SUSS SOLUTIONS FOR LARGE FORMAT PATTERNING

UV Scanning Lithography and Excimer Laser Ablation

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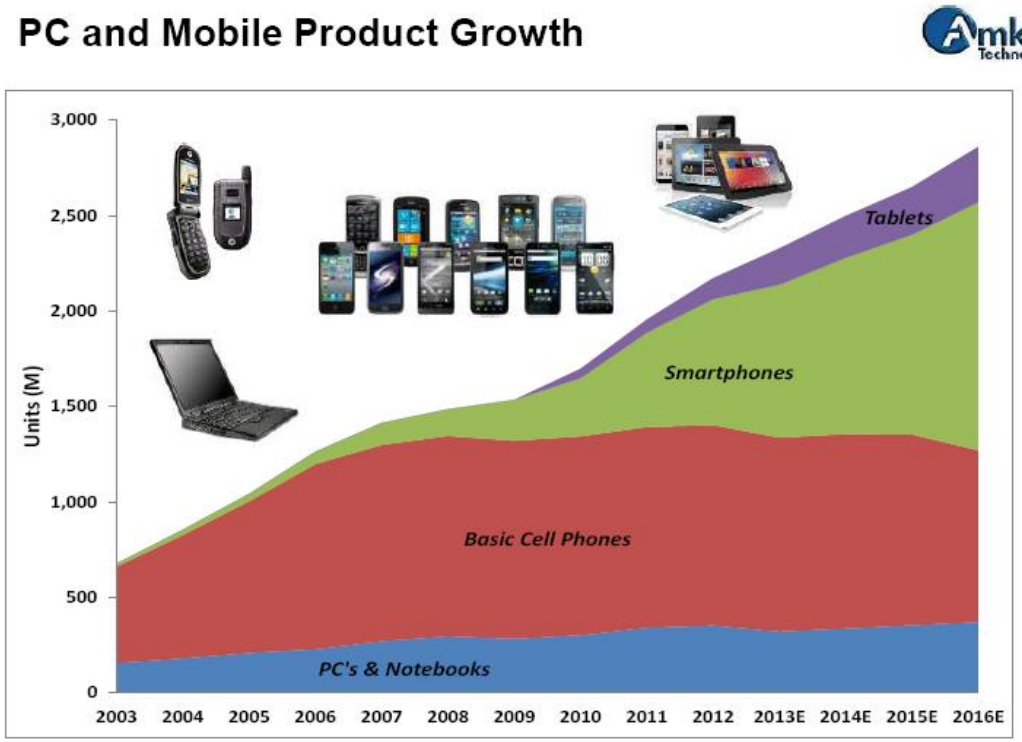
Mobile Applications drive Advanced Packaging Development.

+ Small Form Factor
+ High Performance
+ High Bandwidth
+ Low Power Consumption
+ Low Cost

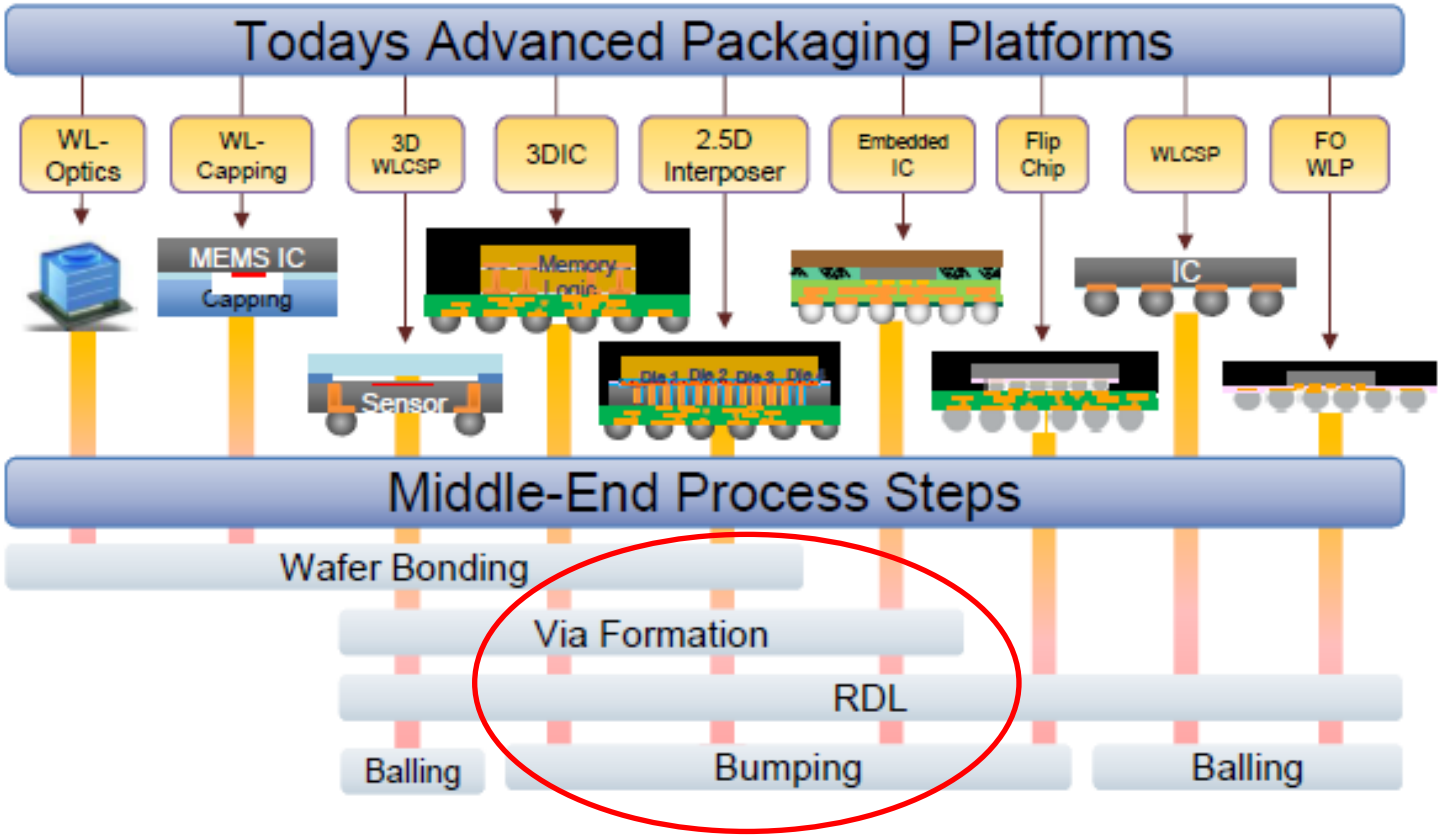
- Smaller L/S and Via
- Higher I/O count
- Higher Yield
- Higher Reliability

+ Higher Performance
+ Lower Cost



Source: TechSearch International, Inc. from various sources, including IDC PC, Media Tablet and Mobile Phone Trackers, March 2012

AP PLATFORMS AND PROCESS STEPS

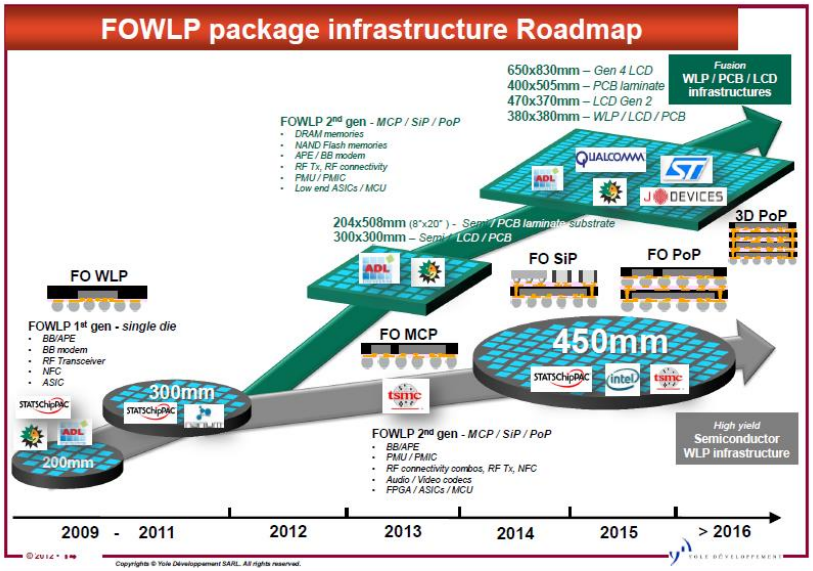


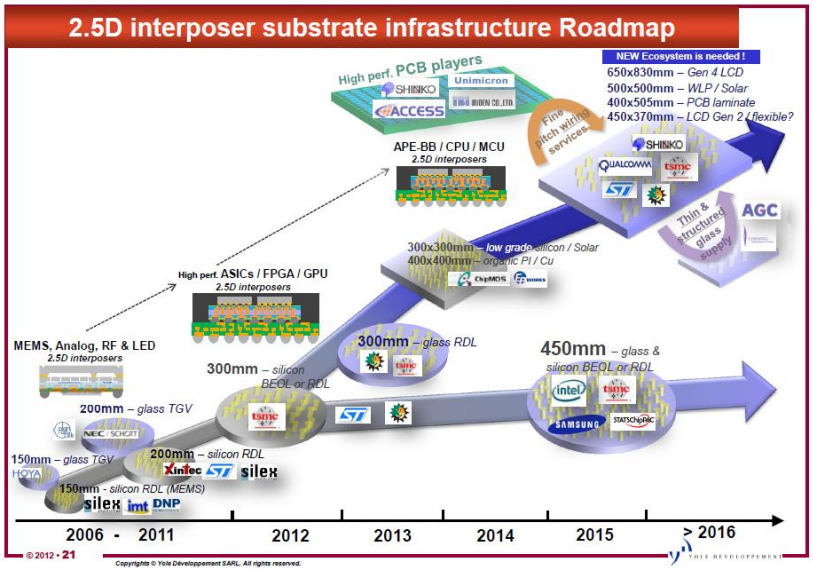
SUSS MicroTec's patterning solution:

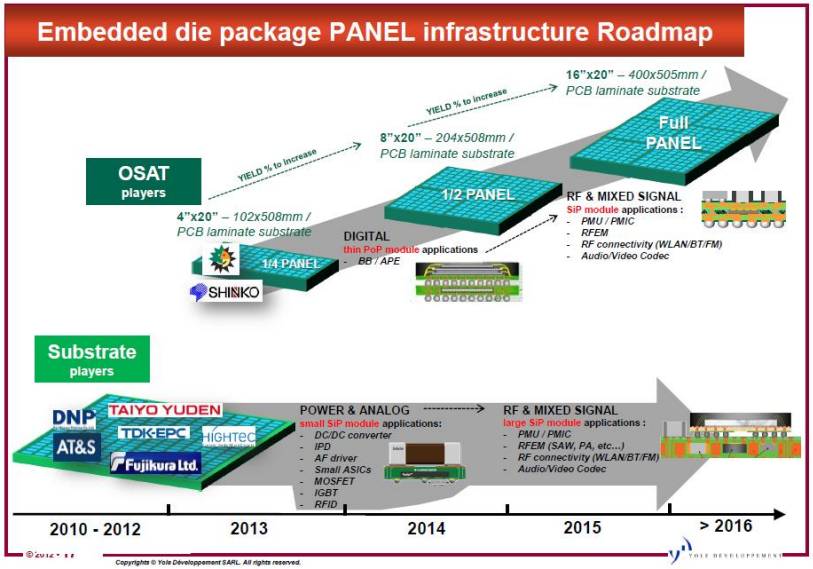
UV Scanner and Excimer Laser Ablation System

AP INFRASTRUCTURE ROADMAP

- All platforms may coexist.
- 450mm being slow, panel based packaging will grow.
- Each sector has different benefits.
  - OSAT, IDM: FOWLP
  - Substrate Manufacturer: Embedded Die
- Same requirements: Cost, Size, Performance
- Collaboration required for reliable infrastructure





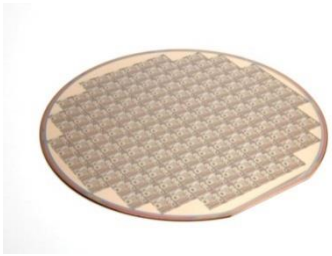


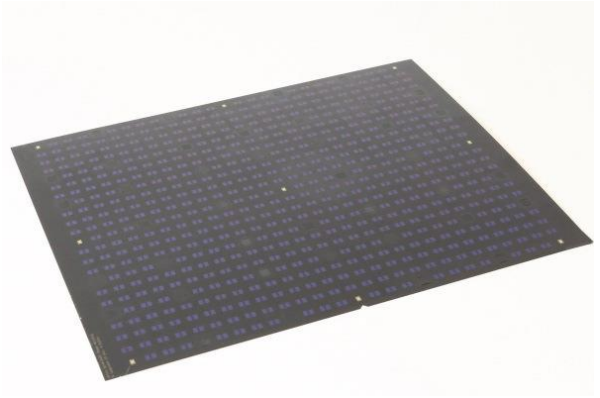
Yole Developpement 2012

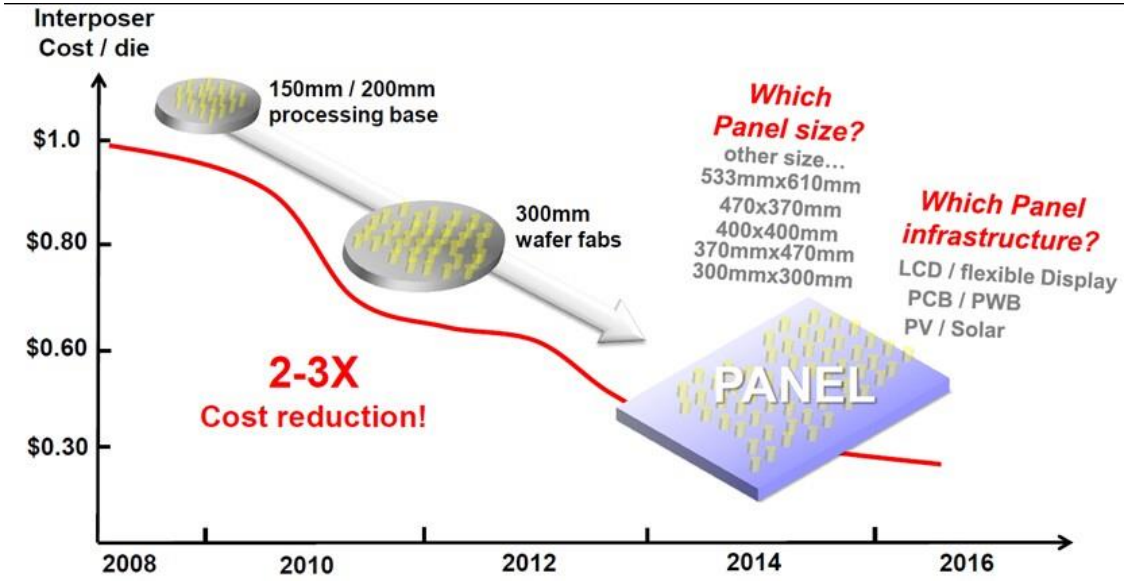
LARGE PANEL ADVANTAGES

- Wafer vs. Panel: technology dependent
- Rectangular: natural choice for better fit and surface utilization
- Throughput: reduced handling/transfer time

- Standards and Infrastructure
  - Process and equipment
  - Size
  - Material







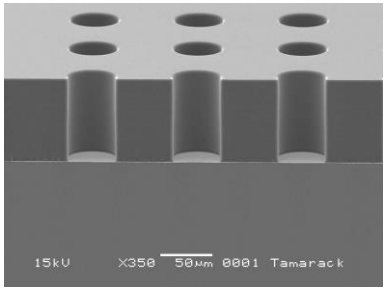
PHOTOLITHOGRAPHY VS. DIRECT ABLATION

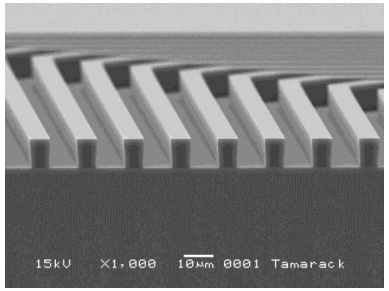
+ Photolithography

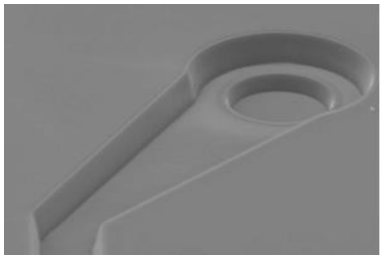
- Proven technology
- Resolution limitation
- Multistep process
- Hazardous/environmentally unfriendly wet chemical process
- Balance of the photo characteristics with the desired thermal/mechanical properties of the material
- Cure of the polymer after photo-process

+ Excimer Laser Ablation

- Direct material removal according to the mask pattern
- Simpler process without wet develop step
- Fine via with high aspect ratio
- Material properties not limited by the need of photo-imaging
- Cure of the polymer before laser processing







SUSS EXPOSURE PRODUCT PORTFOLIO

Mask Aligner

MA200 Gen3
Automatic
150/200mm

MA300 Gen2
Automatic
200/300mm

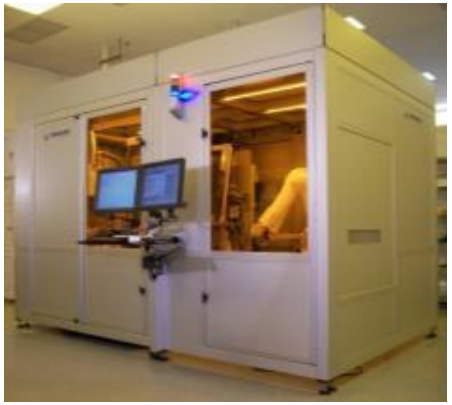
MA/BA8 Gen3
Semi-Automatic
Pieces up to 200mm

MA12
Manual
200/300mm (squares)

Projection Scanner Excimer Ablation System

DSC300 Gen2
Automatic
200/300mm

ELP300 Gen2
Automatic
200/300mm



DSC500 / DSC800
Automatic
450x500mm / 650x780mm

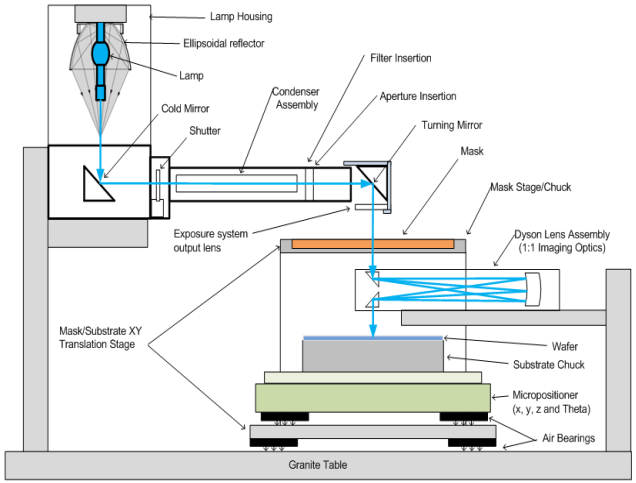
ELP600
Automatic
600x600mm

DSC300/500/800 UV PROJECTION SCANNER

- Proven UV projection scanning technology
- Low cost
- Full-Field No-Stitch 1:1 Projection Imaging
- Alignment accuracy: TSA < 1µm
- Variable NA – high DoF to high resolution
- Full automation
- Wafers: 200mm, 300mm, 450mm
- Panels: 450x500mm, 650 x 780mm

DSC 300 - Wafers

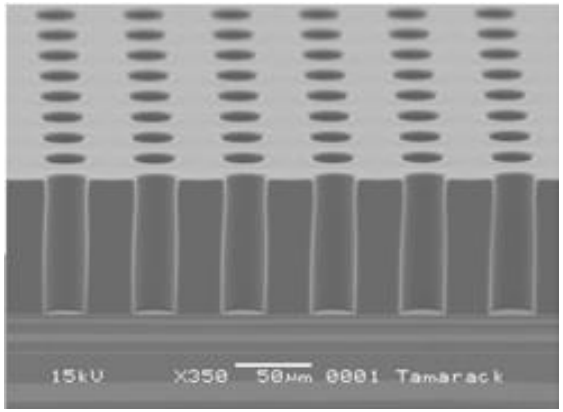
DSC500:
Near Vertical Orientation



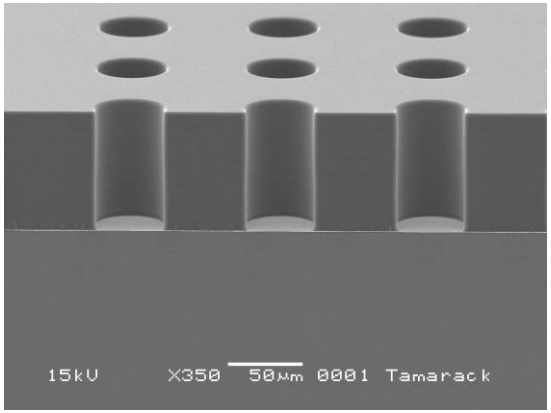
DSC300 Beam Delivery System

DSC500 - Panels

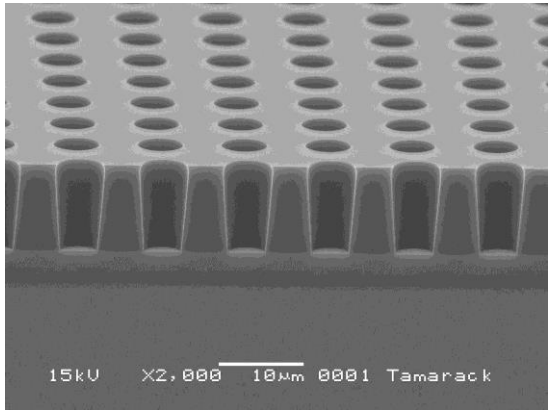
DSC PROJECTION SCANNER IMAGING EXAMPLES



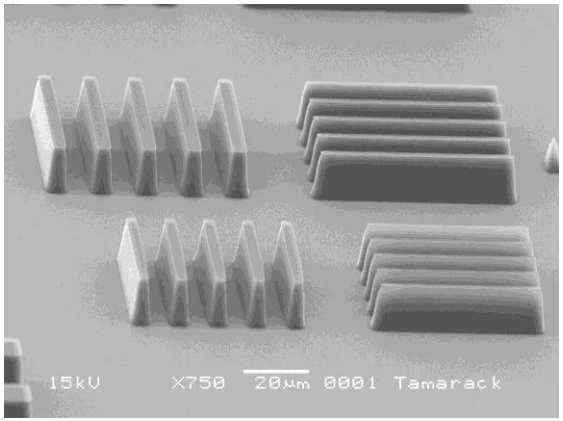
30µm vias in 100µm WBR2100



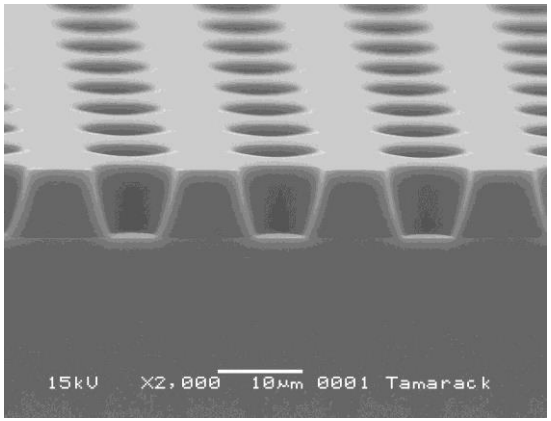
40µm vias in 80µm AZ125nXT



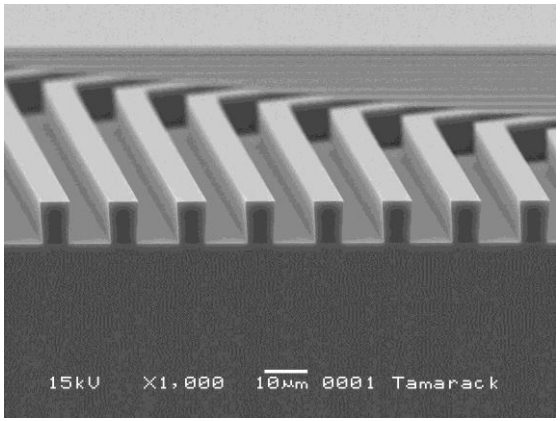
5µm vias in 10µm AZ10XT



6µm and 7µm L/S in 15µm AZ4620



6µm vias in 10µm HD8820 PBO



10µm L/S in 12µm AZ15nxT

ELP 300/600 EXIMER ABLATION SYSTEM

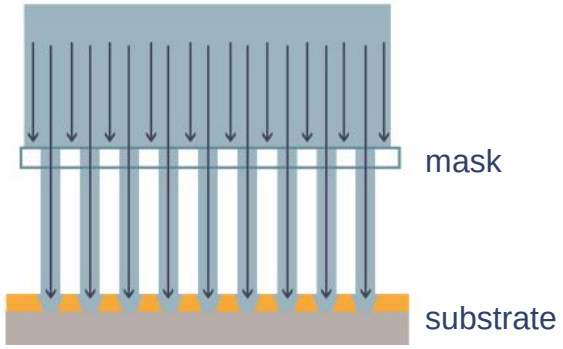
- ELP300: up to 300mm wafer
- ELP600: up to 600mm x 600mm substrate

ELP300

ELP600

EXCIMER LASER ABLATION

- 248nm and 308nm
- Direct removal of the material
  - Add enough energy to break the molecular bonds at the surface.
  - Limited thermal effect for heating or change to adjacent area or underlying material.
- Mask based projection
- Throughput independent of the pattern shape or density.



Suitable Materials:

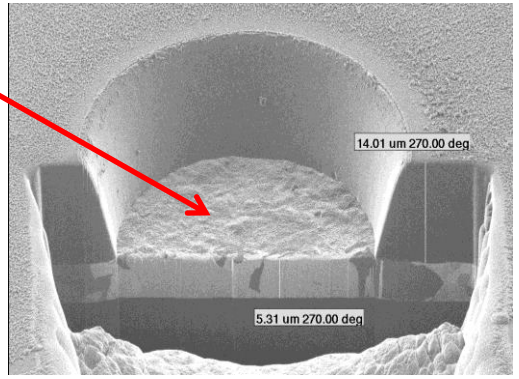
- Most organic materials
  - Polymers/Organic Dielectrics (PI, PBO, BCB, Epoxy etc.)
  - Epoxy Mold Compounds (EMC – filled and unfilled)
- Some inorganics
  - Dielectrics (SiNx < 1µm thick with 248nm)
  - Thin metals (Ti, TiW, TaN, Ta, Cu, Ag, Al, etc. < 600nm thick on organic material)
  - Conductive materials (ITO, IZO, CNT < 1µm thick on organic material)

EXCIMER LASER ABLATION

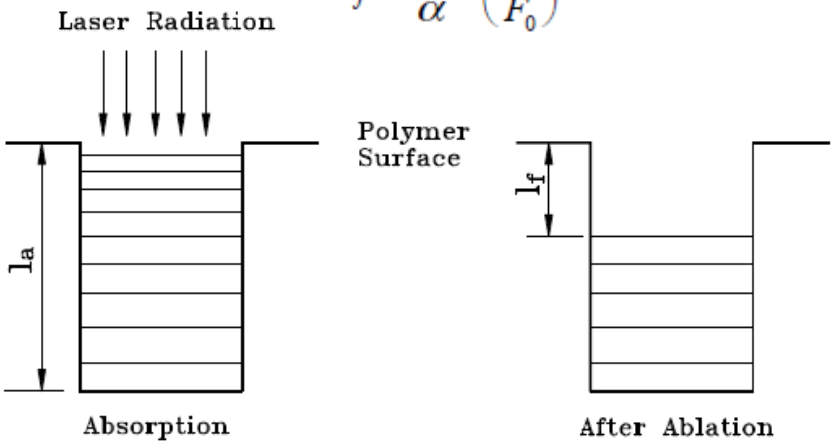
- Fluence and Etch Rate
  - With threshold fluence F_0 ~ constant

  etch depth per pulse (etch rate) can be predicted.
  - Depth control by number of pulses
- Metal Pad as Etch Stop
  - Metal pads (> ~1µm) become natural stop layer for Excimer via ablation.
  - Flexibility for material thickness variation.

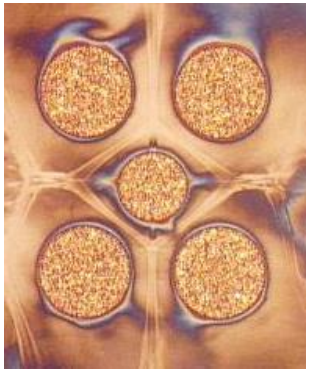
Via 30µm
Stopped on Cu pad
No etching of Cu



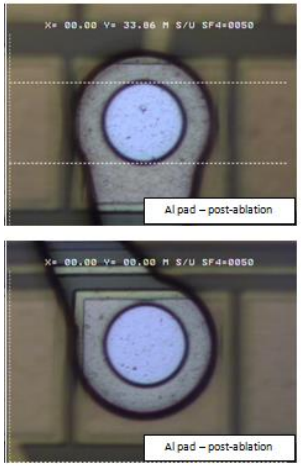
$$l_f = \frac{1}{\alpha}\ln\left(\frac{F}{F_0}\right)$$



Cu Pad



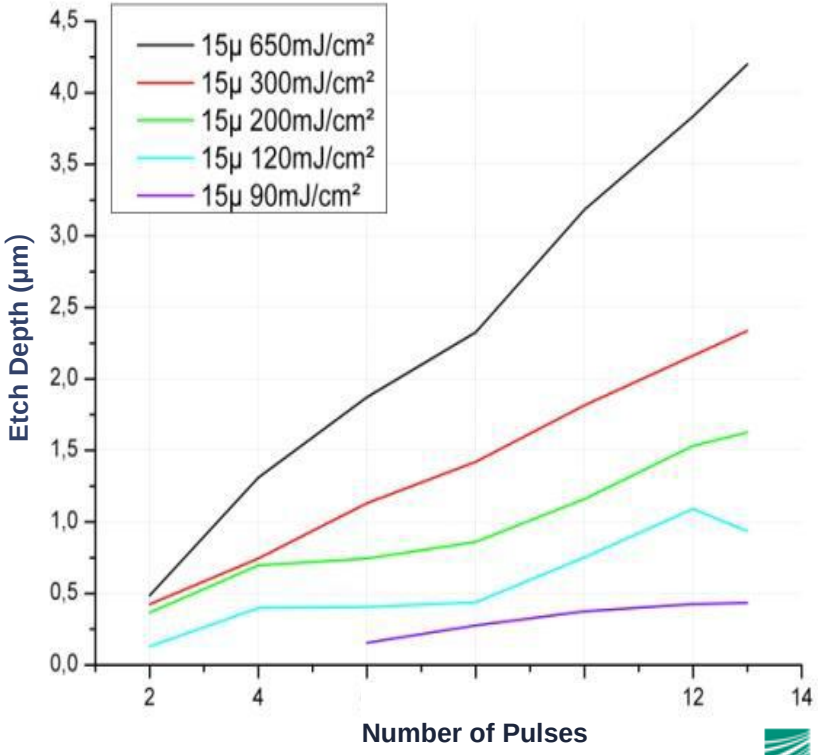
Al Pad

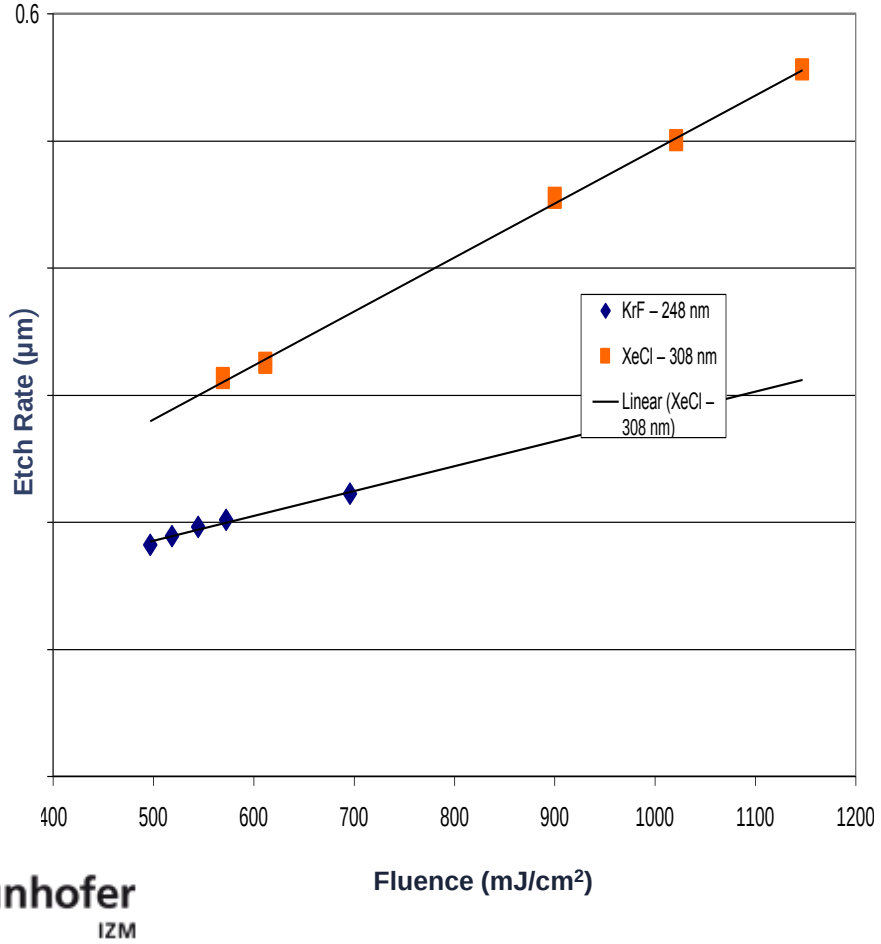


Y. H. Chen, H. Y. Zheng, K. S. Wong, and S. C. Tam, “Excimer laser drilling of polymers”, *Proc. SPIE 3184*, 1997

WAVELENGTH, FLUENCE, PULSE, AND ETCH RATE

- Absorption and etch rate vary:
  - Wavelength
  - Fluence
- Etch depth control by number of pulses

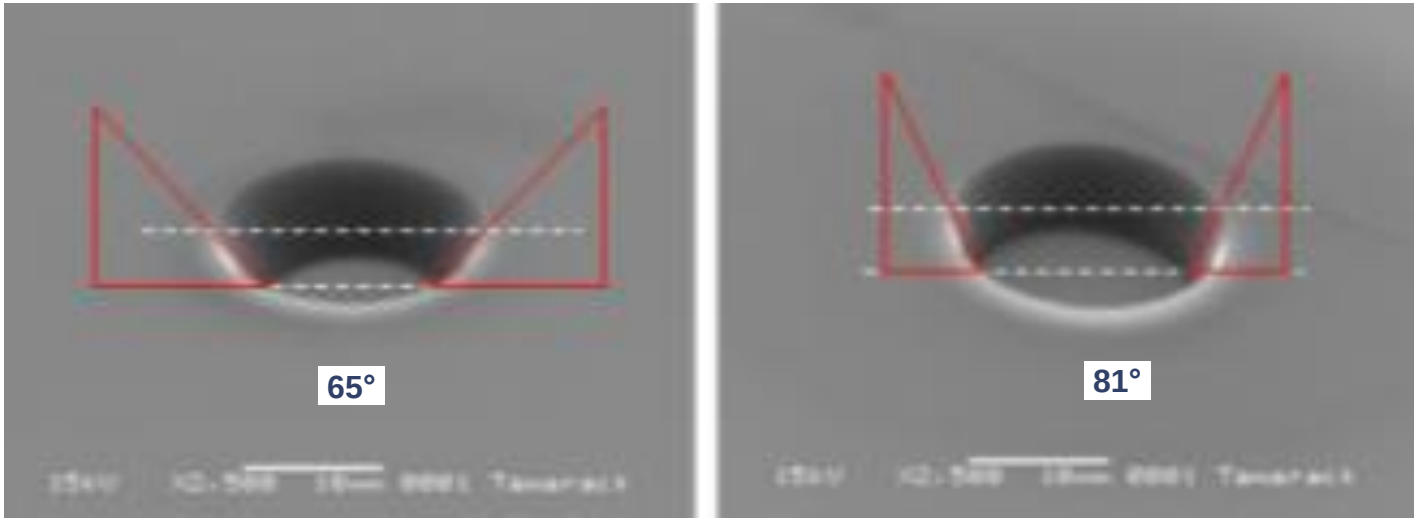




Fraunhofer IZM

SIDE-WALL ANGLE AND FLUENCE

- Side-wall Angle controlled by Fluence
  - Steeper wall with higher fluence
  - Higher etch rate with higher fluence



376 mJ/cm², 45 pulses

1200 mJ/cm², 12 pulses

Fraunhofer IZM

EXCIMER LASER ABLATION ADVANTAGES

+ Technical benefits
  - Higher via resolution < 3µm (2µm demonstrated)
  - High overlay control:
    - 300mm Wafer: +/- 1µm
    - Panels: +/- 2µm
  - Side-wall angle control
  - Limited thermal effect

+ Simpler process
  - Eliminate develop and chemical etch steps
  - Reduce bake/curing step

+ Safety and environmental protection
  - Reduction of hazardous process steps and chemicals
  - Reduction of chemical waste

+ Benefit with Non-Photo Material
  - Cost Reduction
  - Combination of desirable material properties

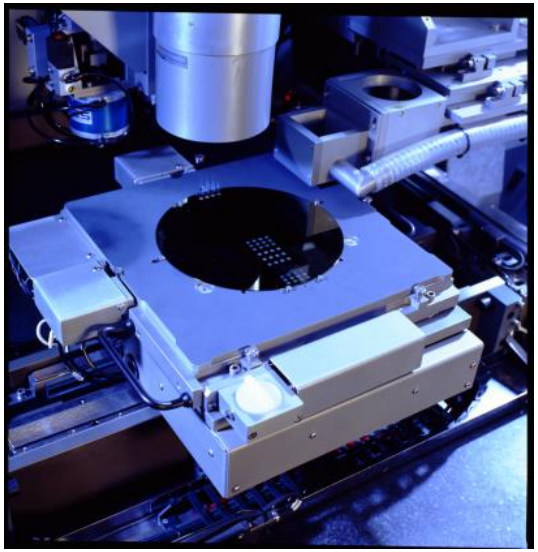


PHOTO AND NON-PHOTO MATERIAL EXAMPLE

- Non-photo material's advantages
  - Desirable properties
  - Low cost

Photo/Non-Photo	Non-Photo	Photo
Material	PI	PI
Manufacturer	HD Micro	HD Micro
Product	PI-2611	HD-4100
CTE (ppm/°C)	3	35
Modulus (GPa)	8.5	3.4
Tensile Strength (MPa)	350	200
Elongation (%)	100	45

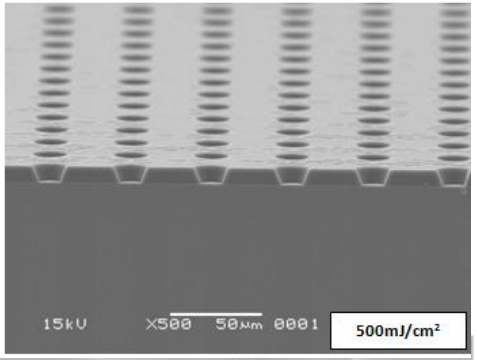
ELP600 – TECHNICAL CHARACTERISTICS

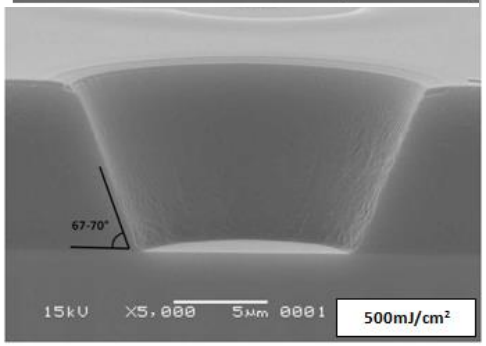
Beam Delivery System	
Wavelength	248nm and 308nm
Projection Lens	2.0x, 2.5x & 5x reduction (up to 100mm diameter)
resolution	vias to ~3µm; Traces to ~5µm (material & depth dependent)
Processing Methods	
Ablation Methods	Step & Repeat; Step & Scan; Continuous Scan
Alignment System	
Type	Global and site-to-site; Auto pattern recognition
Top Side Alignment	< ± 2.0µm
BSA	< ± 3.0µm (future option)
Auto alignment	yes
Manual alignment	yes
Substrate Handling	
Substrate loading	Manual (Auto loading option)
Mask loading	Manual (Auto loading option)
Substrate Size	Up to 600mm x 600mm
Mask	177.8 x 177.8mm, 3.8mm thickness
Carrier Mounted Substrates	Yes
Thin substrates w/o Carrier	Thickness down to 250µm
System Enclosure	
debris removal system	vacuum, external exhaust; (reclaim system option)
safety enclosure	interlocked enclosure for Class 1 Laser Safety
environmental control	ECU (+/- 0.5deg C); HEPA filters
Dimensions	
Main System (Height x Width x Depth)	~2500mm x 2300mm x 2680mm (excluding ECU, Laser & auto substrate loader)
Weigtht (BDS)	~3500 kg

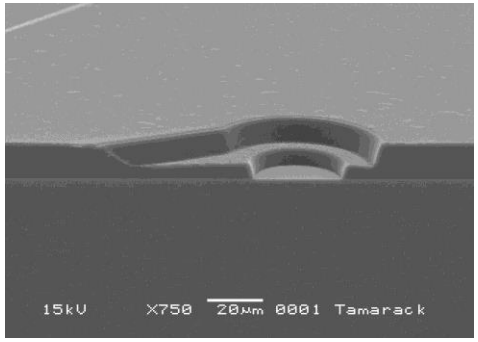
ELP600

ELP EXCIMER STEPPER PATTERNING EXAMPLES (PHOTO MATERIAL)

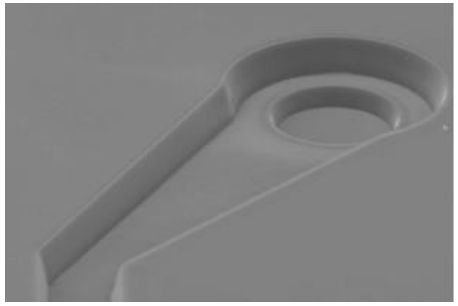
JSR WPR 5100 10µm

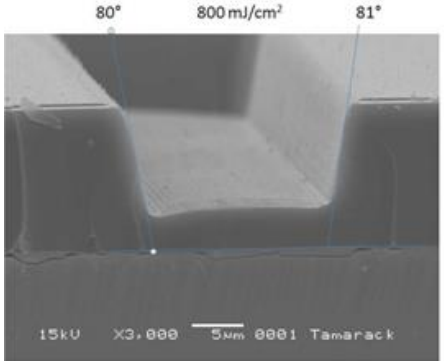




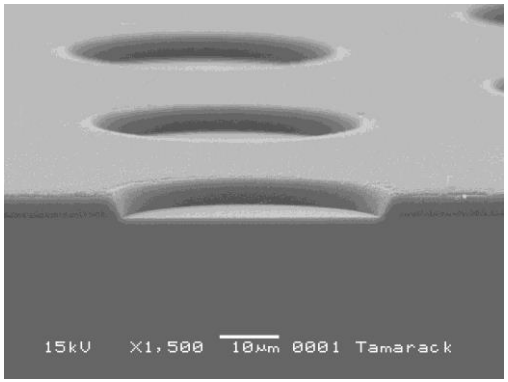


HD8930 PBO 13µm

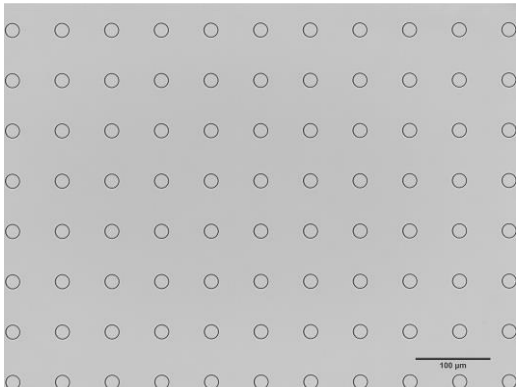




HD4004 8.2µm



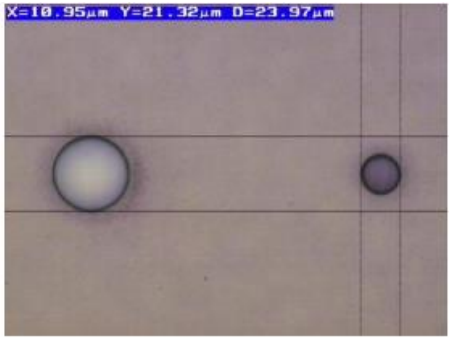
40 µm vias



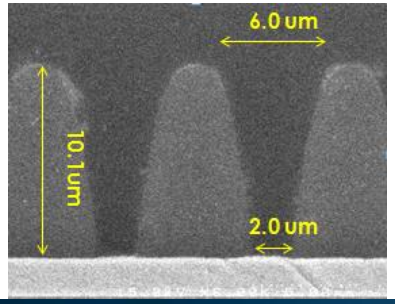
15 µm dia vias

ELP EXCIMER STEPPER PATTERNING EXAMPLES (NON-PHOTO MATERIAL)

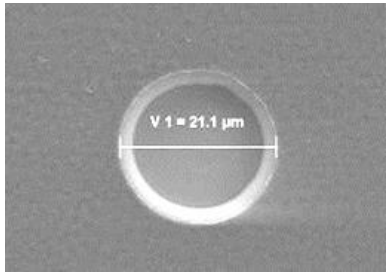
EMC (undisclosed) 10µm



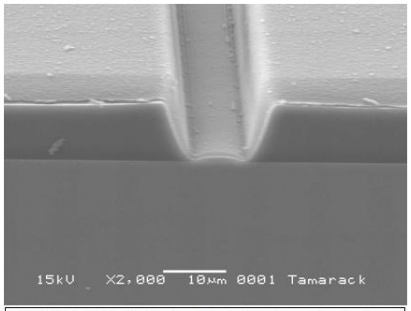
ϕ10,20um vias



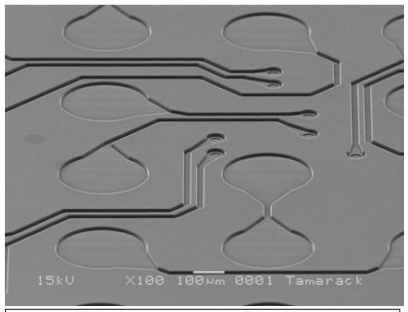
HD (proprietary) 8µm



HD2574

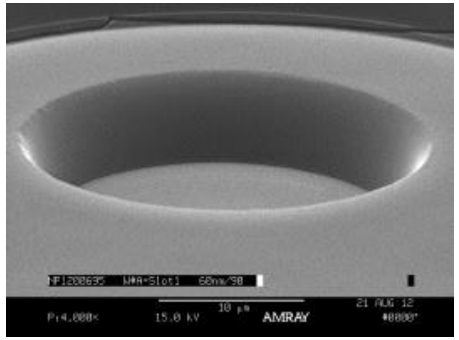


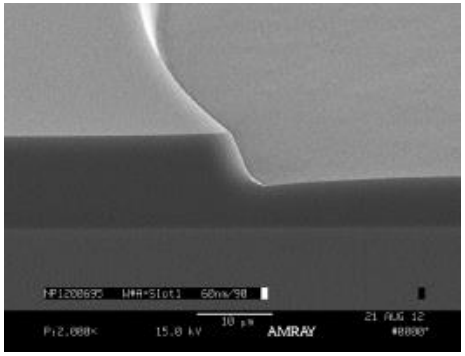
HD2574C – 1000mJ/cm² – Trench/Pads: 16 pulses – Vias: 9 pulses

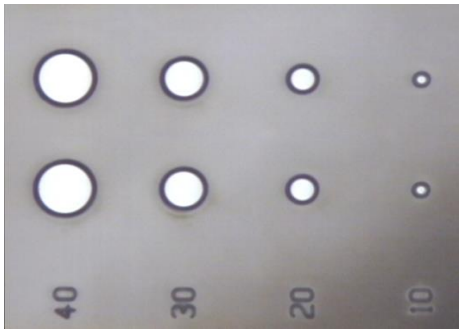


HD2574C – 1000mJ/cm² – Trench/Pads: 16 pulses – Vias: 9 pulses

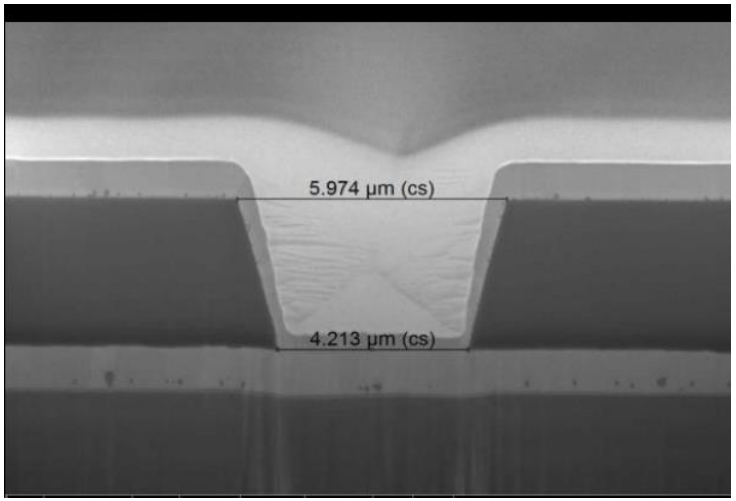
Dow BCB Cyclotene 302X 12µm



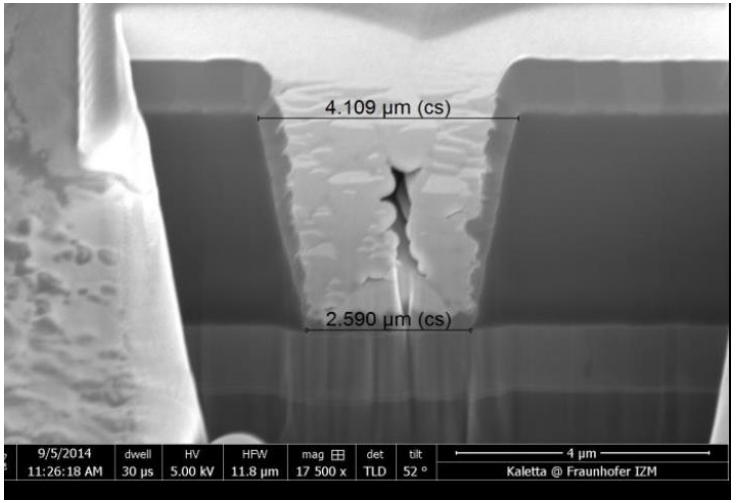




ELP EXCIMER STEPPER PATTERNING EXAMPLES (BCB CROSS SECTION)



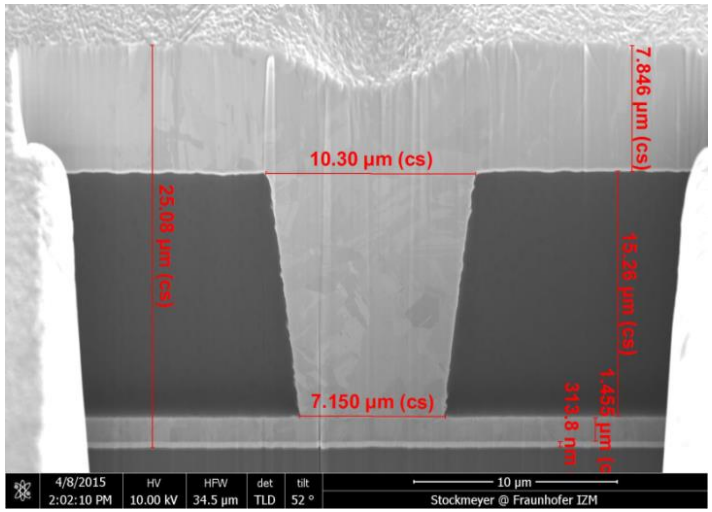
Mask: 7 µm
Top: 6 µm
Bottom: 4.2 µm
650 mJ/cm^2



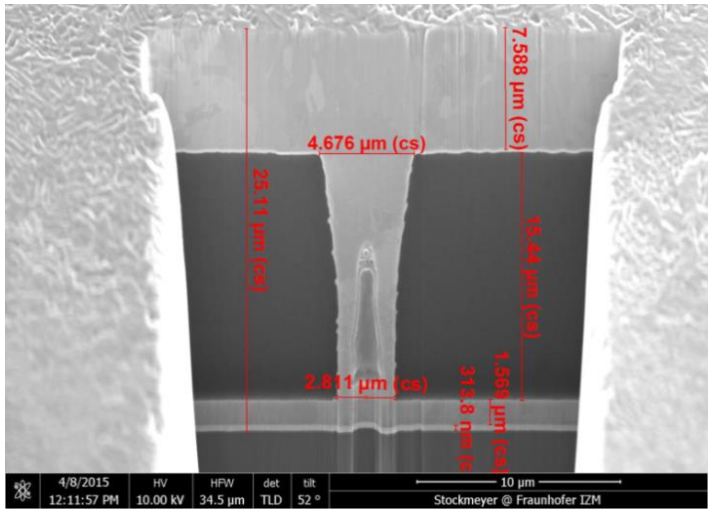
Mask: 5 µm
Top: 4.1 µm
Bottom: 2.6 µm
650 mJ/cm^2

Michael Töpper, Karin Hauck, Mario Schima Danny Jaeger, Klaus-Dieter Lang, “A sub-4 µm Via Technology of Thin film Polymers using Scanning Laser Ablation”, ECTC 2015

ELP EXCIMER STEPPER PATTERNING EXAMPLES (BCB DRY FILM CROSS SECTION)



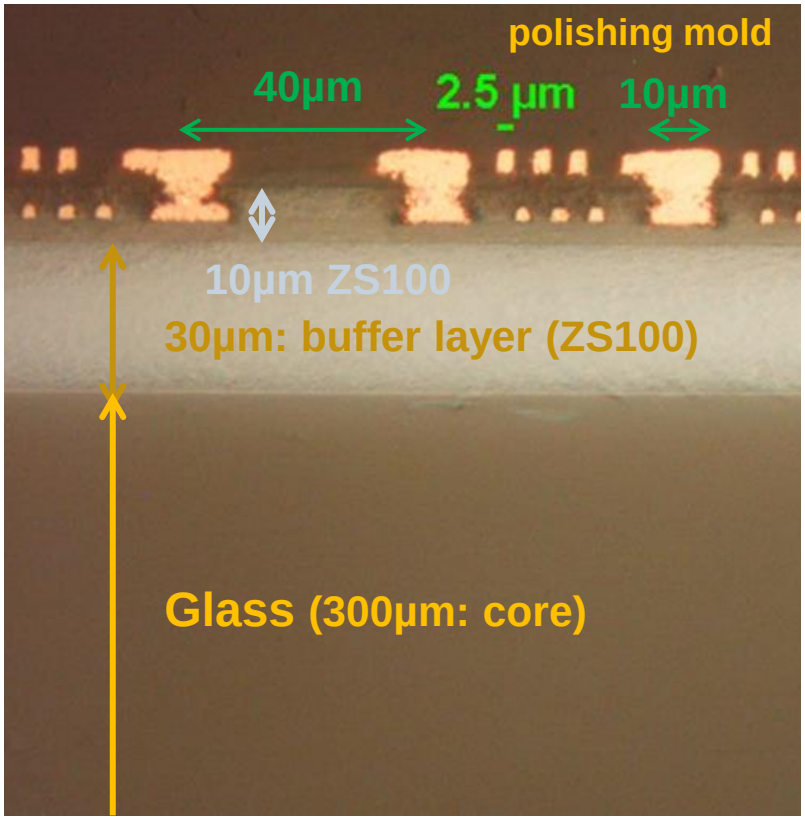
Mask: 10 µm
Top: 10.3 µm
Bottom: 7.2 µm
Thickness: 15 µm



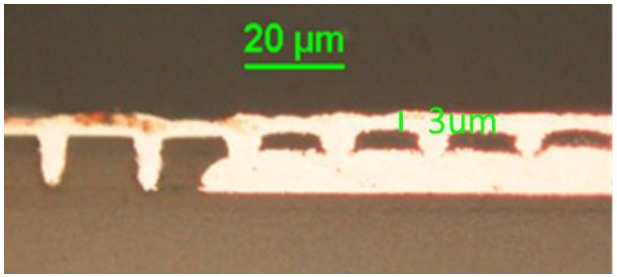
Mask: 5 µm
Top: 4.7 µm
Bottom: 2.8 µm
Thickness: 15 µm

Michael Töpper, Karin Hauck, Mario Schima Danny Jaeger, Klaus-Dieter Lang, “A sub-4 µm Via Technology of Thin film Polymers using Scanning Laser Ablation”, ECTC 2015

ELP EXCIMER STEPPER PATTERNING EXAMPLES (FILLED VIA AND RDL)



2 metal layer with 10µm fully filled micro-vias at 40µm pitch and 2.5µm line



8-10µm fully filled micro-vias at 20µm pitch

Yuya Suzuki, Jan Brune, Rolf Senczuk, Rainer Pätzel, Ryuta Furuya, Fuhan Liu, Venky Sundaram, Rao Tummala, “Demonstration of 20µm Pitch Micro-vias by Excimer Laser Ablation in Ultra-thin Dry-film Polymer Dielectrics for Multi-layer RDL on Glass Interposers”, ECTC 2015 ***Georgia Tech*** **PRC ZEON**

POST LASER ABLATION CLEANING

+ **Post ablation cleaning is required for subsequent processes in most cases.**

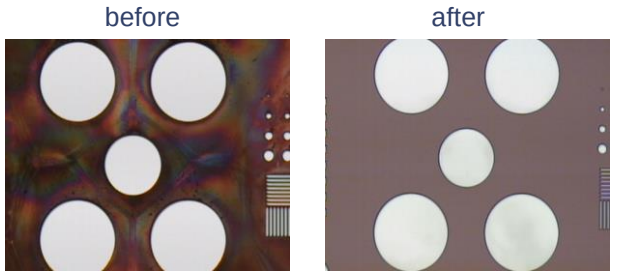
  - **Sacrificial layer**
    + Successful cleaning of HD4104
    + Sacrifiall layer removed with high-pressure CO_2 ionized water

  O_2 plasma cleaning
    + Successful cleaning of PBO, BCB, HD2611, HD4110
    + In-house tool (vacuum plasma) available

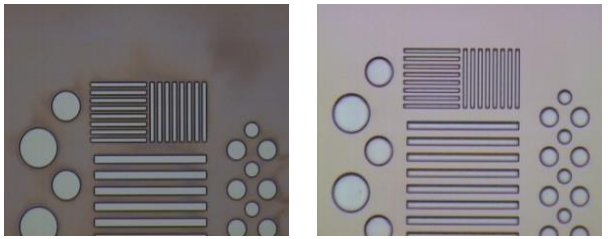
  CO_2 snow cleaning
    + Successful cleaning PBO with most aggressive CO_2 snow
    + 3rd party tool available

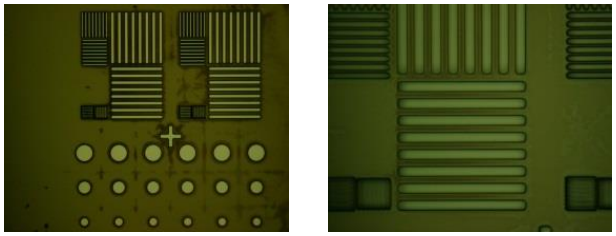
  DPSS Cleaning
    + Successful cleaning PBO (HD8820)
    + Using pico second DPSS Laser
    + In-house tool available

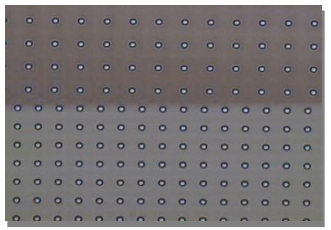
+ **The material determines the cleaning method.**



Sacrificial Layer


O_2 plasma


CO_2 snow


DPSS

SUMMARY

- Mobile products drive packaging trend
  - Cost, Form Factor, Performance, Yield
- Large size rectangular panel will grow for high volume manufacturing.
  - Driven by cost reduction

- Patterning is a major factor along with material development.
  - Suss MicroTec provides Mask Aligner, UV Projection Scanner and Excimer Laser Ablation for patterning applications.
  - UV scanner and excimer laser stepper are available for large format patterning.
  - Excimer laser stepper provides maximum benefits with non-photo materials.
  - Excimer laser stepper applications in RDL Via and Trench formation, SLR and Laser Debonding.

- Demo and evaluation test available
  - In-house at Suss MicroTec
  - Fraunhofer Institute IZM

ELP600


Thank you!