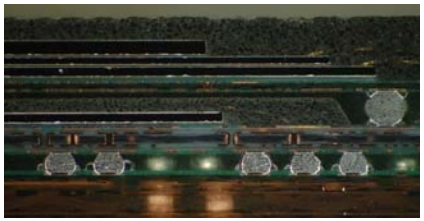
Emerging →



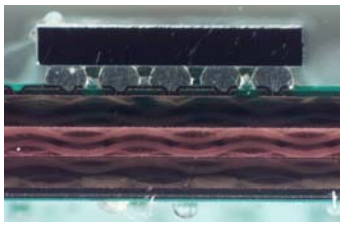
Stacked Die Edge Through Silicon via

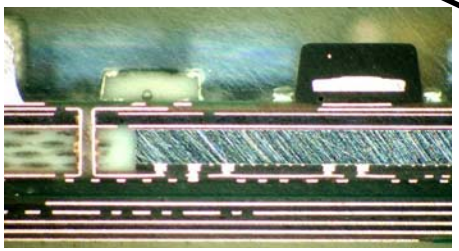
Today →

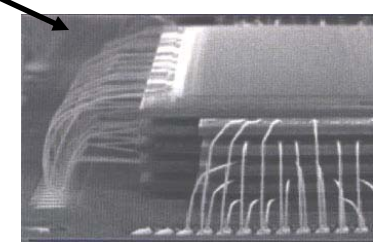












Flip Chip & CSP | **Package on Package** | **Embedded Package** | **Stacked Die Wire Bond**

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Coatings used in 3D Device Fabrication

Nordson ASYMTEK

Low K Dielectrics

Pre-applied underfills

Small Gap <25 microns, Copper Pillar connections

Laser Dicing / Ablation protection coatings

Protection of solder balls, bond pads, from laser ablation products

Laser back side marking coatings

Wafer or Die markings applied to the back side of the wafer

Die Bond Coatings / Tape

Wafer Backside Coatings

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Goals for Wafer Backside Coating

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Material Properties:

- A polymer coating
- 1000 to 4000 cps viscosity fluids
- 20% fillers, 1 micron particles

Goals:

- Coat 200 & 300 mm wafers, from 25 to 100 microns thickness
- Die bond line thickness typically 5 to 20 microns
- 10% thickness uniformity variation
- Better than 80% transfer efficiency
- Throughput 20 wafers / hour or greater

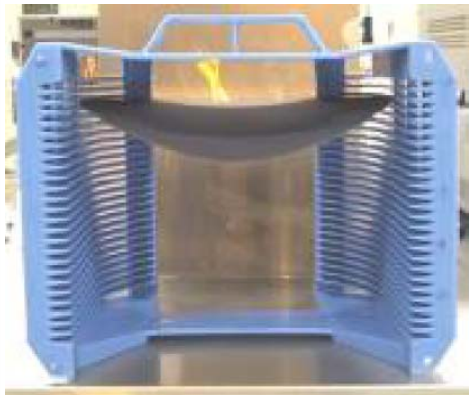
Ancillary Goals:

- Coat the backs of diced die (DBG) process
- Coat over bumps on wafers – pre-applied materials
- Coating process to protect bumps on wafers during laser dicing

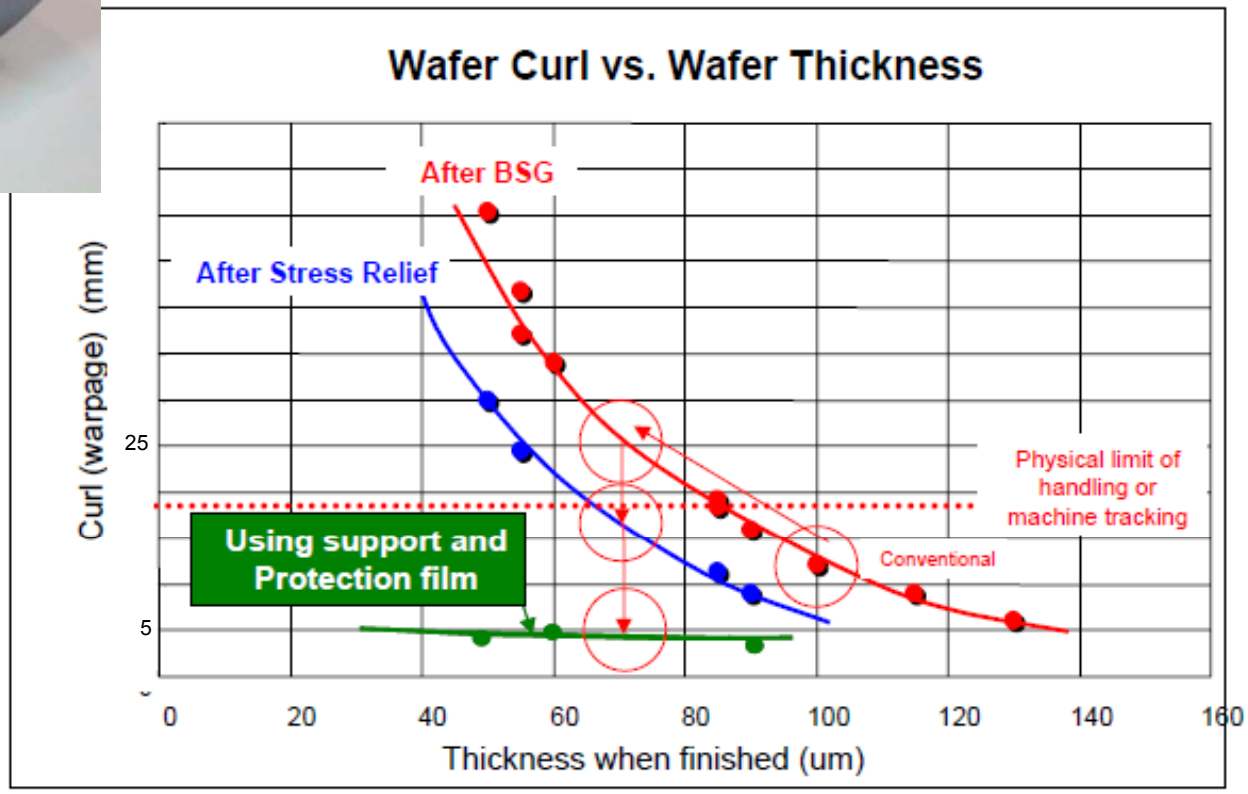
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Wafer Thinning and Handling





"We have found that wafer thinning is easier than we expected" **Bill Bottoms**



Shinichi Maekawa, Recent Assembly Process to Achieve 9 stack MCP, 12th Annual KGD Packaging & Test Workshop, Sep 2005, Napa CA (Toshiba)

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Wafer Coating Methods

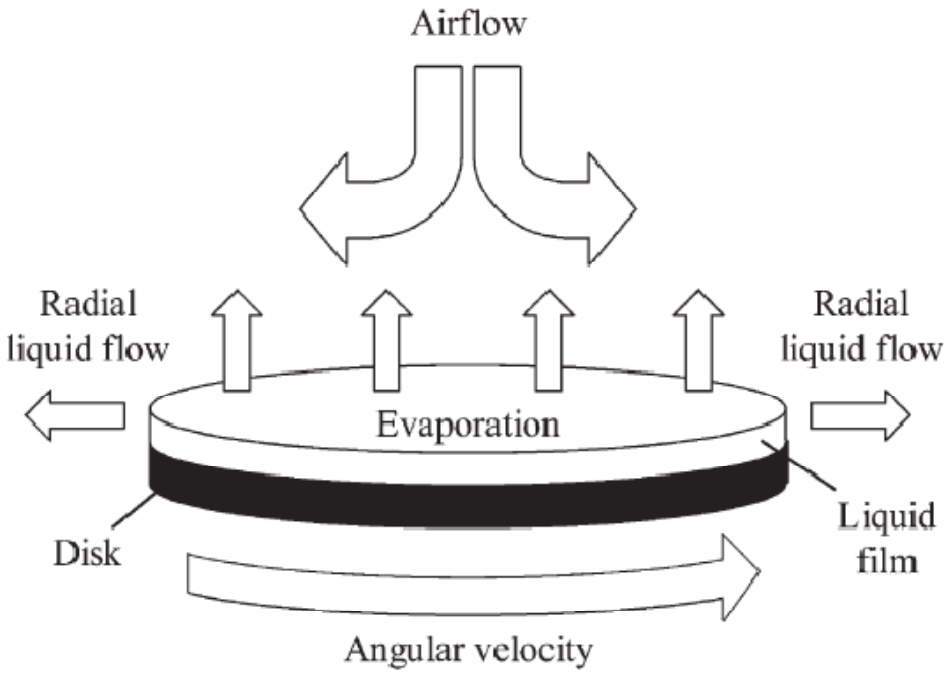
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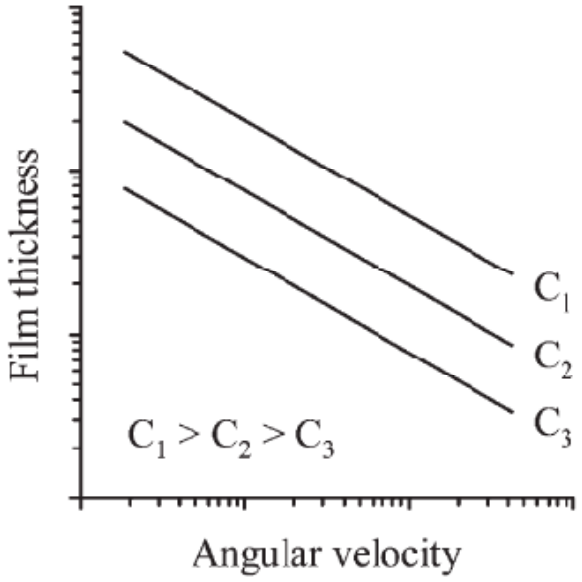
Wafer Coating Methods

Spin Coating

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Spin Coating



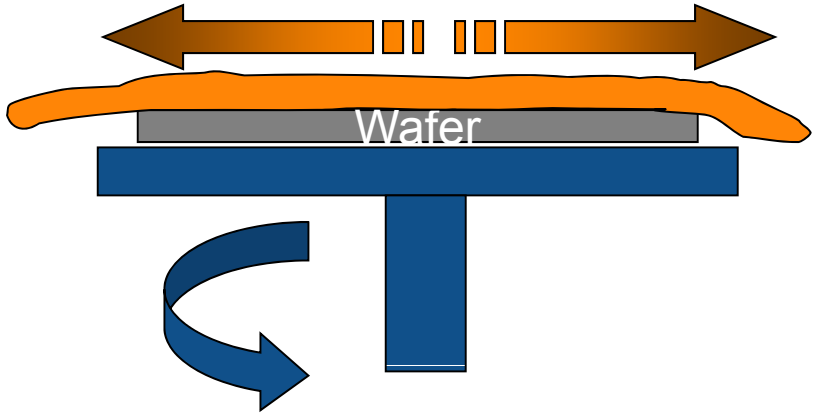


Annu. Rep. Prog. Chem., Sect. C, 2005, 101, 174–201 | 177

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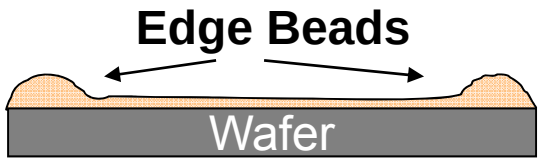
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Spin Coating – Limitations



300mm wafer – 80% fluid applied to the wafer is wasted

200mm wafer – 48% fluid applied to the wafer is wasted



Edge Bead, time and cost to remove

To get thick uniform coatings fluid is often diluted and spun onto the wafer. Several repeated coatings‘ are used to get the correct thickness

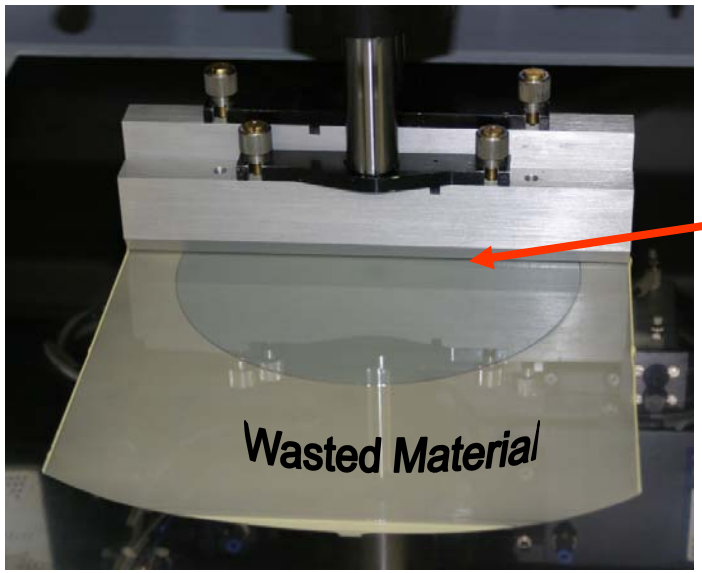
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Wafer Coating Methods

Stencil Printing

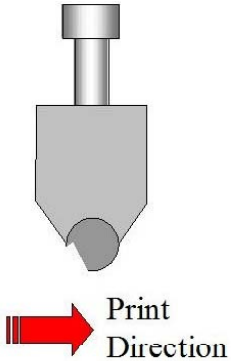
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Screen & Stencil Printing



Wafer Contact





(patent pending)

Stencil print process (Material A)

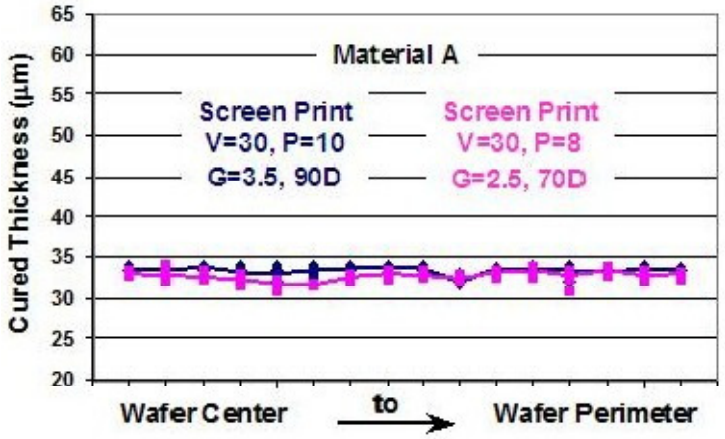
Material	A	B
Function	WL Die Attach	Protection
Viscosity	42,000 cps	4,000 cps
Specific Gravity	1.5 g/cc	1.8 g/cc
Color	Yellow	Black
Conductive	No	No
B-Stage Capable	Yes	No
Snap Cure Capable	Yes	No

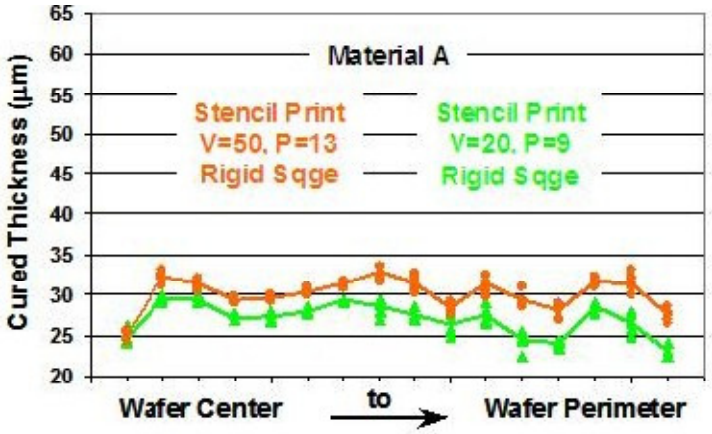
The mesh screen was designed at 120 wires per inch using 65µm diameter stainless steel wire (140µm mesh openings / 140µm mesh thickness) with 13µm thickness emulsion defining a 198mm diameter circular aperture. The metal stencil was manufactured by electroforming a nickel foil at 50µm thick and also using a 198mm diameter circular aperture size.

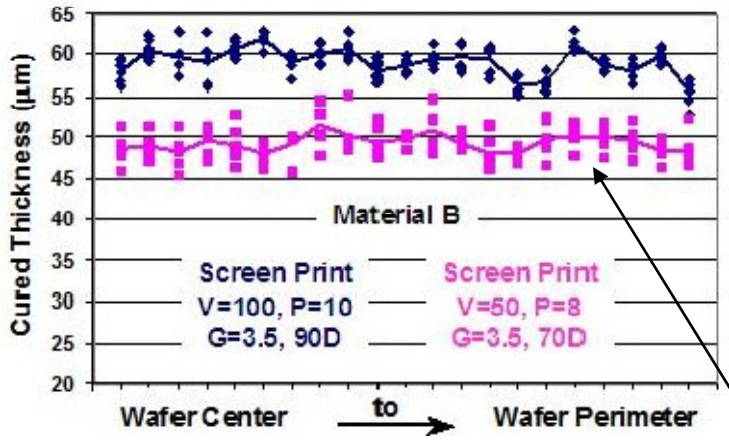
Mark Whitmore & Jeff Schake, 33rd International Electronics Manufacturing Technology Conference 2008

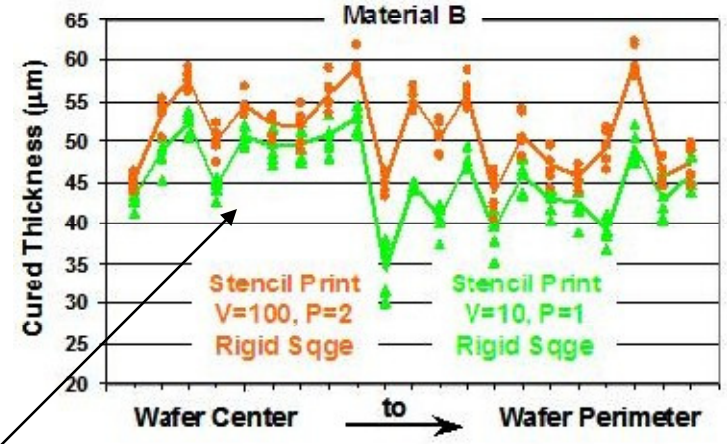
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Screen & Stencil Printing Scoop Analysis









Screen Print

Stencil Print

Believed to be caused by a non-flat wafer vacuum wafer chuck

V= squeegee velocity (mm/sec)
P = squeegee pressure (kg)
G = print gap (mm)
Sq = squeegee type (D = Shore A durometer, RB = rigid bar design)

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Screen Printing - Limitations

Contact process – wafer damage

Waste of fluids – Stencil / Screen cleaning

Cost of stencils or screens to make 25 micron coatings

Can you make a 10 micron film using printing?

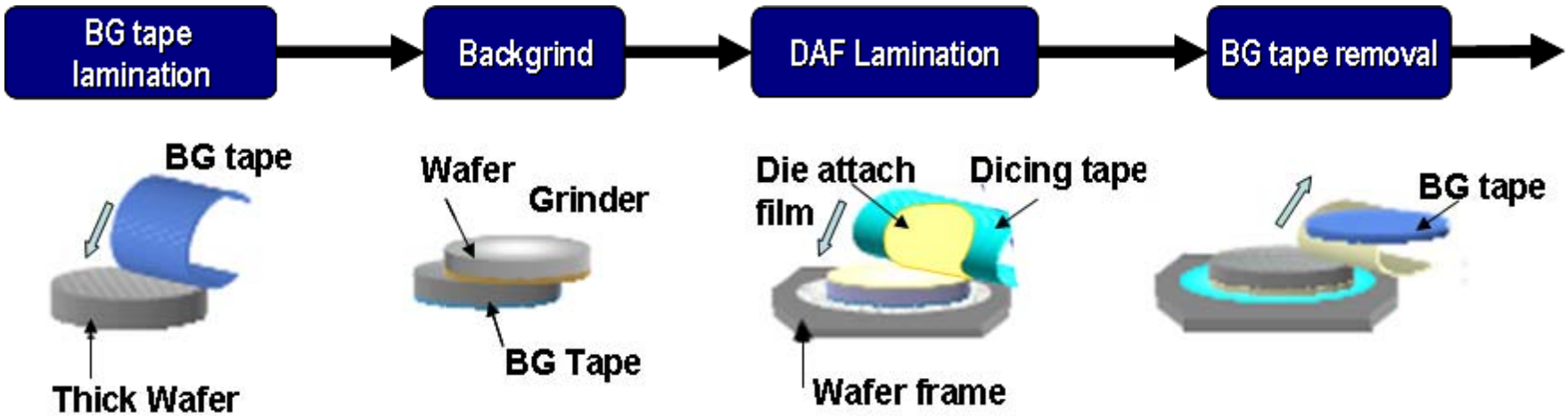
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Wafer Coating Methods

Die Attach Films - DAF

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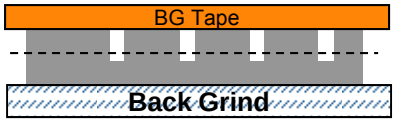
Die Attach Film (DAF) Lamination Process



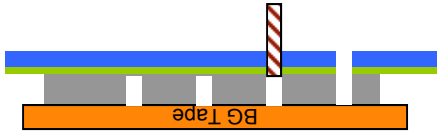
Not suited for Dice before Grind (DBG) Process



Dice Wafer



Apply BG Tape
& Grind to the slots



Apply Die Attach Film
(DAF) dice again

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Flash Memory Assembly Costs Using DAF

1+ 4 MICRO SD CARD ASSEMBLY COST COMPARISON

Company	Comp A		Comp B		Comp C	
Material Cost	$0.63	69%	$0.64	73%	$0.56	68%
Substrate	$0.23	25%	$0.24	27%	$0.20	24%
Au Wire	$0.15	16%	$0.15	17%	$0.13	16%
Die Attach and Other Direct Materials	$0.23	26%	$0.23	27%	$0.22	26%
Indirect Materials	$0.02	2%	$0.02	2%	$0.02	2%
Labor Cost	$0.05	6%	$0.04	5%	$0.05	6%
Overhead Cost	$0.24	26%	$0.19	22%	$0.21	26%
Machine Depreciation	$0.21	23%	$0.18	19%	$0.19	22%
Utility and Others	$0.03	3%	$0.03	3%	$0.03	3%
Total Die-free Assembly Cost	$0.91	100%	$0.88	100%	$0.83	100%

Die attach materials accounts for approximately 25% of a final die stack costs

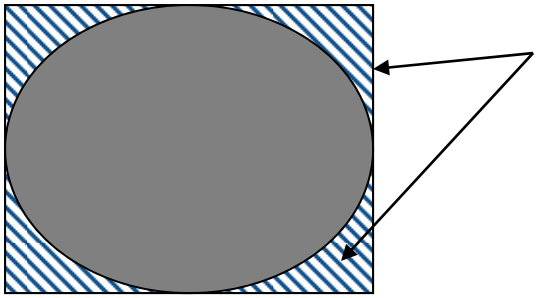
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Die Attach Film – Limitations

Cost of the film – die bond pastes are typically 20 to 30% lower cost

Manufacturing methodology will not allow manufactures of DAF to reach similar price points to paste

Not suitable for Dice Before Grind Process



Waste **Area of Square 300 x 300 = 90000 sq mm**

Area of Circle $3.142 \times 150^2 = 70695$ sq mm

19305 sq mm waste (21% waste)

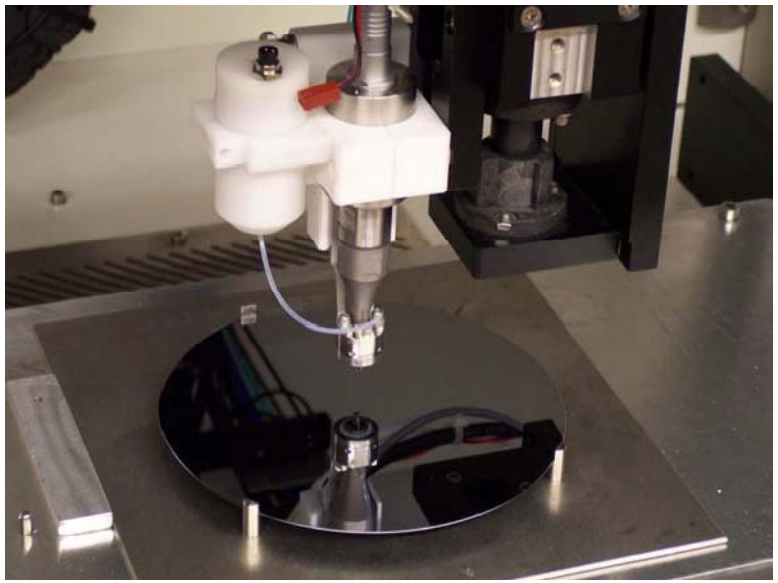
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Wafer Coating Methods

Ultrasonic Spray

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Ultrasonic Coating Head



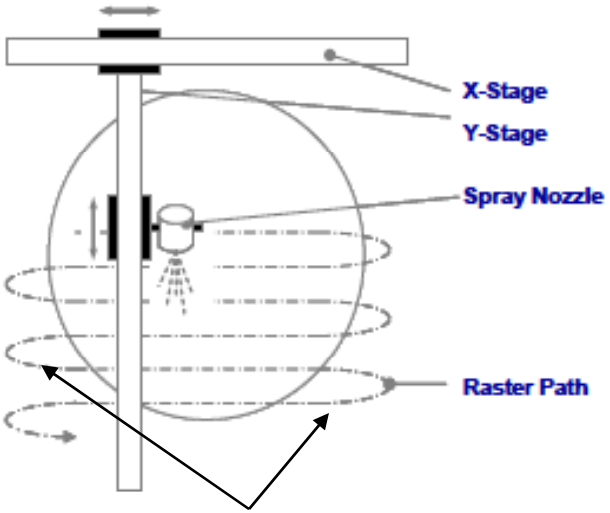
- **Deposition: dry coating thickness sub micron and up.**
- **Deposition Uniformity: Better than ± 3%**
- **Surface Appearance: Defect free coating with no edge bead effect**
- **Transfer efficiency: A transfer efficiency of 97 to 99% is verified by the weight of dry coating on the substrate when compared with the amount metered through the spray head.**

Negative - Limited viscosity range < 100cps

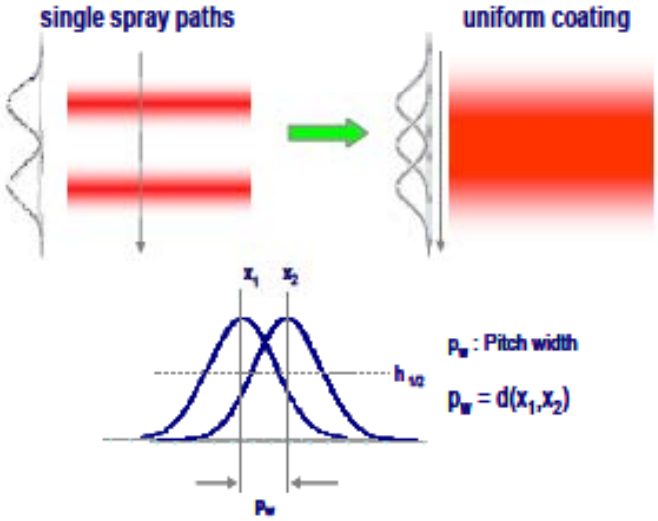
Note: Adhesion is improved with higher molecular weight materials
In this case 1000 and 4000 cps

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Raster Spray Coating



Slow process due to time lost at turn around



Difficult to control overlap

Keith A. Cooper, Clif Hamel and Bill Whitney, Conformal Coating for High Aspect Ratio Features , Suss, Technical Publications

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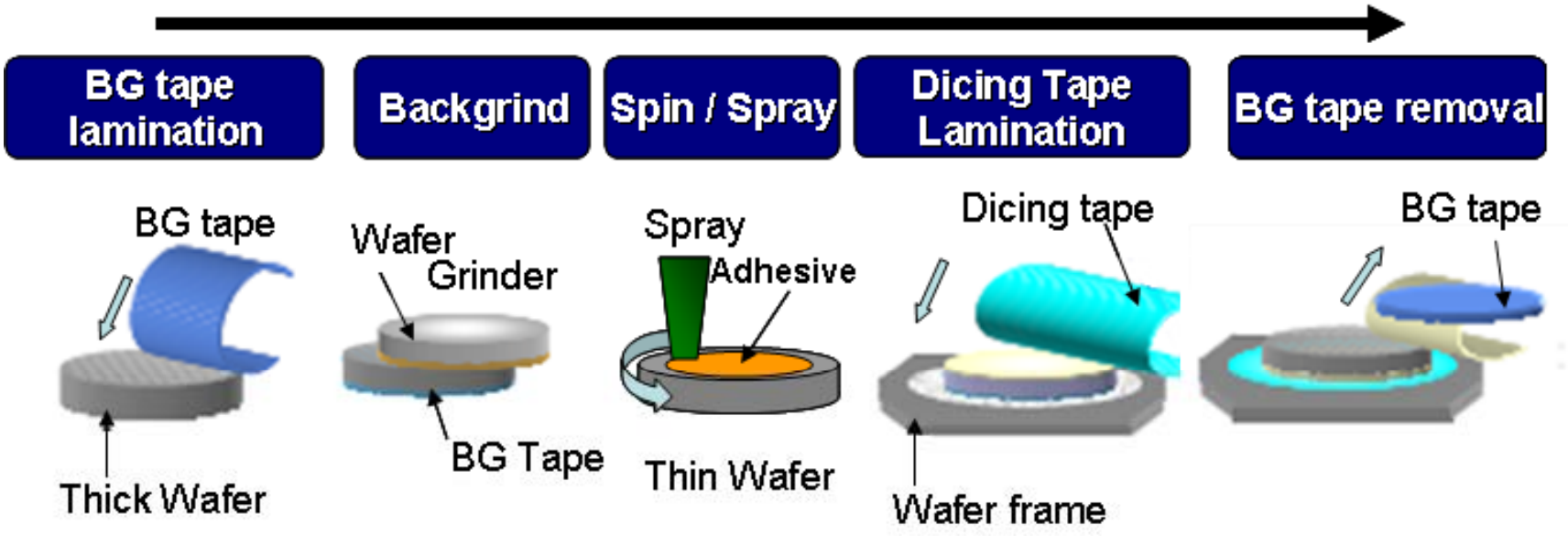
Wafer Coating Methods

Spin / Spray Coating

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Wafer Back Side Spray Coating

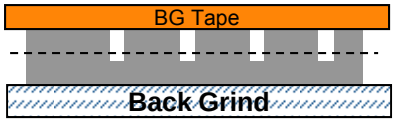
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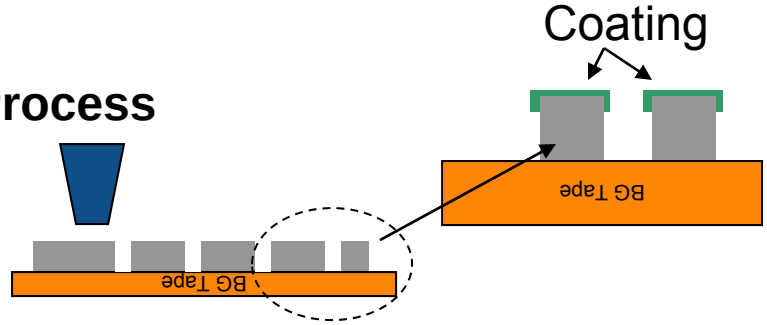
Ideally **suited for Dice before Grind (DBG) Process**



Dice Wafer



Apply BG Tape
& Grind to the slots

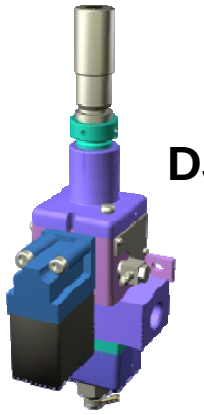


Inside BG system
Spray on die bond
adhesive

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Equipment

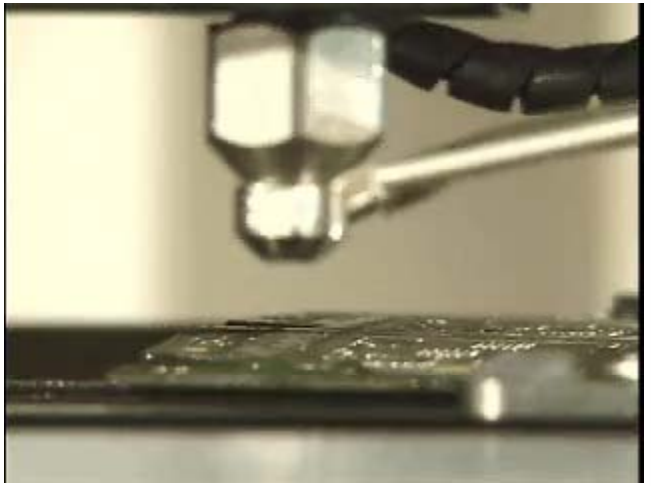
- Equipment
  - Platform choice
    - **S-9XX - Small footprint, high through-put**
    - **MFC standard**
  - Coating Technology
    - **DJ-2200**
    - **Proven technology from our flux coating**



DJ-2200



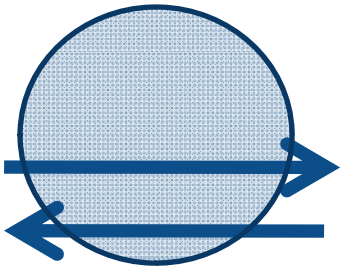
Spectrum 900 series Platform



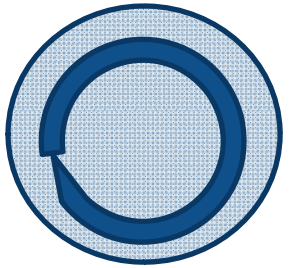
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Coating Head Paths Tested

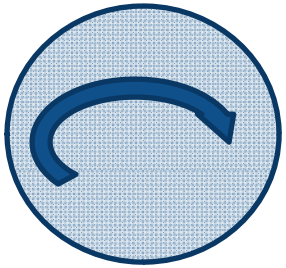
- **Coating Processes Evaluated by Asymtek**
  - **Linear coating**
    - **Standard spray pattern in X and Y**



  - **Step Spray (Patent applied)**
    - **Concentric rings using MFC**



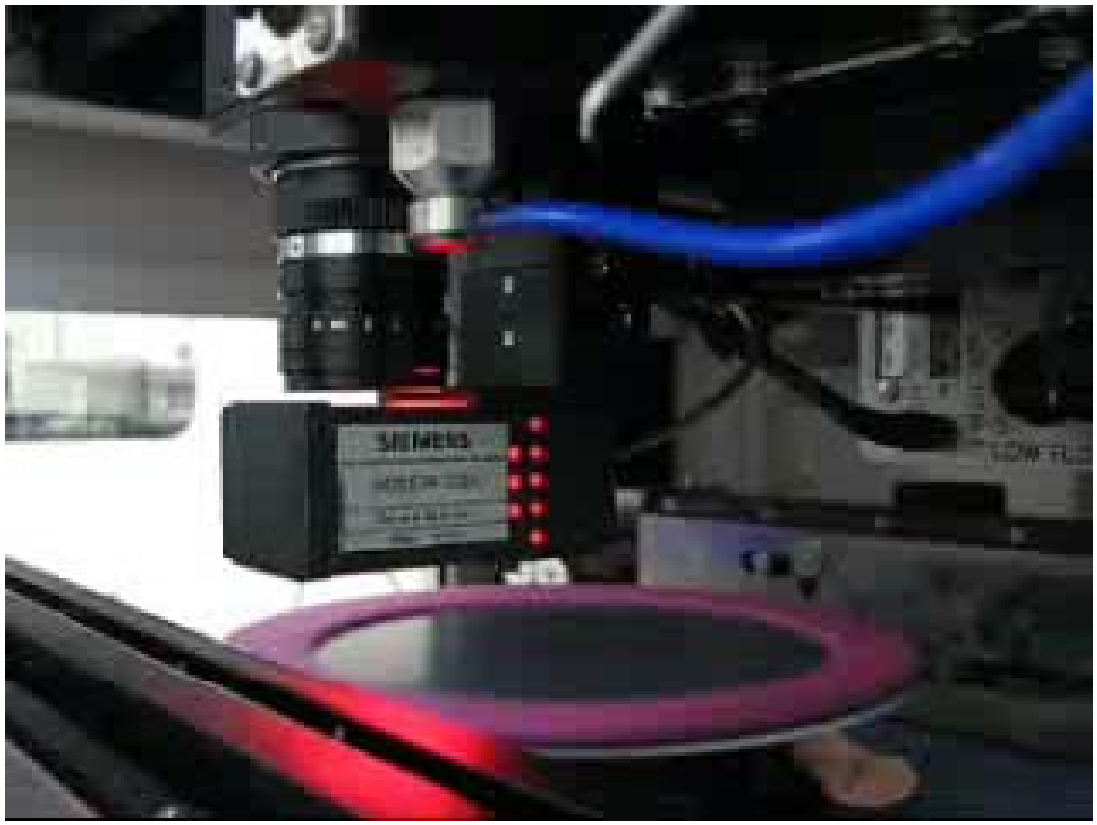
  - **Curved Trajectory (Patent applied)**
    - **Path curves**
    - **Current Preferred coating Profile**



Fluid properties, coating thickness, and tolerance determines which process to use

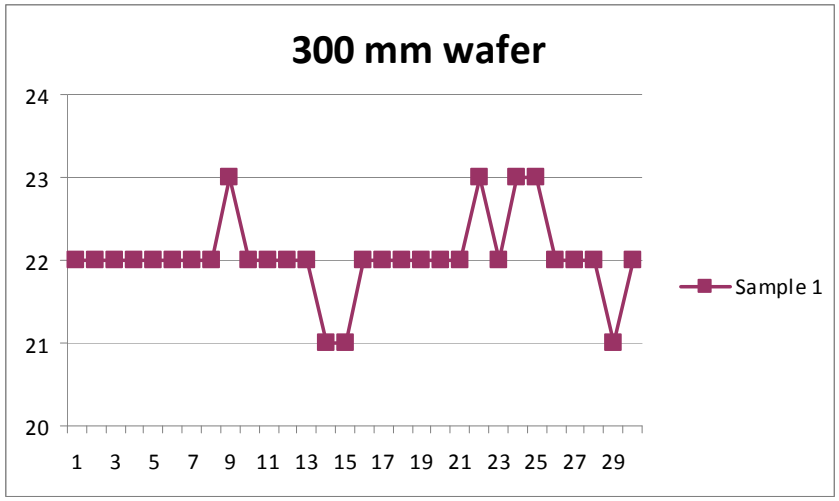
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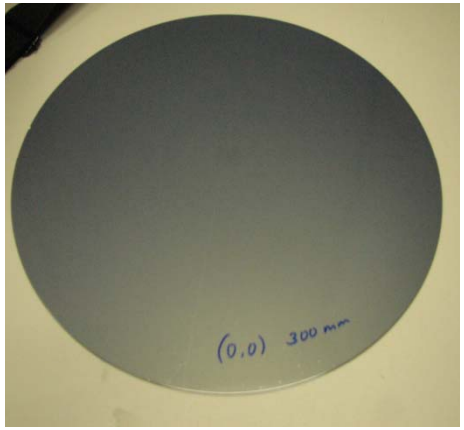
Spin / Spray Process

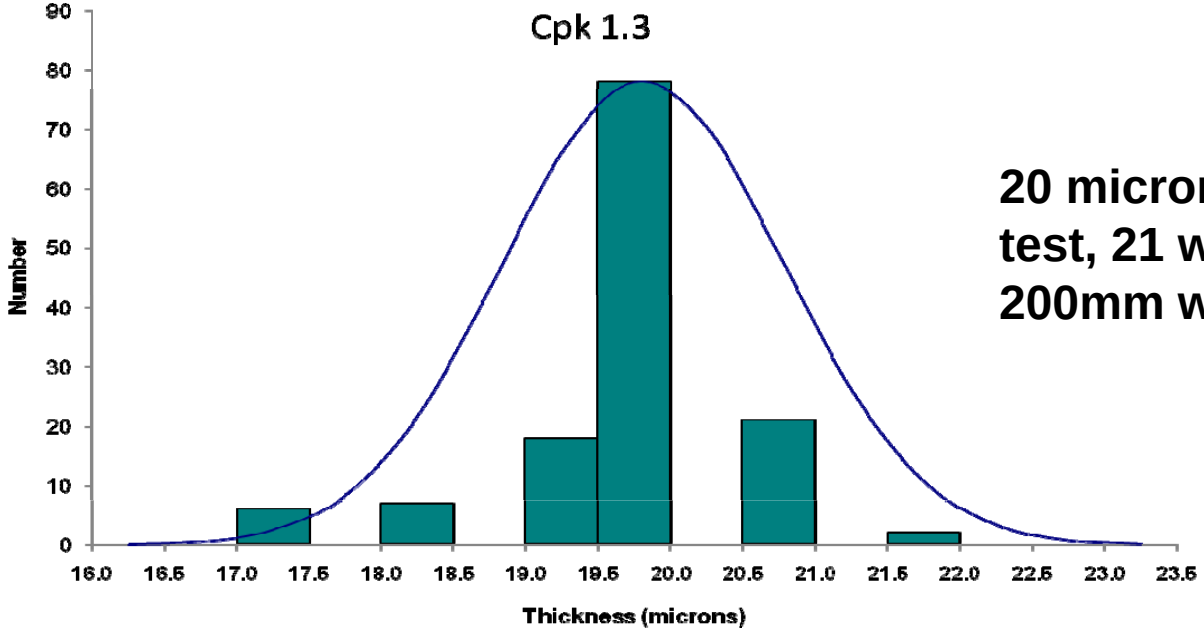


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Coating Thickness Test Results - 20 Micron Target



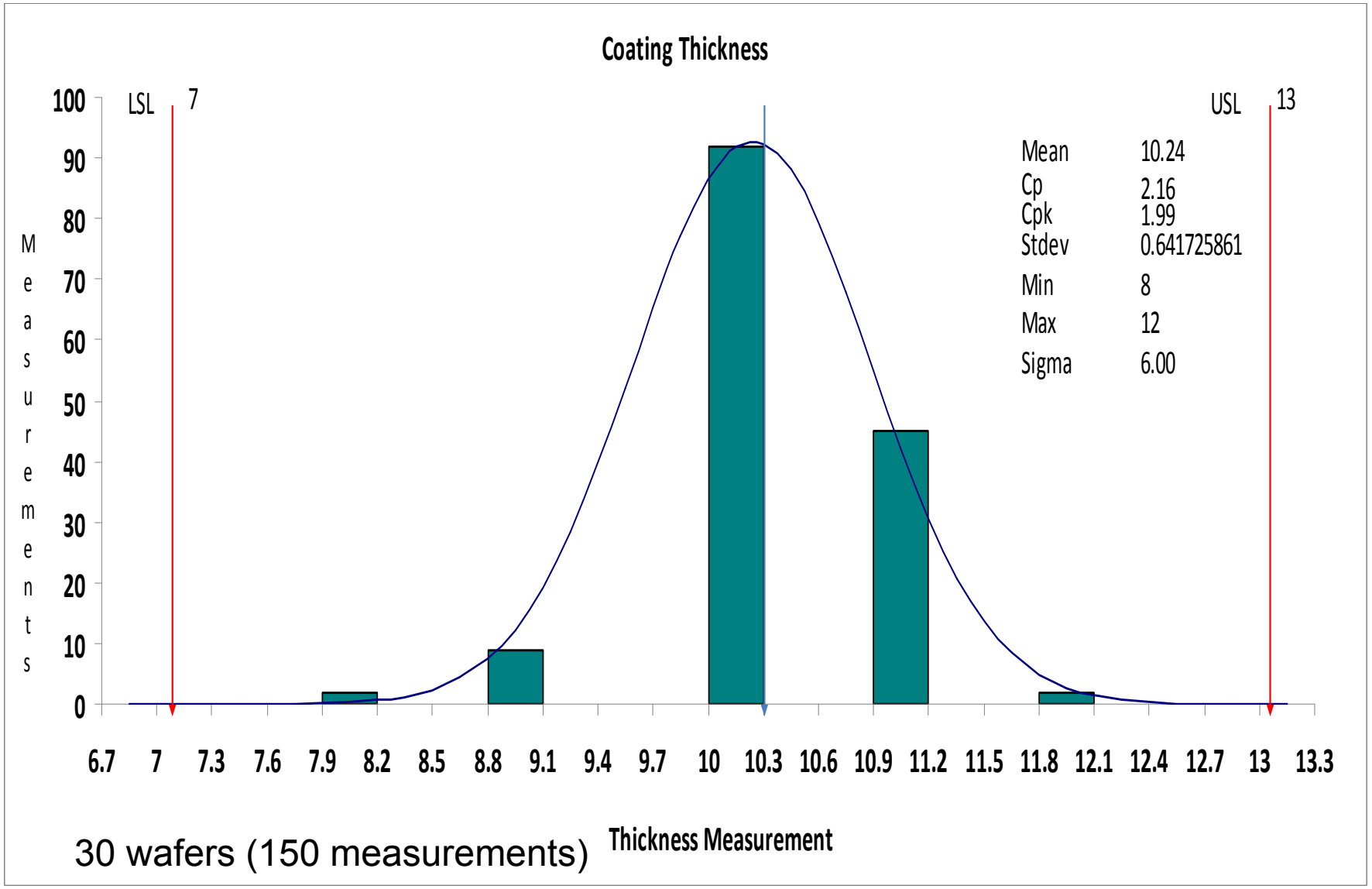




20 micron thickness test, 21 wafers, 200mm wafers

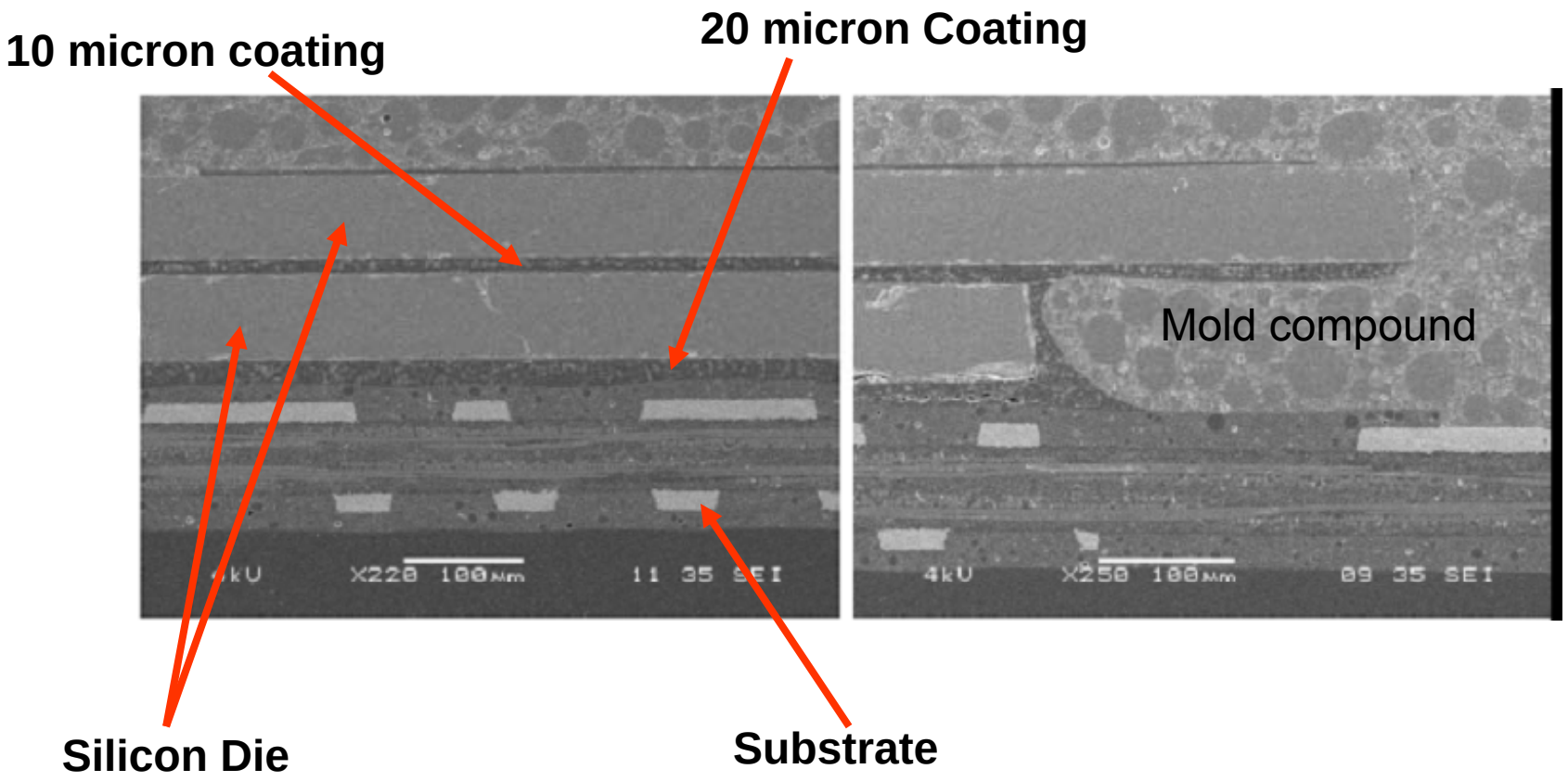
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Coating Thickness Test Results - 10 Micron Target



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Cross Section of a two die stack using Spin / Spray WBC coatings After Molding



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Coating Efficiency

Nordson ASYMTEK

Waste Goal <20%

	Blank Wafer wt. [gm]	Dis. Wafer wt. [gm]	Initial Syringe Wt. [gm]	After dis. Syringe wt. [gm]	Wafer net dis wt. [gm]	Syringe net dis. wt. [gm]	Wastage [gm]	Wastage [%]	Dist. From edge [mm]
1	52.71736	53.58820	36.05879		0.87084	1.06406	0.19321	18.2	0
2	51.27330	52.14630			0.87300	1.06406	0.19106	18.0	0
3	51.56872	52.44310			0.87438	1.06406	0.18967	17.8	0
4	51.69056	52.56854		31.80257	0.87798	1.06406	0.18608	17.5	0

200mm wafers
20 micron film

400% more efficient than spin coating

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Coating Method Comparison

Nordson ASYMTEK

Method	Pro	Con	Con
Spin	**Established process**	**80 % Waste**	
Print	**Fast simple**	**Wafer Contact, Waste on Screen**	**Difficult to make 5, 10 micron films**
Ultrasonic Spray	**Fine atomization Uniform coating**	**Restricted to very low viscosity**	
DAF	**Established process**	**Expensive 30% higher than Spin / Spray**	**No suited for DBG process**
Spin/Spray	**Good Transfer Efficiency Significantly Lower process cost Selectable Film thickness**	**Wet process (Can be integral to wafer backside grinder)**	

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Summary

This development project was initiated to find a more cost effective solution to applying wafer backside coatings:

We have reviewed many methods of coating wafers and determined that the Spin / Spray process is capable of consistently producing 10 and 20 micron films

This process has the potential to significantly reduce the cost of Wafer Backside Coatings

This process is capable of using high viscosity, solvent less / filled materials

This process is a non-contact, Zero wafer breakage allowed

Simple software change to adjust film thickness on wafer

Ideally suited for the Dice Before Grind process

Process applicable to many other types of wafer coating materials

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Thanks to the Staff of Asymtek

In particular Alex Dejene for the work on preparing samples and contributing to the process development

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