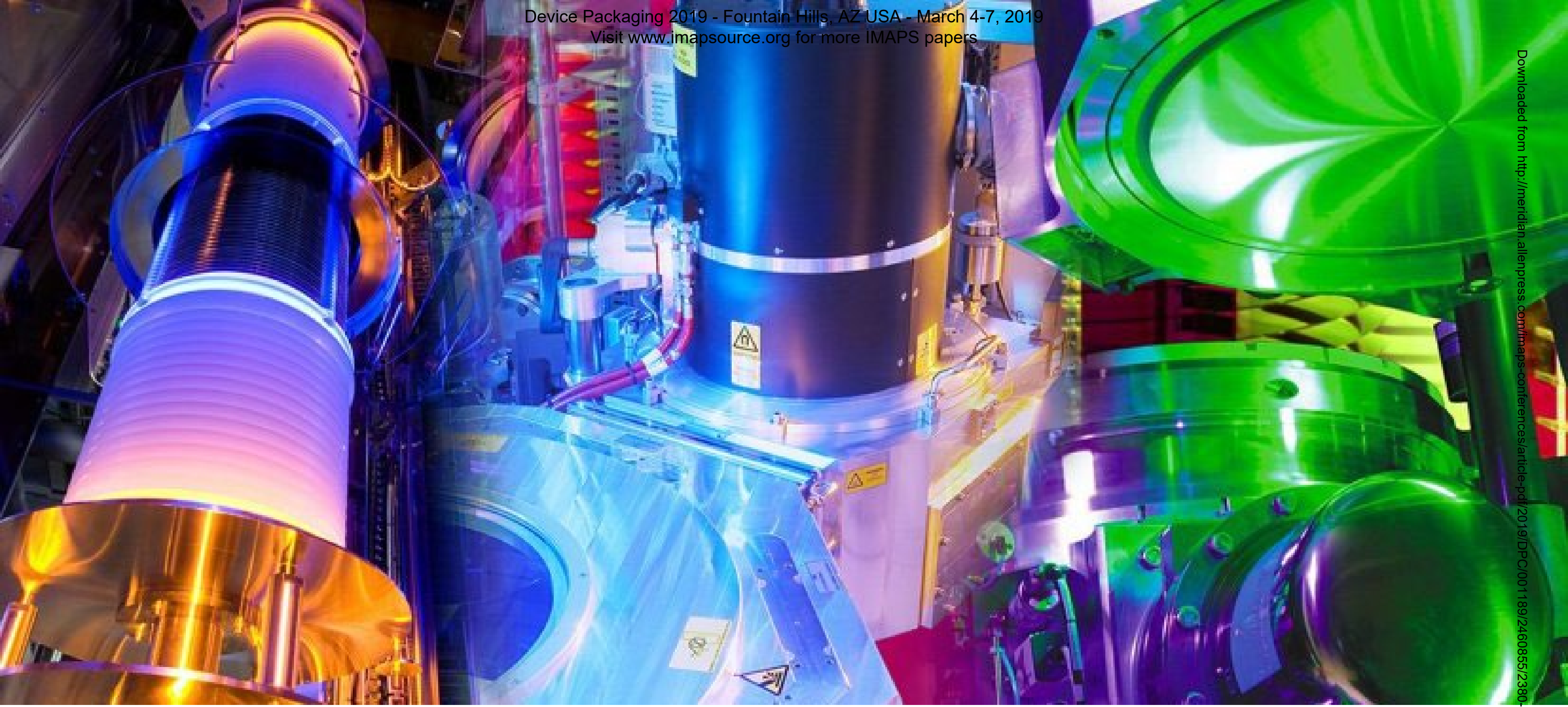

Dicing Tape behavior within a Plasma Dicing Environment

Stewart Fulton (SPTS) / Takuo Nishida (LINTEC)

IMAPS DPC 4th – 7th March 2019, Arizona

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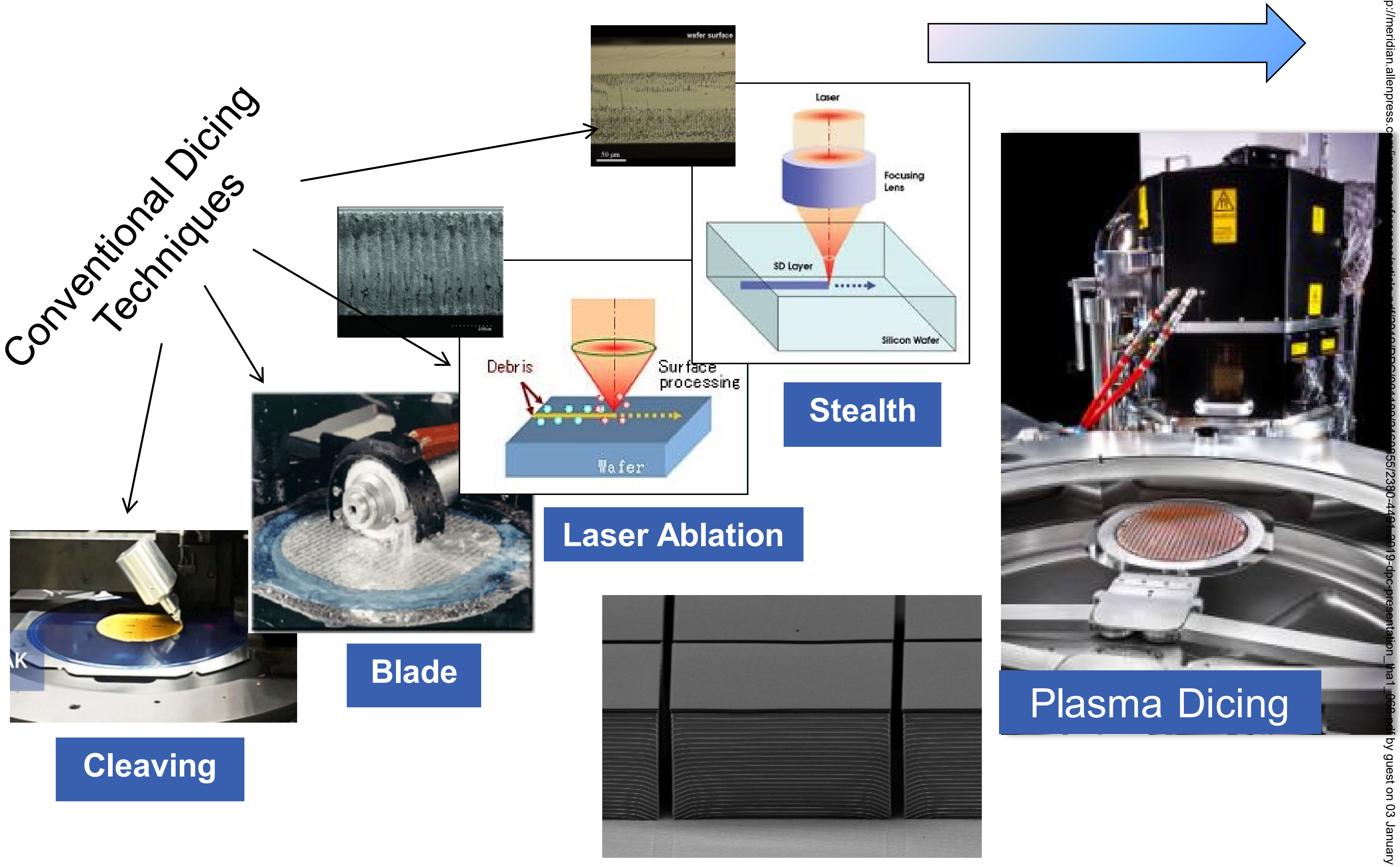
Plasma Dicing-The next step in evolution of die singulation



Conventional Dicing Techniques

Cleaving

Blade

Laser Ablation

Stealth

Plasma Dicing

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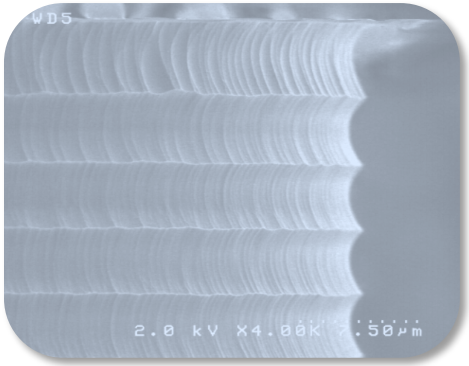
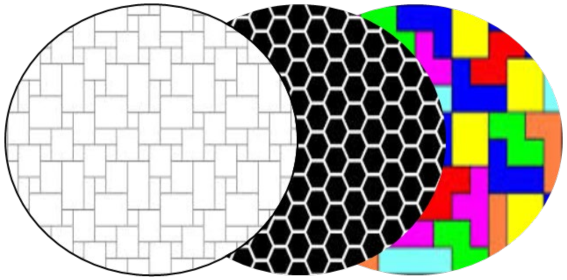
The Benefits of Dicing with Plasma

- Limited Damage
  - Bosch etch creates clean scallops
  - No vibrations, debris, water
  - Increased die strength
  - Yield improvement
- Die Density
  - Narrower dicing lanes
  - Die shape/location can be varied
- Throughput
  - Parallel process
  - Largely independent of die size
  - Cluster approach for higher output/floor area





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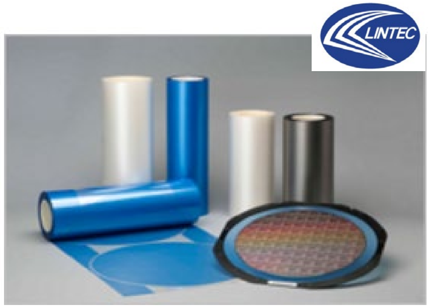
Dicing tape

- Properties of tapes have been designed for traditional dicing techniques
  - The mechanical stresses of saw dicing
  - Thermal challenges of full cut laser dicing
  - The UV transparency for back-side stealth dicing
- Tape performance needs to be characterised for plasma dicing to ensure successful damage free die pick-up



Can we use standard dicing tapes for Plasma Dicing?

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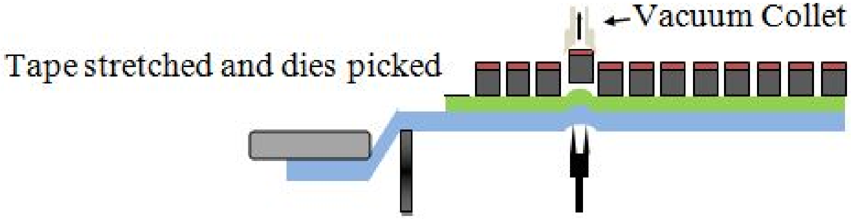
Dicing tape tests

- Out-gassing and thermal performance of tape
- Elongation and tensile strength measurement
- Plasma exposure and adhesive curing (SF_6 & O_2 plasma)
- Die pick-up force measurement (saw diced versus plasma diced die)



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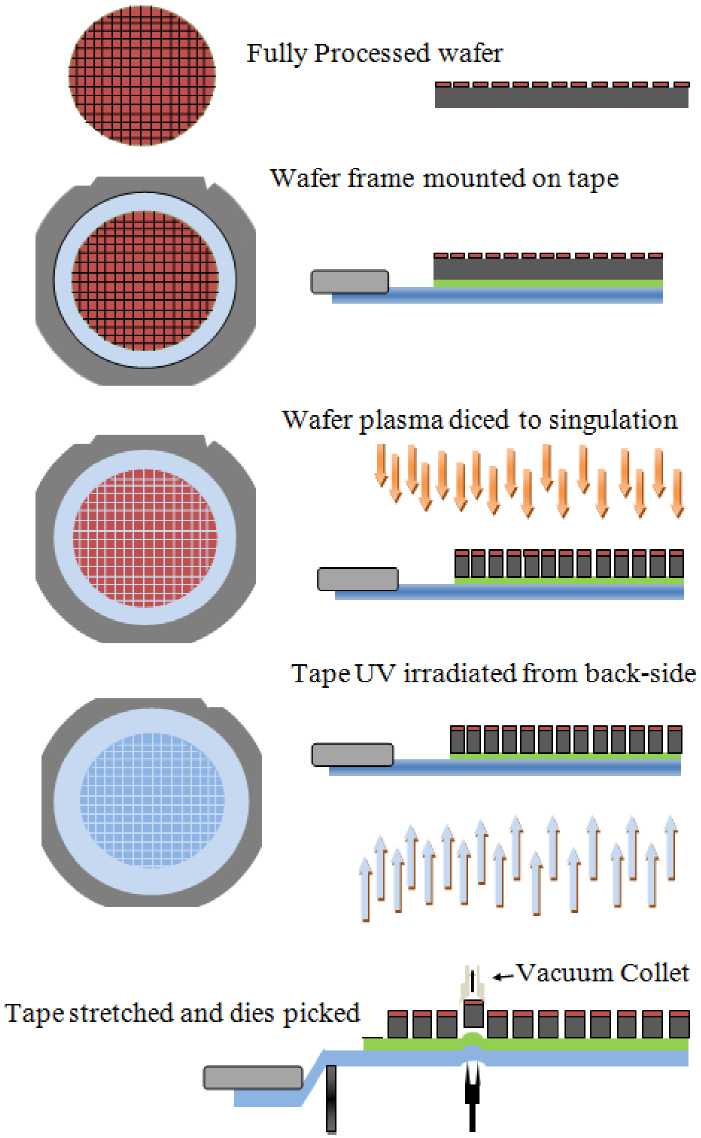
Dicing tape

Typical use of tape during dicing and die pick-up



Fully Processed wafer

Wafer frame mounted on tape

Wafer plasma diced to singulation

Tape UV irradiated from back-side

Vacuum Collet

Tape stretched and dies picked

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What is plasma dicing?

The “Bosch” Process

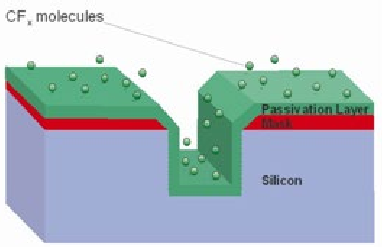
- Si etch process
- Repeating loops

Phase 1 Polymer dep

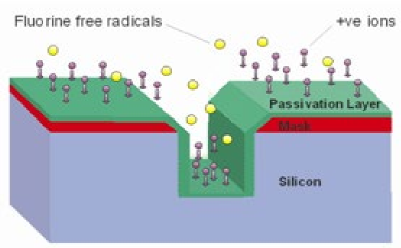
Phase 2 Polymer removal

Phase 3 Isotropic Si etch

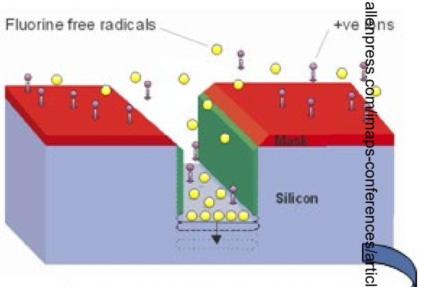
Phase 1



Phase 2

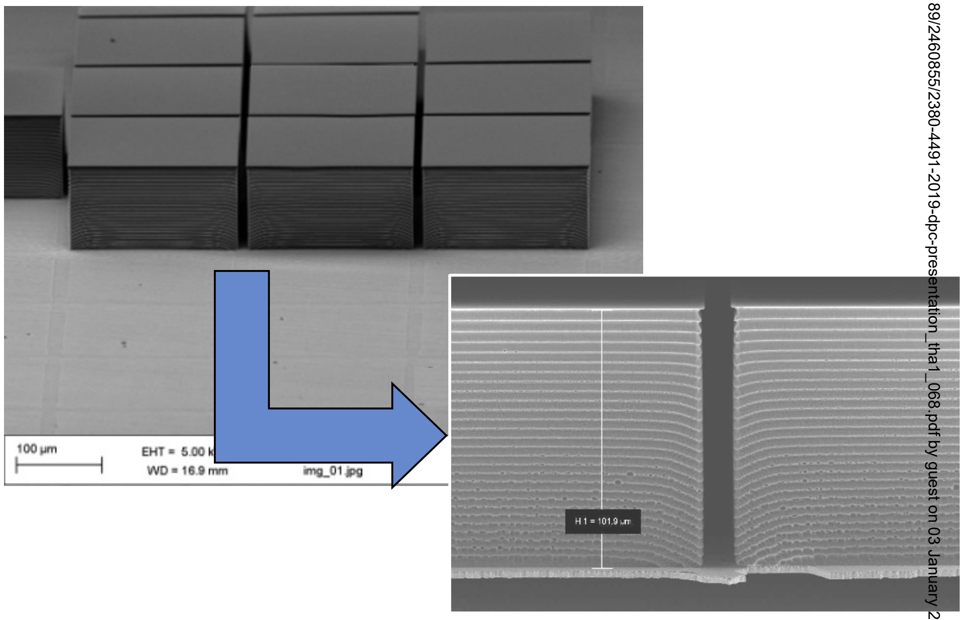


Phase 3



Back to Phase 1

A time multiplexed deep anisotropic etching technique used in high volume manufacture for Deep Silicon Etching Applications e.g. MEMS, TSV, etc



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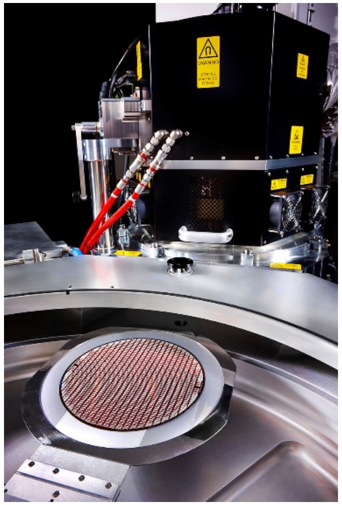
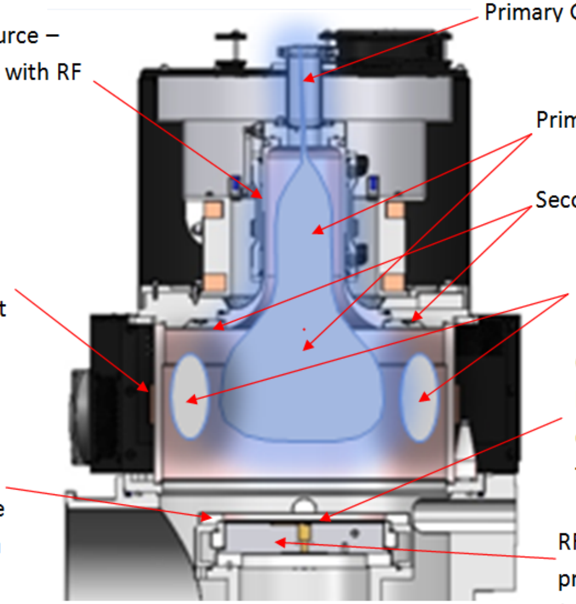
Dicing tape performance in a plasma

- Dicing tape tests were performed using a Rapier S Plasma dicing module
  - Tests were performed on PO (Polyolefin) & PVC (Polyvinylchloride) tapes of varying adhesive strengths

A dual source plasma reactor designed for high silicon etch rate with low cross wafer non-uniformity

Rapier S Plasma Dicing Process Module





Primary (DSi) source – Bell jar chamber with RF at 13.56MHz

Secondary (ICP) source – Ceramic chamber with RF at 13.56MHz

Frame Cover Ring used to protect the frame from plasma exposure.

Primary Gas Inlet

Primary plasma

Secondary gas inlets

Secondary plasma

Chilled platen with ESC, electrostatically clamping the tape framed wafer.

RF driven platen providing pulsed Bias (HF or LF RF)

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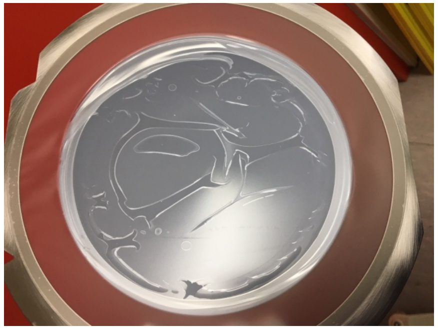
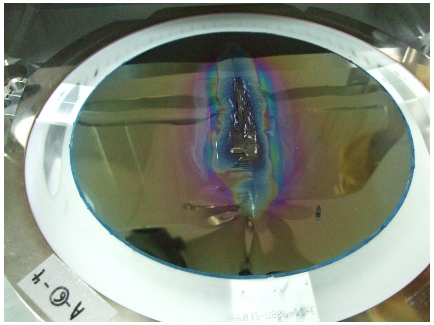
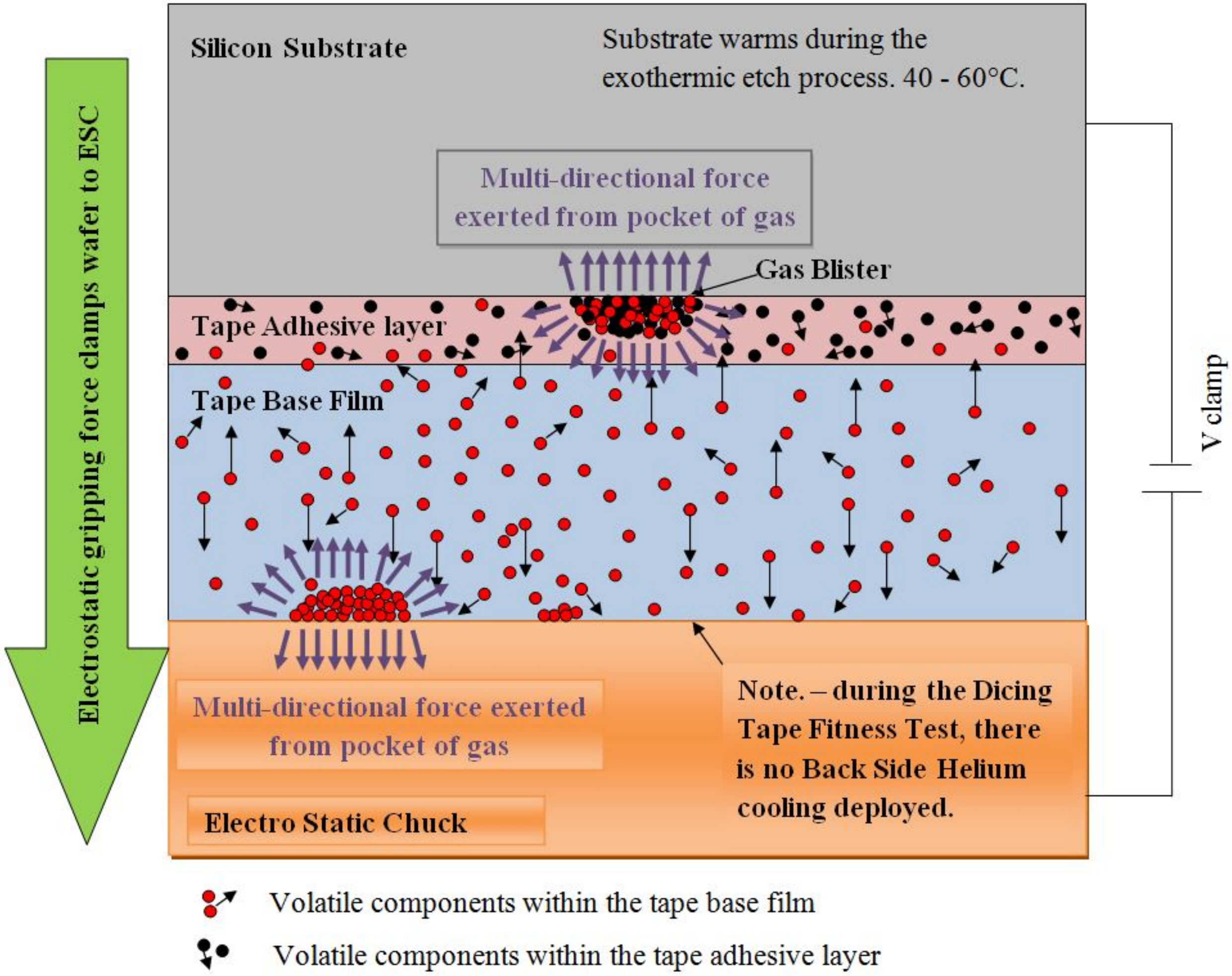
Tape outgassing & thermal performance

What happens when tape out-gasses and why is it important?



Tape out-gassing can cause gas blister underneath thinned wafer causing declamp or substrate damage





Substrate warms during the exothermic etch process. 40 - 60°C.

Note. – during the Dicing Tape Fitness Test, there is no Back Side Helium cooling deployed.

Volatile components within the tape base film

Volatile components within the tape adhesive layer

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Tape performance results

- Polyolefin tapes with low to medium adhesive strength and thinner base film demonstrated best results

Tape ID	Base Film	UV or non-UV	Adhesive classification	Base & Adhesive thickness [um]	Adhesive Strength (before/after UV) [mN/25mm]	Average Score	Risk of declamp
PO10	PO	UV	Type B	80/5	4900/80	19.0	**Very low**
PO9	PO	UV	Type B	80/5	2800/160	19.0	**Very low**
PO8	PO	UV	Type A	80/10	4100/120	17.5	**Low**
PO7	PO	UV	Type B	80/10	1960/200	17.4	**Low**
PO6	PO	non-UV	Type B	80/5	800/800	17.4	**Low**
PET1	PET	UV	Type A	25/10	13800/220	17.4	**Low**
PO5	PO	non-UV	Type B	80/10	880/880	16.4	**Low**
PO11	PO	UV	Type B	110/100	8580/30	16.0	**Medium**
PO4	PO	UV	Type B	80/5	4400/100	15.6	**Medium**
PO2	PO	UV	Type A	80/15	12300/690	13.0	**Medium**
PO3	PO	UV	Type A	80/5	8400/750	12.8	**Medium**
PO1	PO-ESD	UV	Type B	80/5	4700/100	7.8	**Medium**
PVC3	PVC-DEHP-ESD	UV	Type A	80/10	3300/320	4.8	**High**
PVC2	PVC-other	UV	Type A	80/10	3300/320	3.0	**High**
PVC1	PVC-DEHP	UV	Type A	80/10	2800/290	2.7	**High**

Note ! The out-gassing & thermal performance test uses a highly aggressive etch to allow differentiation between tapes.

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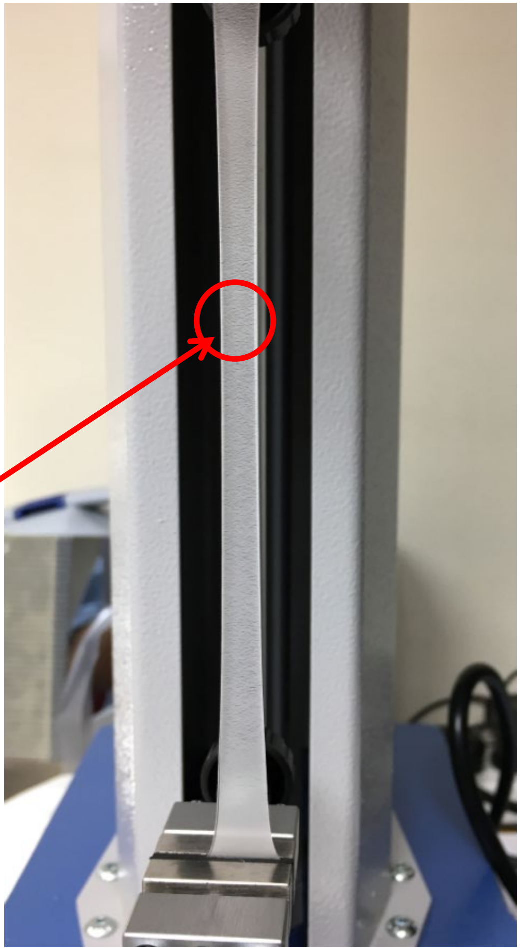
Tape elongation and tensile strength

- Elongation & tensile strength was measured after exposure to different plasma or non-plasma environments
  - Heat
  - Vacuum
  - Individual gas plasma
  - Partial plasma dicing process

- Tapes Used:
  - LINTEC UV Tapes PO2 & PO10
  - LINTEC UV Tape PVC1



Tape stretched during elongation and tensile strength tests

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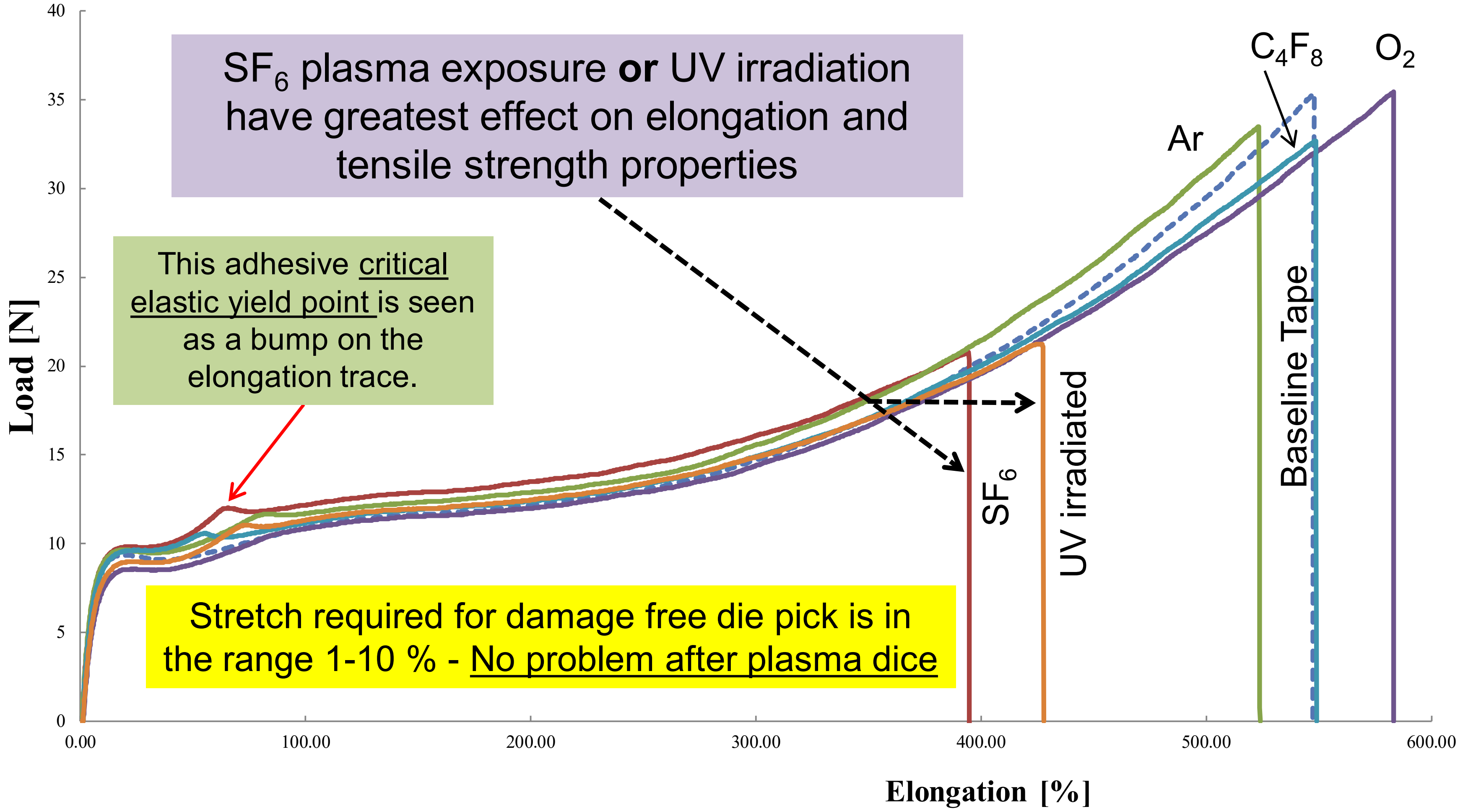
Tape elongation and tensile strength

Tape PO10 - CD Elongation curve on Baseline Tape versus exposure to different plasma species



SF_6 plasma exposure **or** UV irradiation have greatest effect on elongation and tensile strength properties

This adhesive critical elastic yield point is seen as a bump on the elongation trace.

Stretch required for damage free die pick is in the range 1-10 % - No problem after plasma dice

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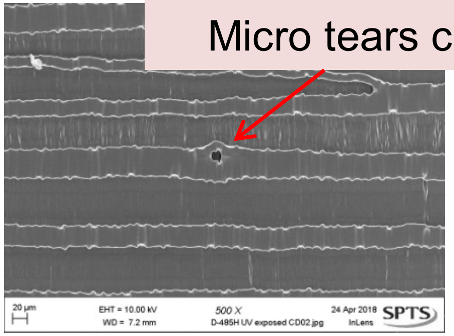
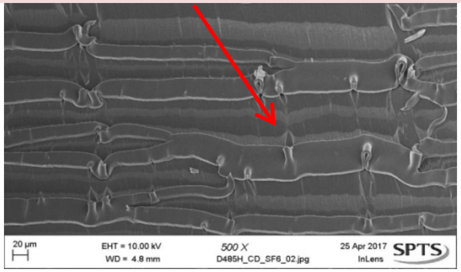
Tape elongation and tensile strength

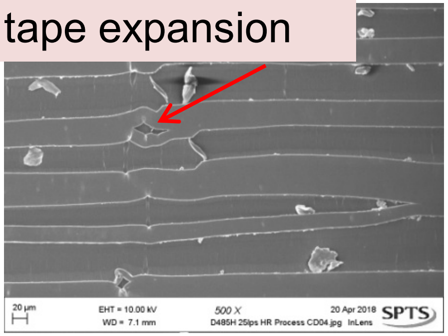
Micro tears caused by firmly attached adhesive limiting tape expansion



UV irradiation

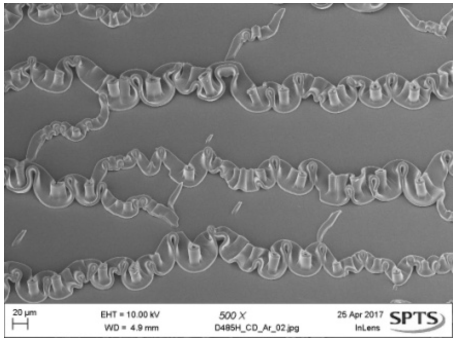


SF_6 Plasma

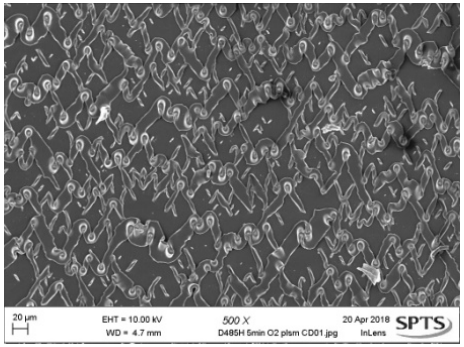


Dicing Plasma

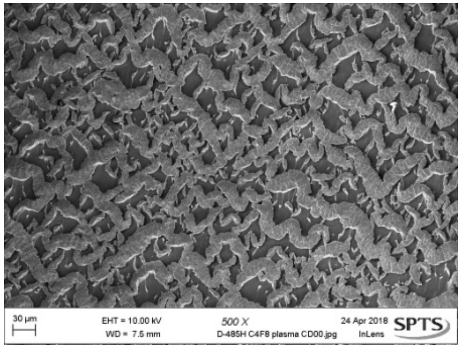
Similar looking SEM images for samples UV irradiated or exposed to SF_6 or dicing plasma



Ar Plasma



O_2 Plasma



C_4F_8 Plasma

Similar looking SEM images for samples exposed to Ar, O_2 and C_4F_8 plasma

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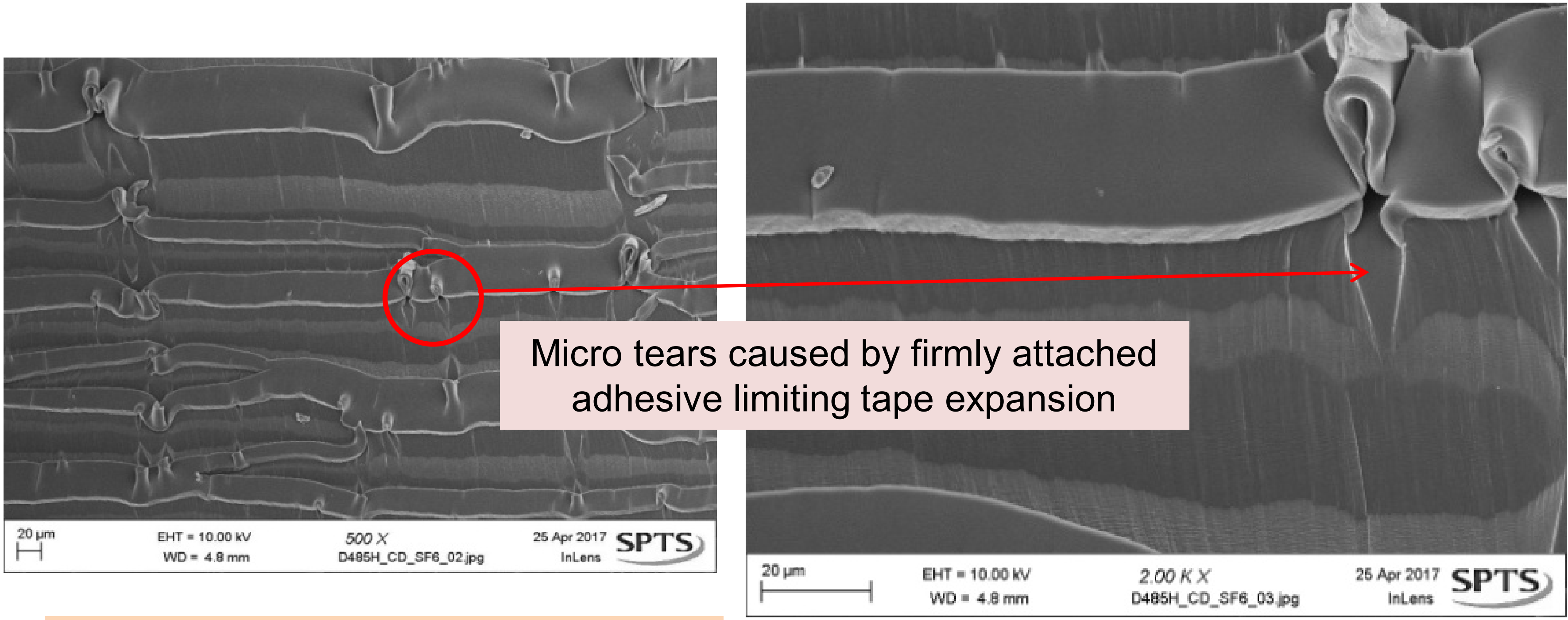
Tape elongation and tensile strength

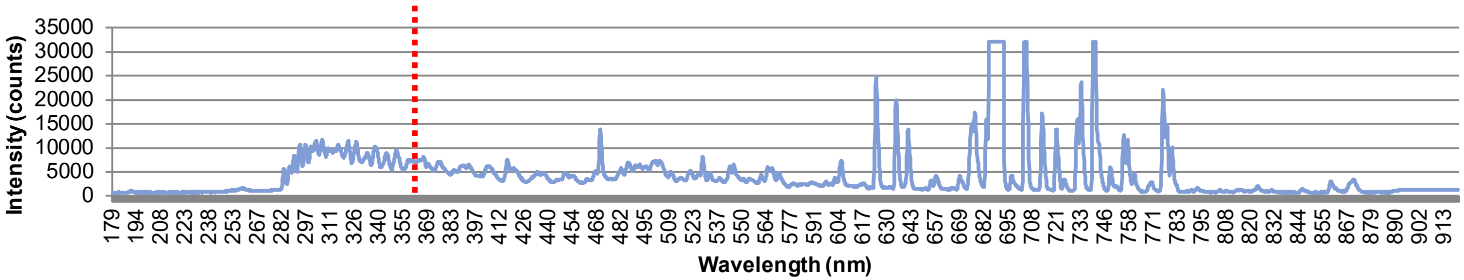
UV sensitive Adhesive cured from UV wavelengths within SF_6 plasma spectra



Micro tears caused by firmly attached adhesive limiting tape expansion

Wavelength of UV recommended for adhesion release is around 365nm

SF_6 Plasma Spectra



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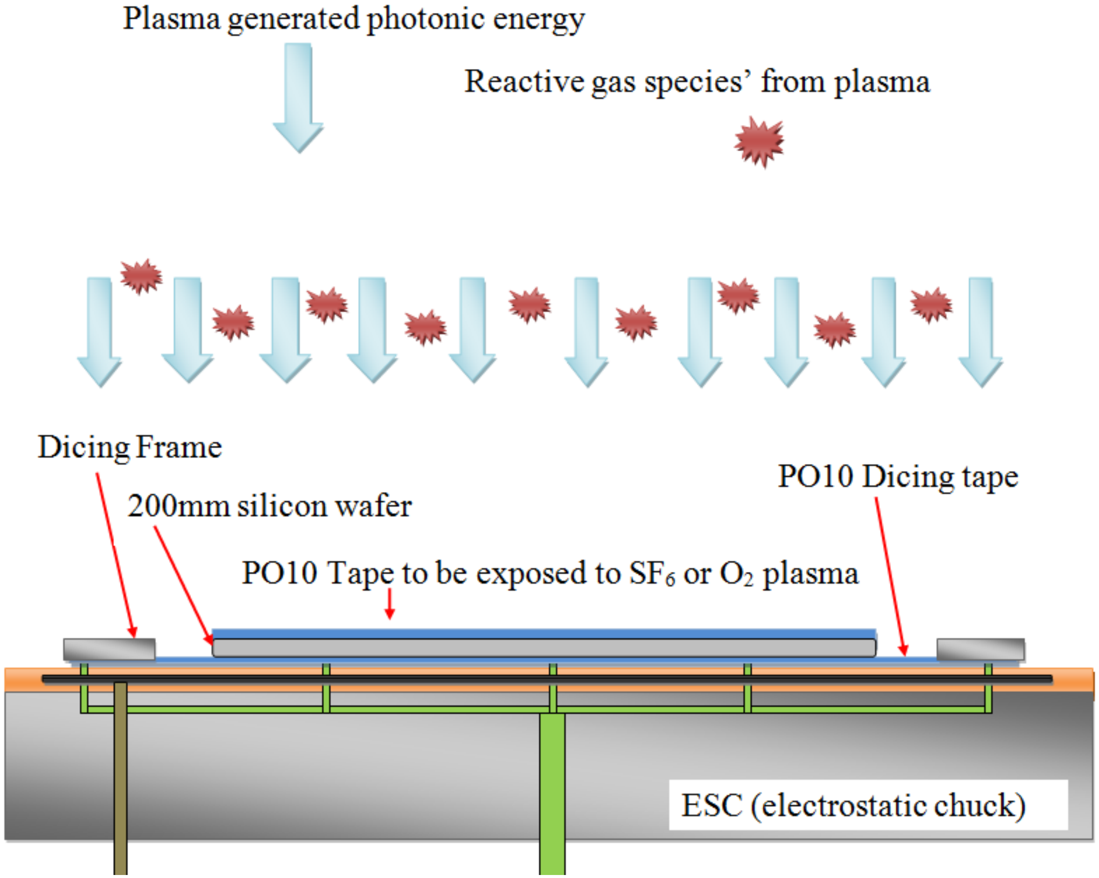
Plasma exposure and adhesive curing

- Further investigation into a link between plasma exposure and the adhesive curing process
  - SF_6 plasma and O_2 plasma

Adhesive Peel Strength measurement after plasma exposure



Plasma generated photonic energy

Reactive gas species' from plasma

Dicing Frame

200mm silicon wafer

PO10 Dicing tape

PO10 Tape to be exposed to SF_6 or O_2 plasma

ESC (electrostatic chuck)

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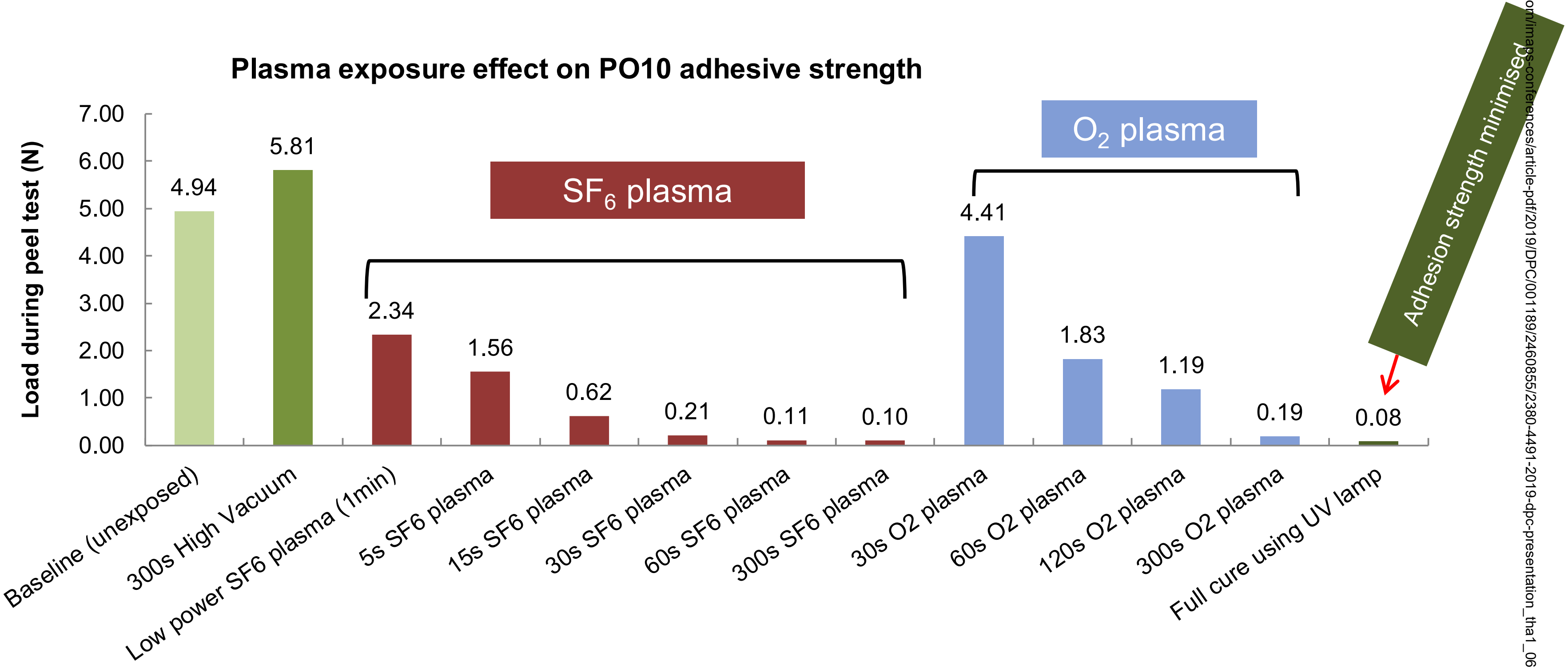
Plasma exposure and adhesive curing

- Plasma exposure can trigger the adhesive curing process
- Curing rate dependent on plasma species & exposure time


Plasma exposure effect on PO10 adhesive strength

SF_6 plasma exposure cures UV adhesive faster than O_2 plasma
60s SF_6 plasma – 99% cured   60s O_2 plasma only 60% cured

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Die Pick-Up Force Measurement (plasma dicing v saw dicing)

SPTS
An orbotech. Company

- 10x10mm die size
  - Plasma diced @ SPTS (dicing kerf widths of 10, 20 and 40µm).
  - Saw diced @ LINTEC Corporation Research Centre in Japan 40µm kerf widths

- Tapes
  - UV tapes PO2 - soft adhesive P010 – hard adhesive

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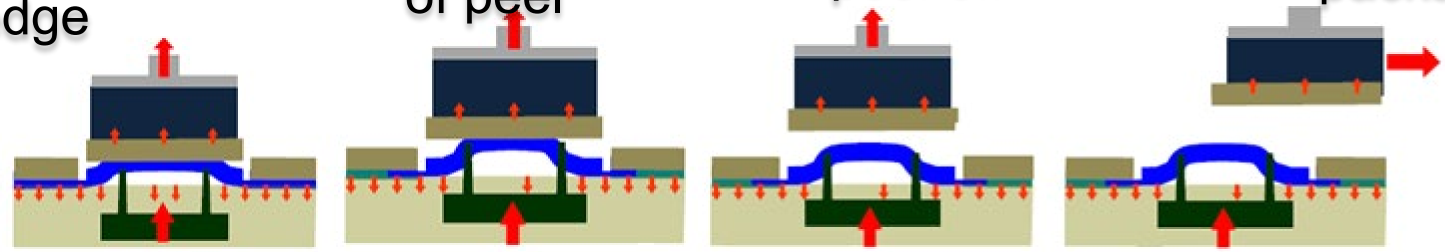
Die Pick-Up Force Measurement

Tape expanded 5mm
Vacuum collet grips top side of die

Needle set pushed upward to separate die from tape



Peeling at chip edge

Propagation of peel

Peel end & successful peel-off

Collet with chip transfers for packaging

Needle load (N) is related to the pick-up force required for successful die separation from tape

LINTEC journal paper – N. Saiki, K. Inaba, K. Kishimoto, H. Seno, and K. Ebe, "Study on peeling behaviour in pick-up process of IC chip with adhesive tapes," *Journal of Solid Mechanics and Materials Engineering*, vol. 4, no. 7, pp. 1051-1060, 2010

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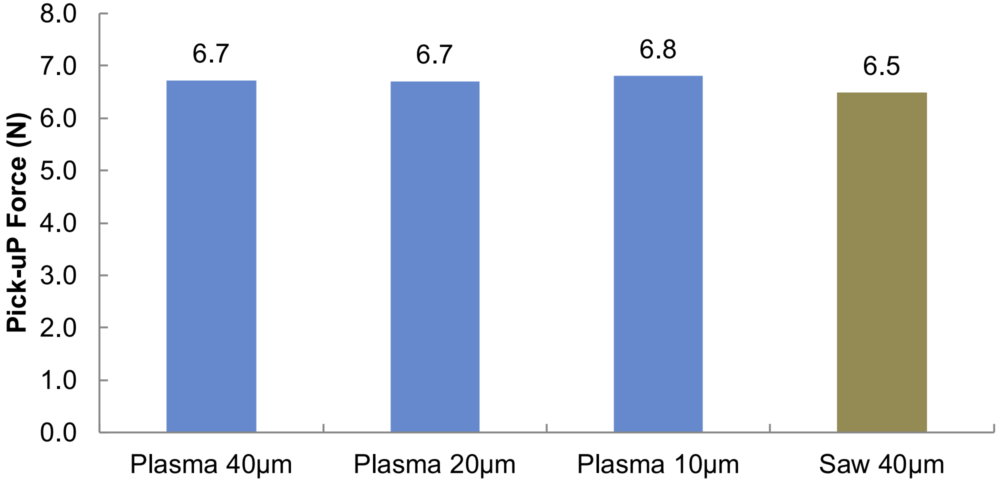
Die Pick-Up Force Measurement - Results

- PO10 tape (hard adhesive)
  - Pick-up force on plasma diced dies comparable with saw diced dies

10x10mm Die Pick-Up Force measurements from PO10
Plasma dicing versus saw diced wafers



- PO2 tape (soft adhesive)
  - Pick-up force measurement on <u>plasma diced & saw diced</u> samples not possible
  - Post UV adhesive strength not designed for 10x10mm devices

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Conclusion

- Adhesive curing is triggered by plasma exposure
  - Limited to dicing lane area at singulation
  - No detrimental effect at die pick-up
  - Plasma dicing has minimal effects on tape elongation and tensile strength – no problem during tape stretch
- Selection of tape should be tailored for die size, die thickness & plasma dicing etch rate

Can we use standard dicing tapes for Plasma Dicing?

YES

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