CORNING

Glass for Advanced Semiconductor Applications: Myths and Opportunities

Peter L. Bocko Ph.D.
CTO – Glass Technologies
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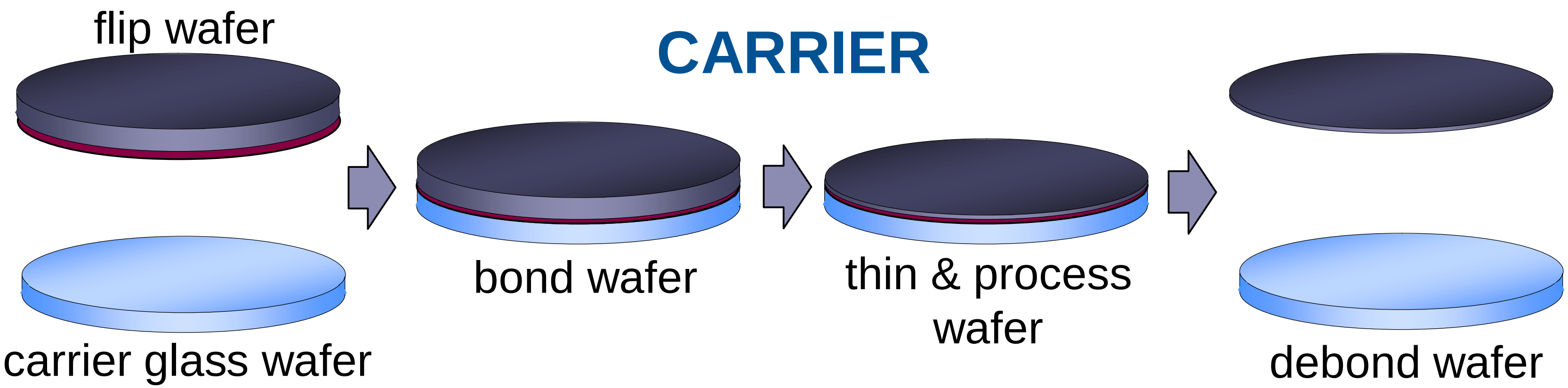
Outline

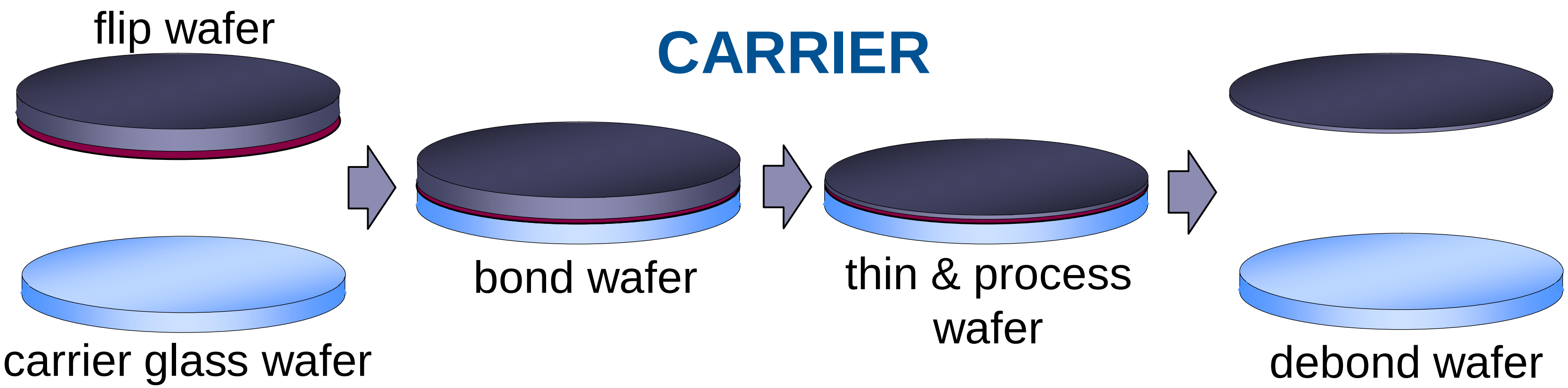
- New Roles for Glass in the Semiconductor Industry
- What Is Needed for 3DS-IC Packaging
- Myths about Glass
- Conclusion: Glass is a an Excellent Substrate for 3DS-IC Applications

Roles Of Glass In Advanced Semiconductor Packaging



Roles Of Glass In Advanced Semiconductor Packaging

CARRIER



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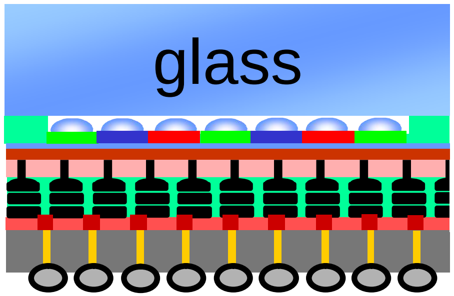

Back-illuminated (BSI) CMOS image sensor

Roles Of Glass In Advanced Semiconductor Packaging

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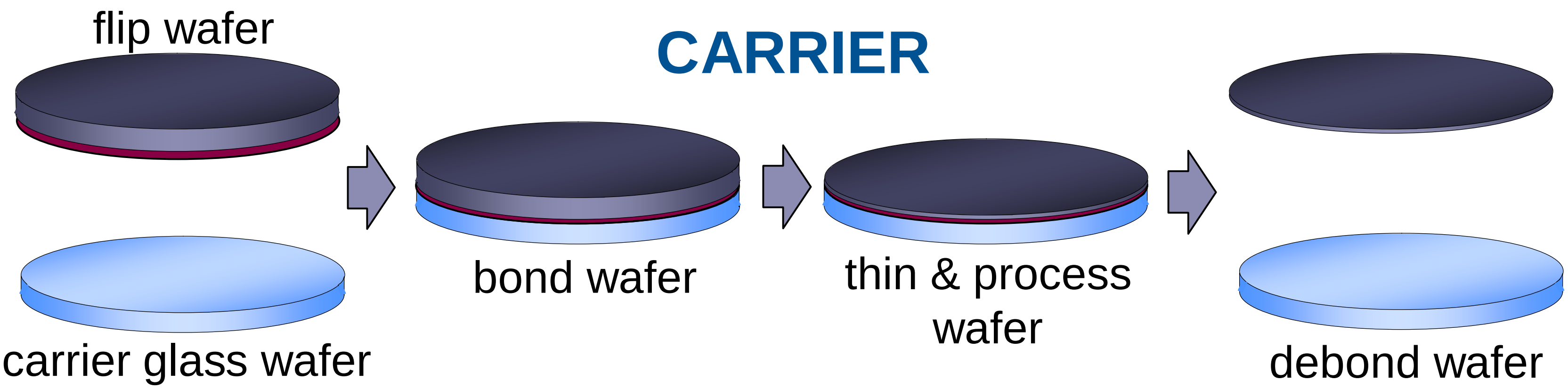

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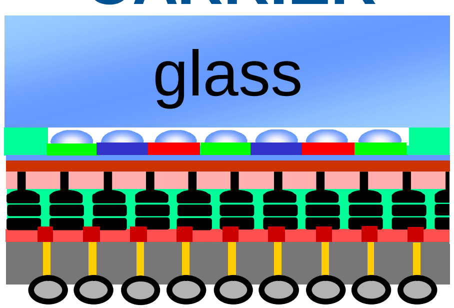
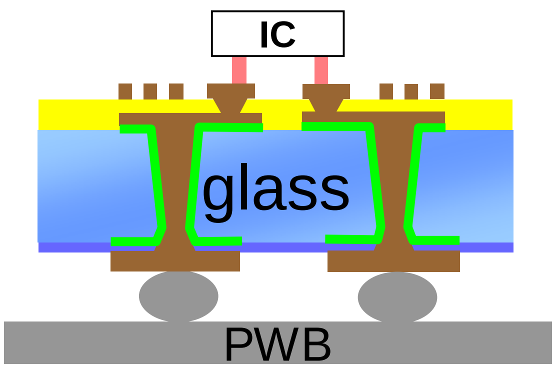


Back-illuminated (BSI) CMOS image sensor

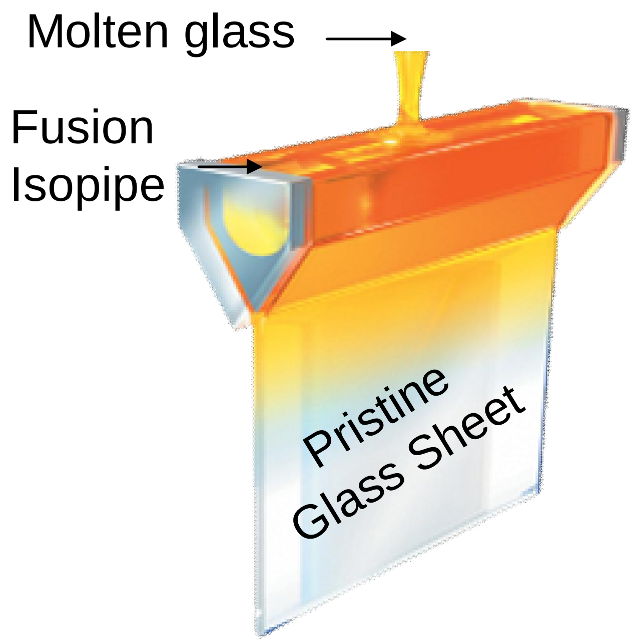
INTERPOSER



3D System Start with Glass Interposer

Corning's Strategic Intent In Semiconductor Glass

Advanced Optical Melting
Fusion Sheet Forming Process



Corning's Strategic Intent in Semiconductor Glass

Advanced Optical Melting Fusion Sheet Forming Process

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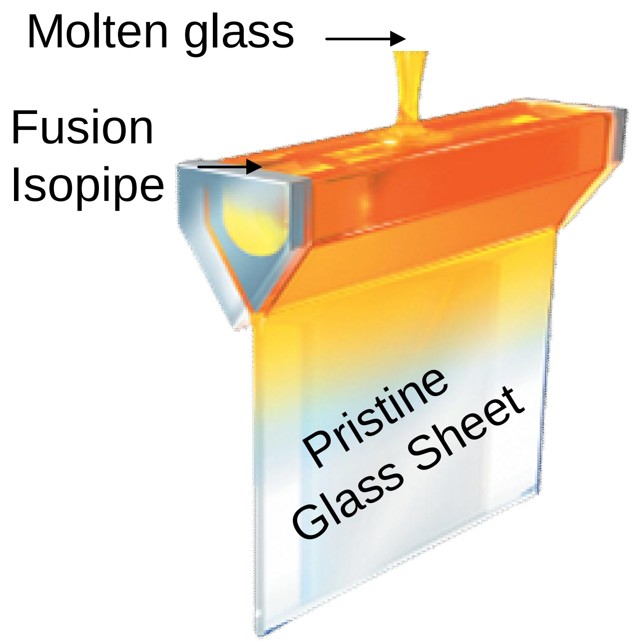
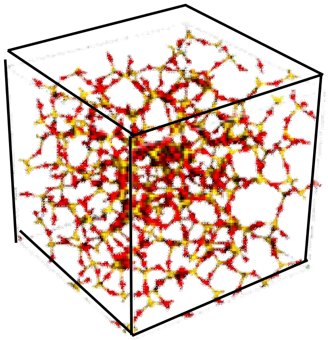
Innovative Aluminosilicate Glass Compositions





Corning's Strategic Intent in Semiconductor Glass

Advanced Optical Melting Fusion Sheet Forming Process

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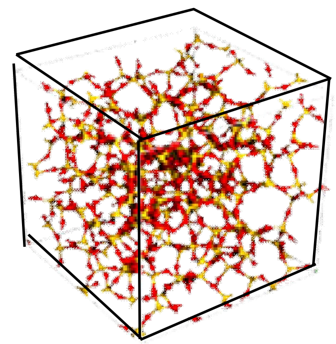
Innovative Aluminosilicate Glass Compositions

Molten glass

Fusion Isopipe



Pristine Surface

Optimized Expansion

Profoundly Flat

Thin & Strong

What is Needed for 3DS-IC Packaging

- A substrate that can support a silicon device wafer during the thinning and stacking process as a carrier
- A substrate that can be used as an interposer
- Key attributes for such substrates:
  - Smooth and clean surface
  - Low total thickness variation (TTV)
  - Low warp/bow
  - High edge strength
  - Strength & reliability
  - CTE similar to silicon
  - Good chemical durability

Glass Myths

1. Glass is weak

Glass Can Be Made Strong

- **The strength of glass, like silicon, depends upon the defect population.**

- Unlike silicon, glass failure occurs almost exclusively **due to tensile stress applied to surface flaws**. Glass, as an amorphous material, is not subject to failure along crystallographic planes or from crystal defects.

- If the surface were free of defects, glass strength could be very high (>10GPa). Typical, non-technical glass in every-day use has strength on the order of 10's MPa corresponding to flaw sizes >100μ. In technical glass, for example fusion formed LCD substrates with a pristine surface (flaw size in the micron range), GPa scale strength can be achieved.

- Recipe for achieving high mechanical reliability for advanced semiconductor applications: start with a pristine surface and minimize surface damage in process. Simple.

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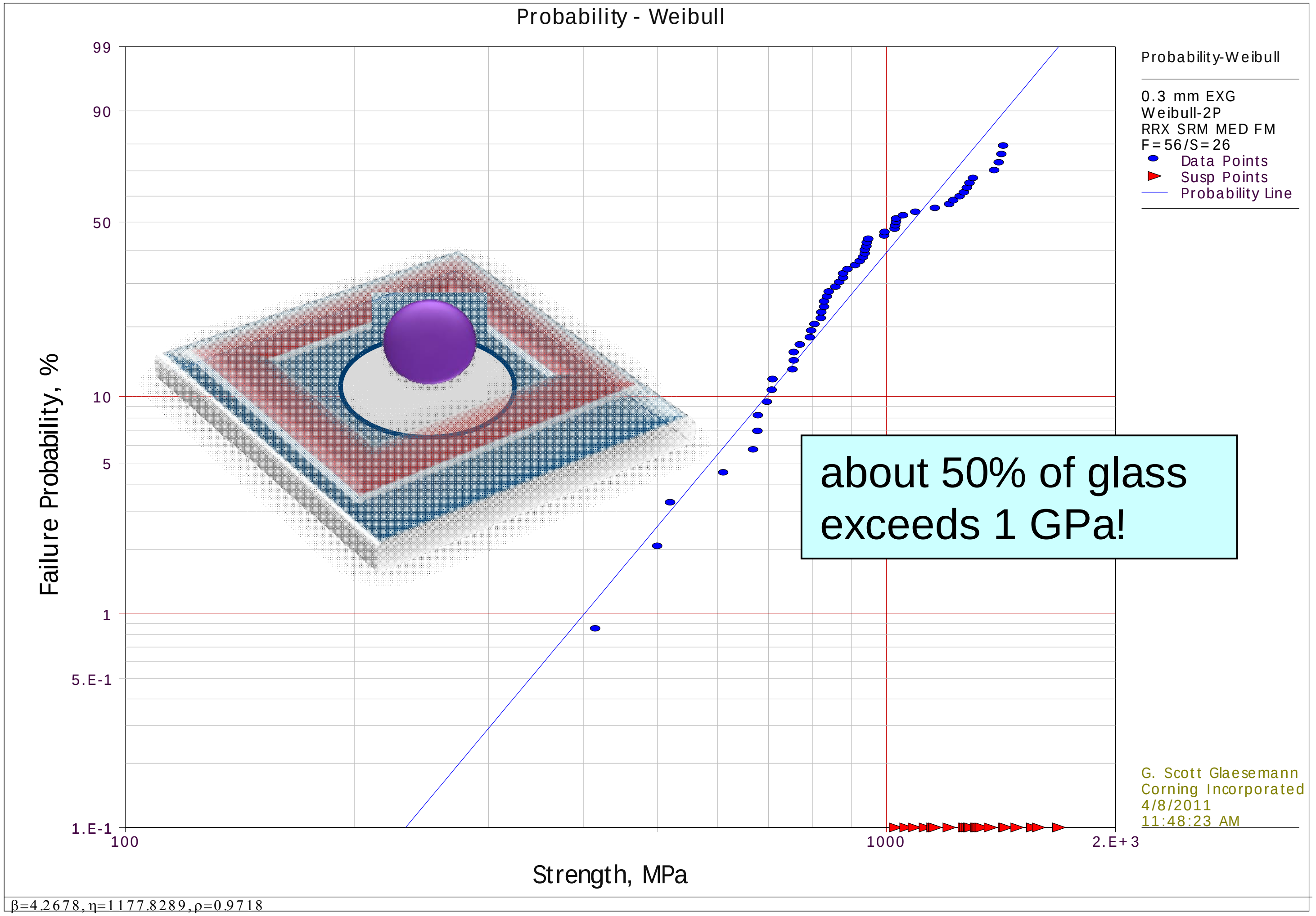
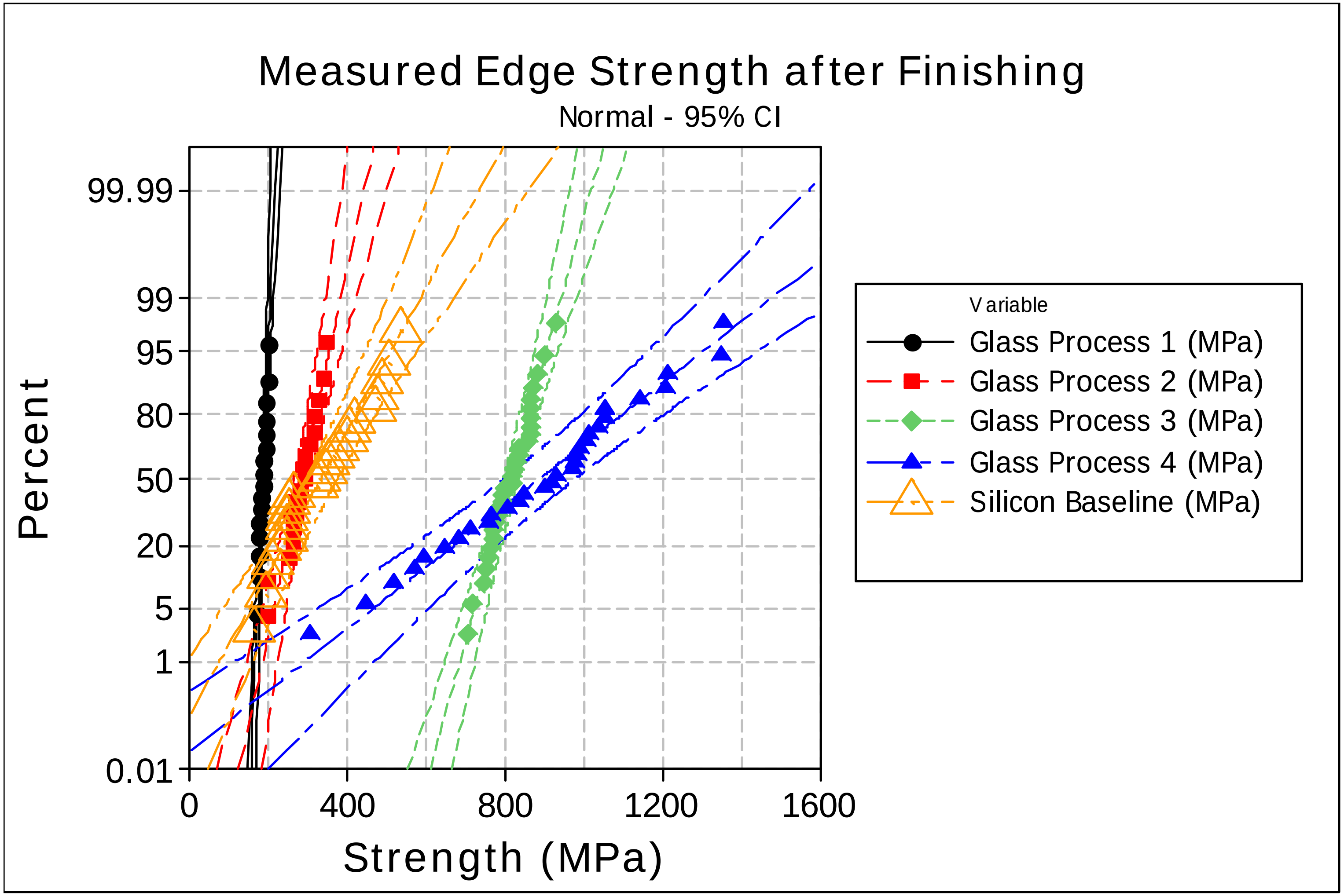
- **Recipe for achieving high mechanical reliability for advanced semiconductor applications: start with a pristine surface and minimize surface damage in process. Simple.**

FACT: Surface strength of thin semiconductor quality wafer glass is amazingly strong!



FACT: Glass can be engineered to have edge strength higher than silicon

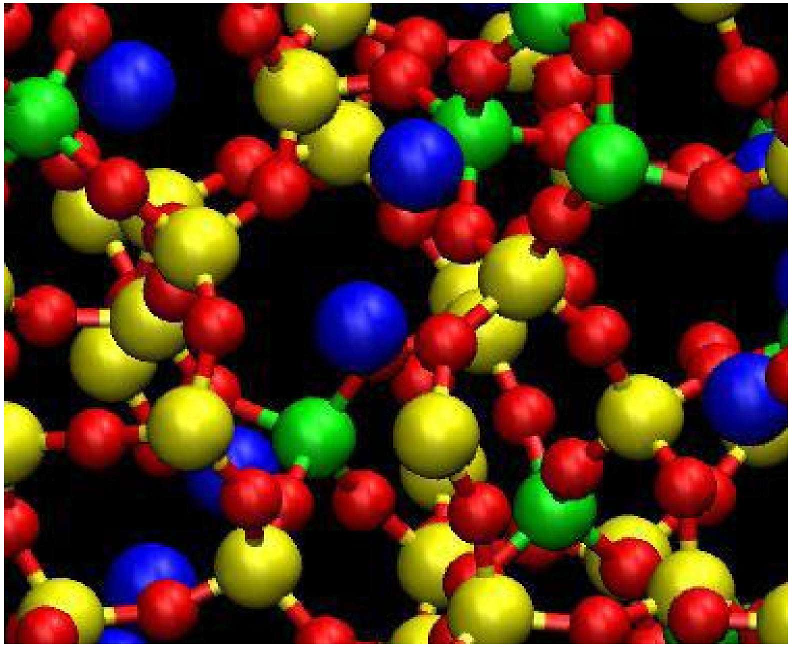
(True for edge and notch)



Glass Myths

1. Glass is weak
2. **All glasses are the same**

FACT: Not all glass is created equal. Glass Composition Matters!



computer molecular model of a glass optimized for scratch resistance

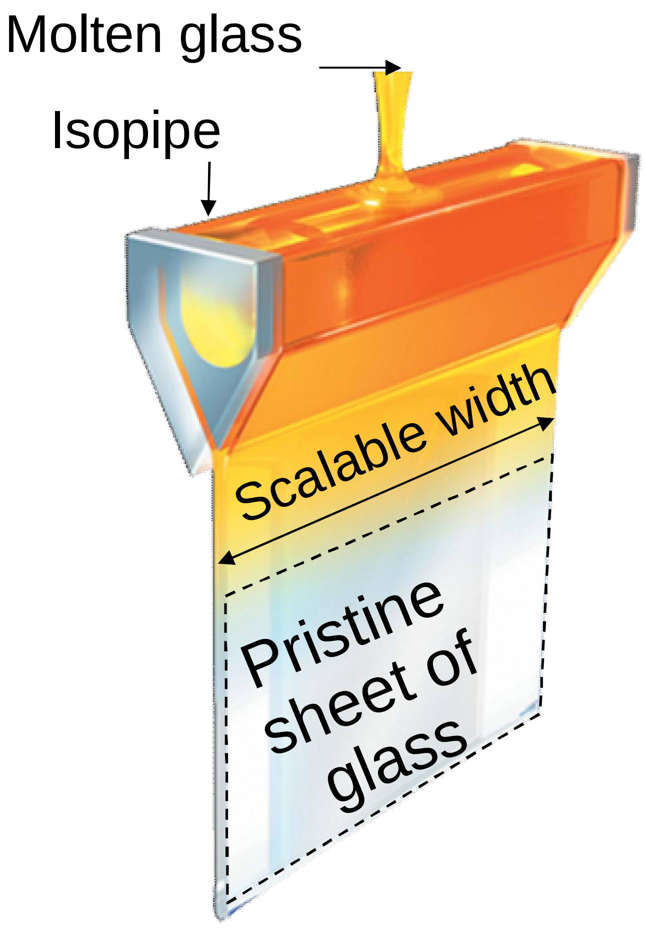
Properties Under Control By Glass Chemistry

- Thermal Properties (Expansion)
- Chemical Durability
- Mechanical Strength
- Surface Hardness
- Elastic Properties
- Optical Properties
- Electrical Properties

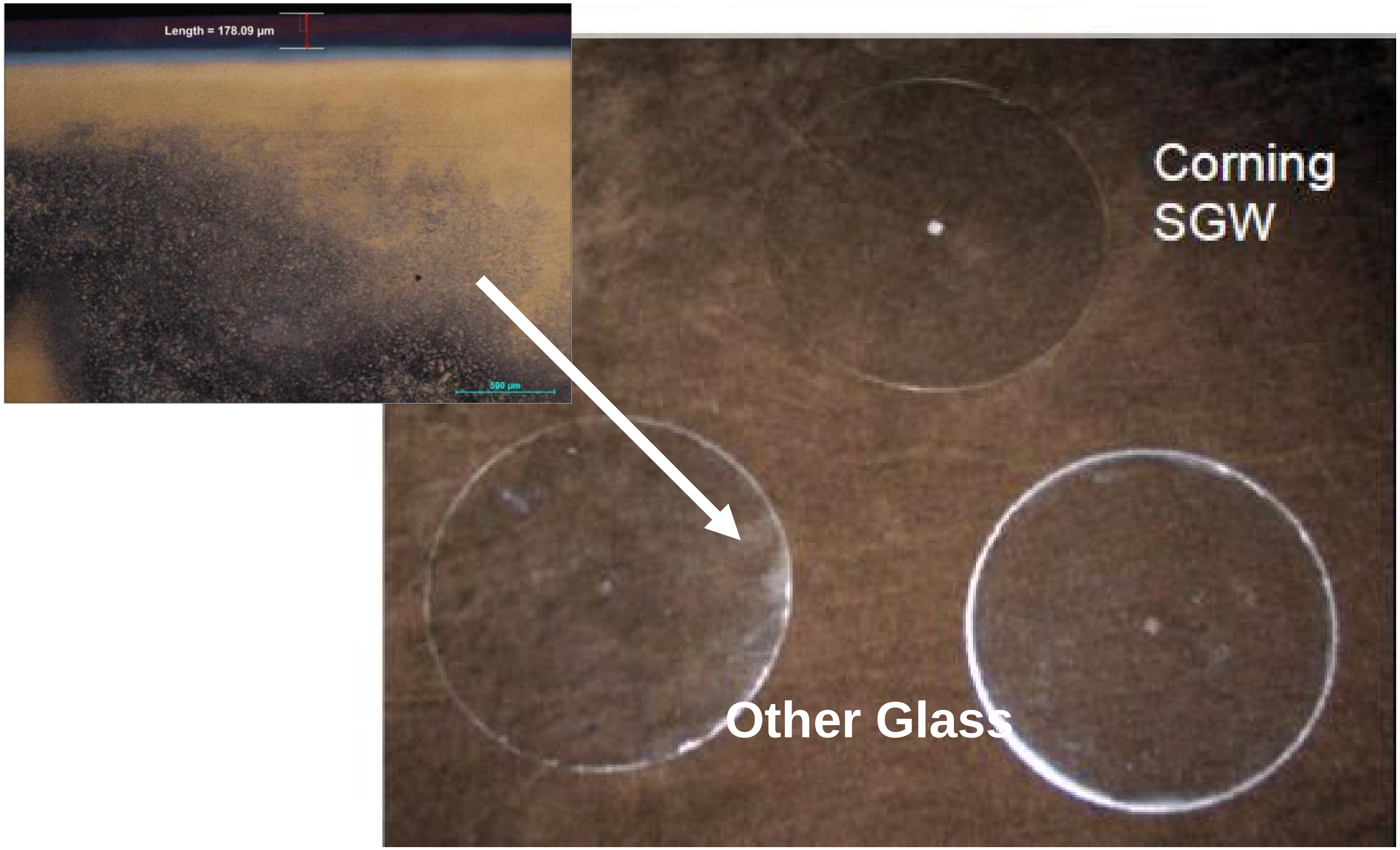
FACT: Not all glass is created equal. Process matters!

Corning Fusion Glass

- Surface formed in air
  - no polishing required
- Excels in thickness variation control
- Low warp/bow
- Good overall uniformity (TTV)
- Superior surface roughness characteristics are not affected by shift to large or thinner sheet
- Scalable to large sizes



FACT: Chemical durability is a critical attribute that differentiates candidate glasses

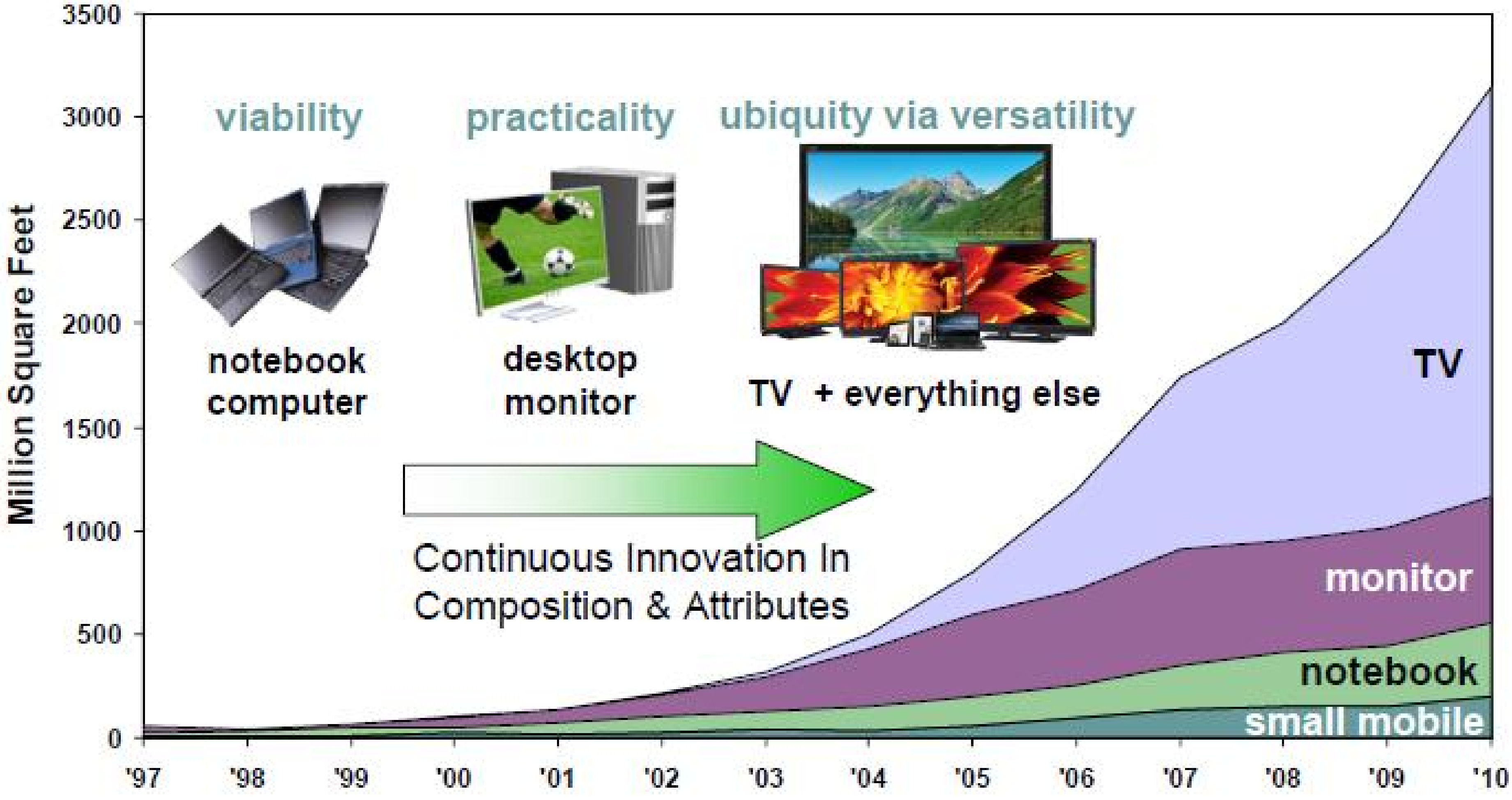


Haze following wet chemical etch in glass carrier wafers is a limiting factor in the recyclability of glass carriers

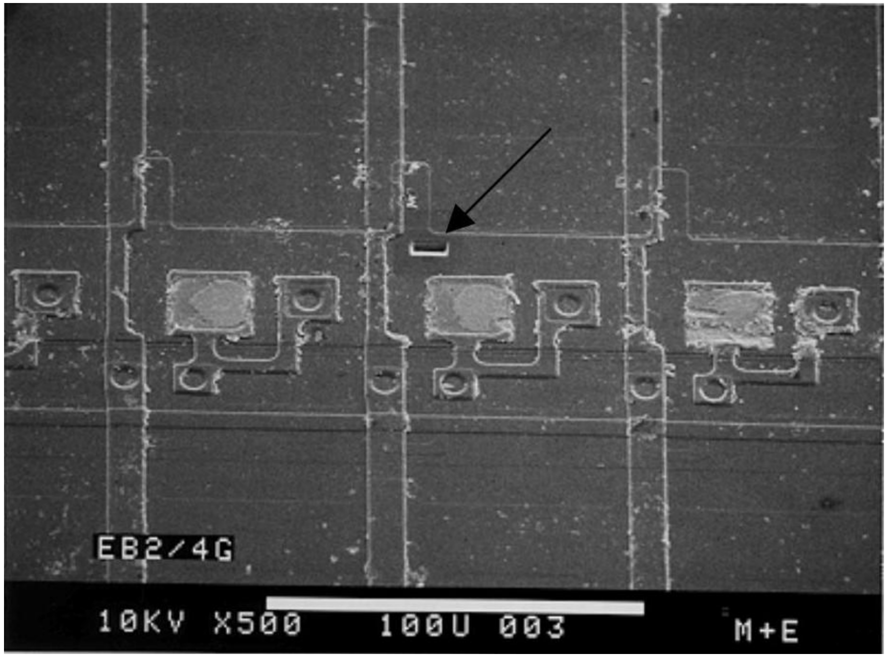
Glass Myths

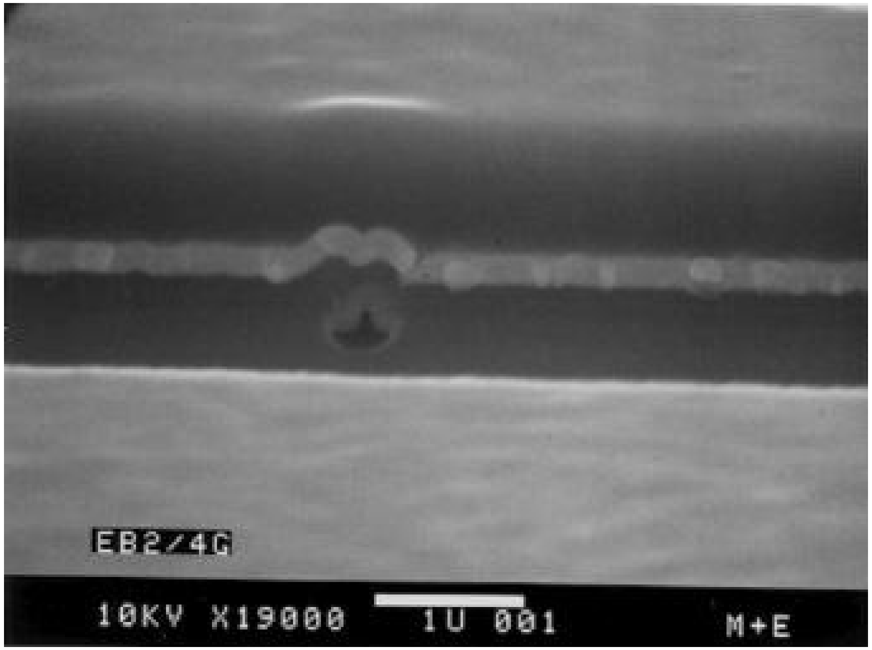
1. Glass is weak
2. All glasses are the same
3. **Glass is not compatible with precision semiconductor processing**

FACT: Aluminosilicate glass substrates enabled the winning large area electronics platform of the LCD revolution



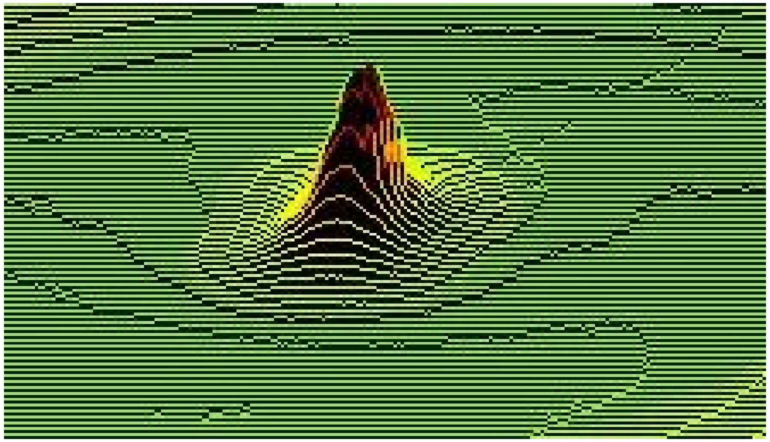
FACT: We have developed capability to control particulate contamination on LCD substrates to the sub-μ level



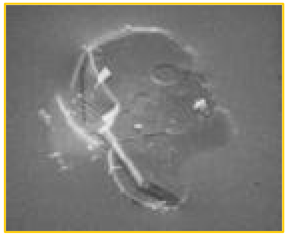


S&T analysis of defect from p-Si customer process showing submicron surface anomaly ca. 1998

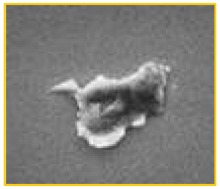
Particles near and on the surface impact the surface topography



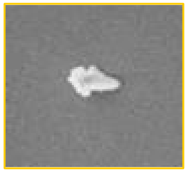
Driving to increasingly stringent levels – maximum allowable particle size has been continuously improved



30 μ

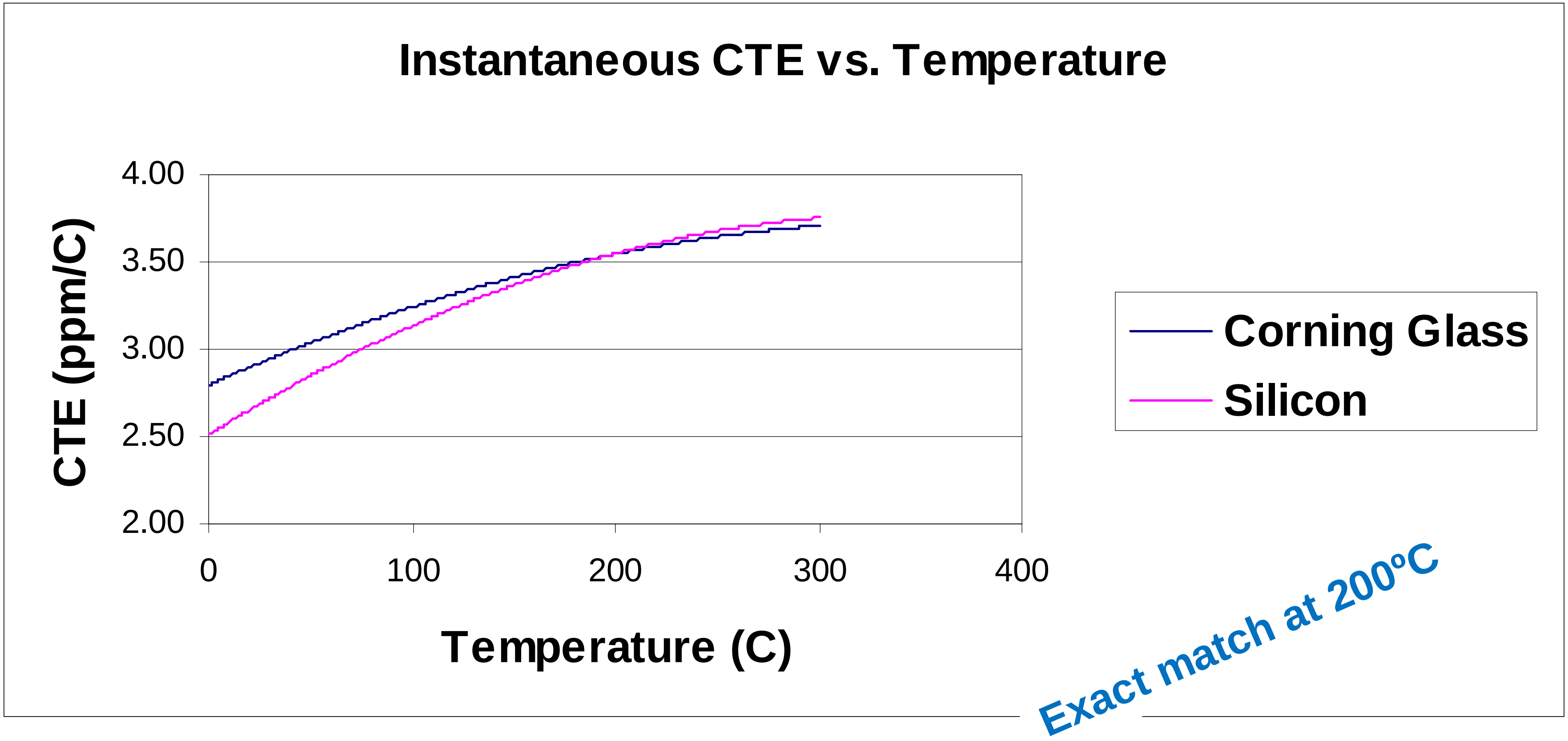


10 μ

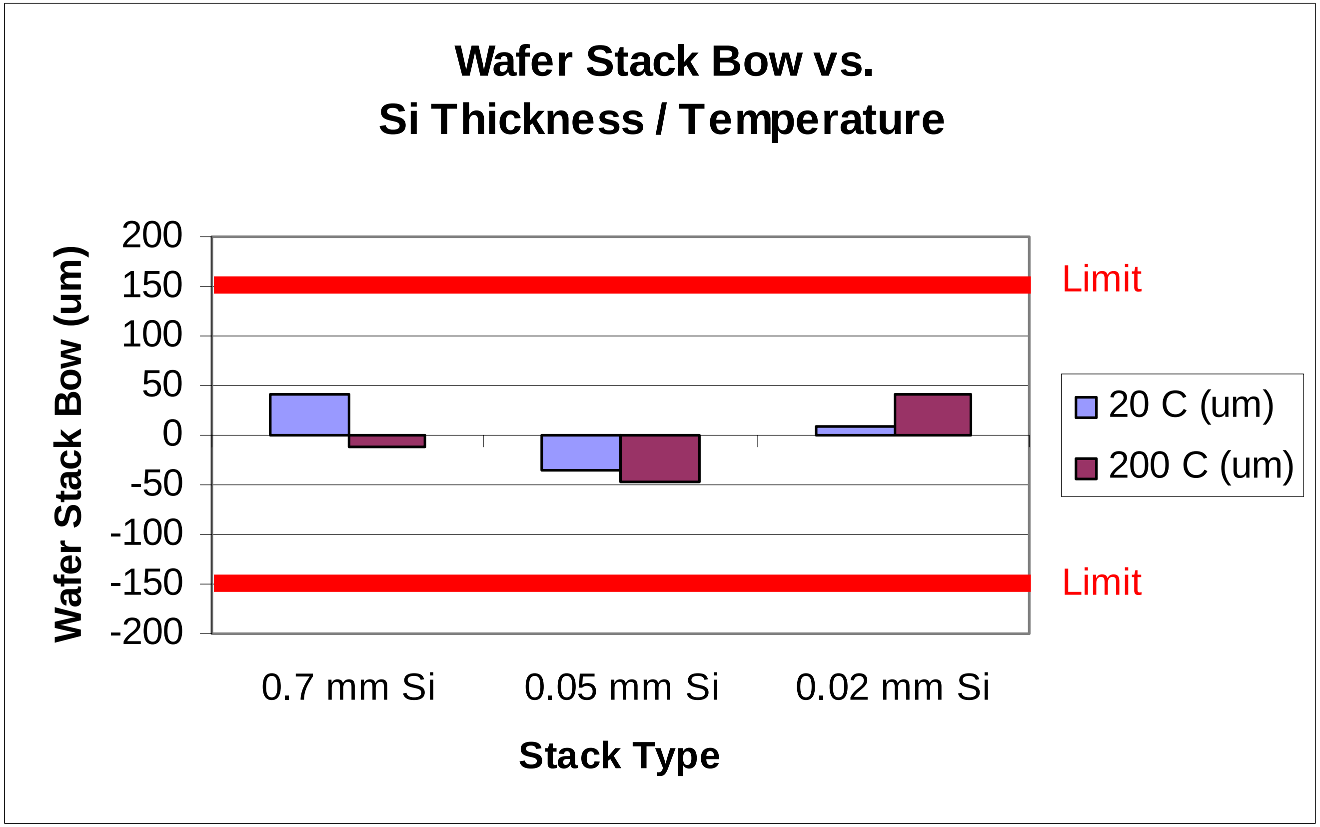


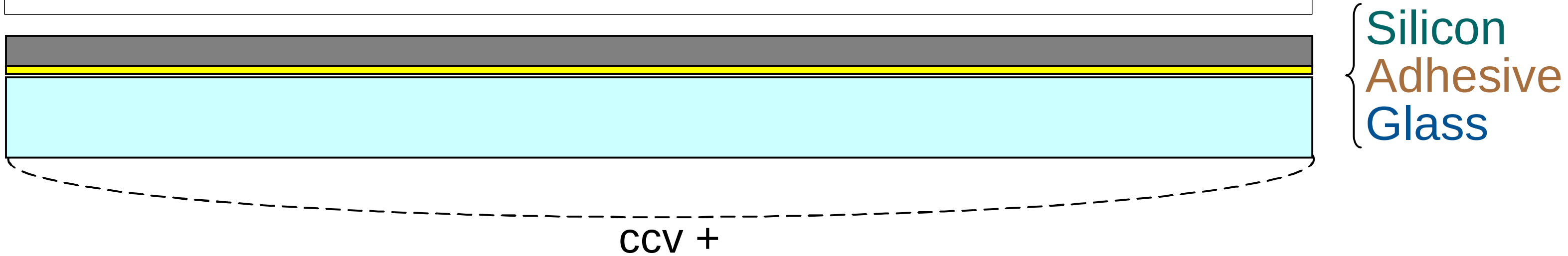
3 μ

FACT: CTE of glass is a close match to silicon



Wafer stack bow as a function of temperature



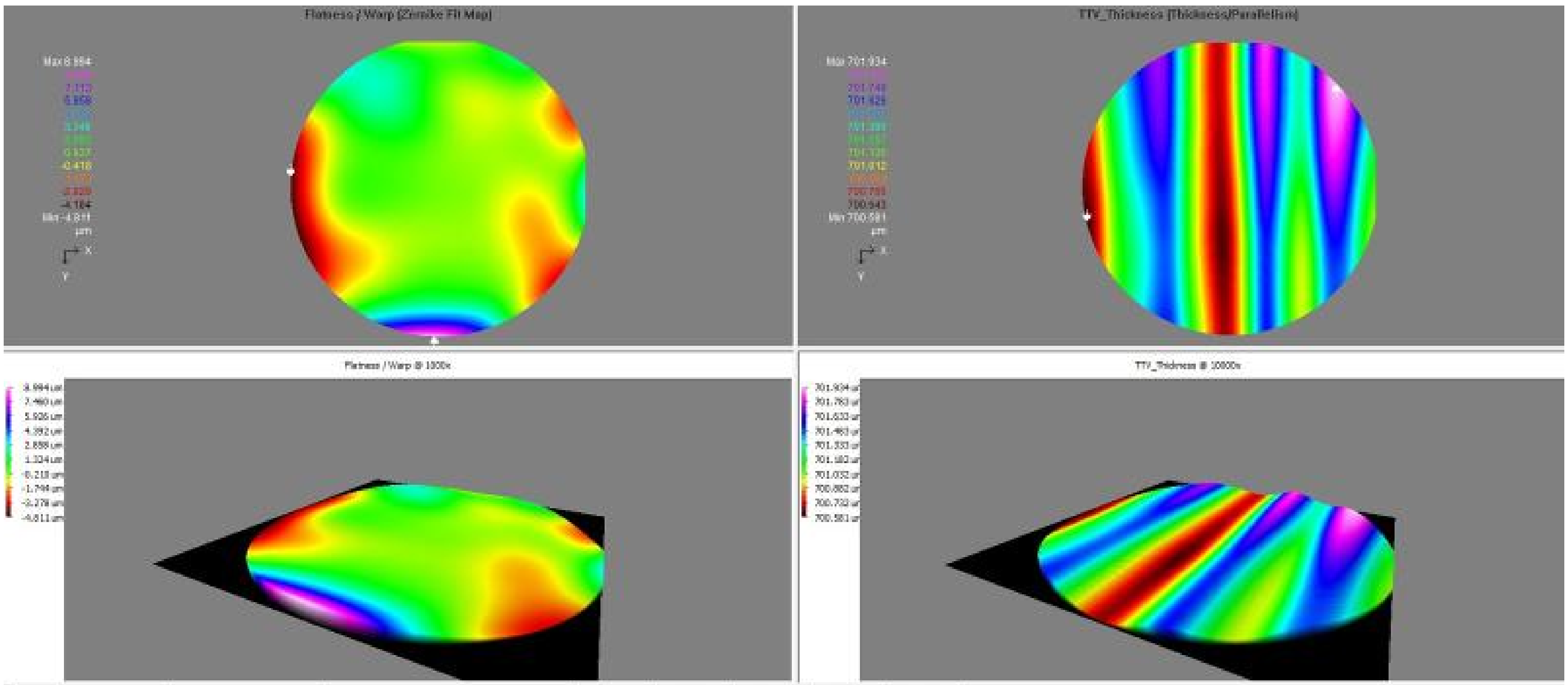


Glass Myths

1. Glass is weak
2. All glasses are the same
3. Glass is not compatible with precision semiconductor processing
4. **Glass has to be ground and polished to meet specs**

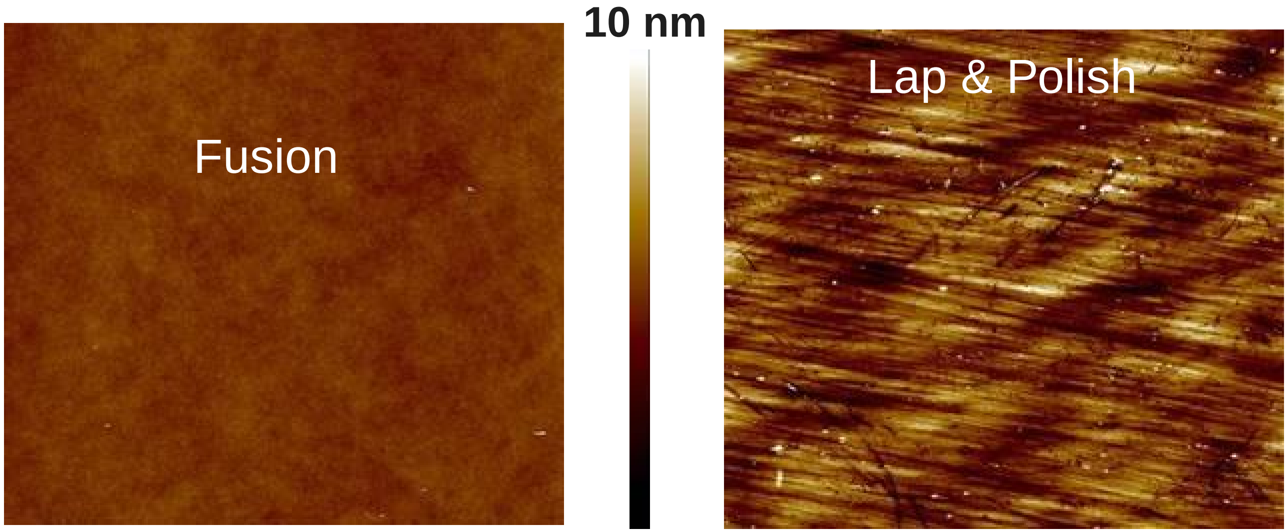
FACT: Outstanding TTV & warp variation can be achieved in the as-formed (non-polish) fusion surface

Champion Wafer | 300□0.7mm | 1.352□total thickness variation | 13.8□warp



				TTV_Thickness	TTV_Thickness	TTV_Thickness	TTV_Thickness	Flatness / Warp
ResultID	AcquireTime	Recipe Name	Tiff Name	Thickness	MAX	MIN	TTV	TIR
168	1/20/2011 11:07:33 AM	C:\TMSUL6\recipes\EXG_0.7.rcp	C:\EXG Data\0.7EXG Data\622_square_blank_24_A2.tif	0.70126 mm	0.70193 mm	0.70058 mm	1.352 μm	13.886 μm

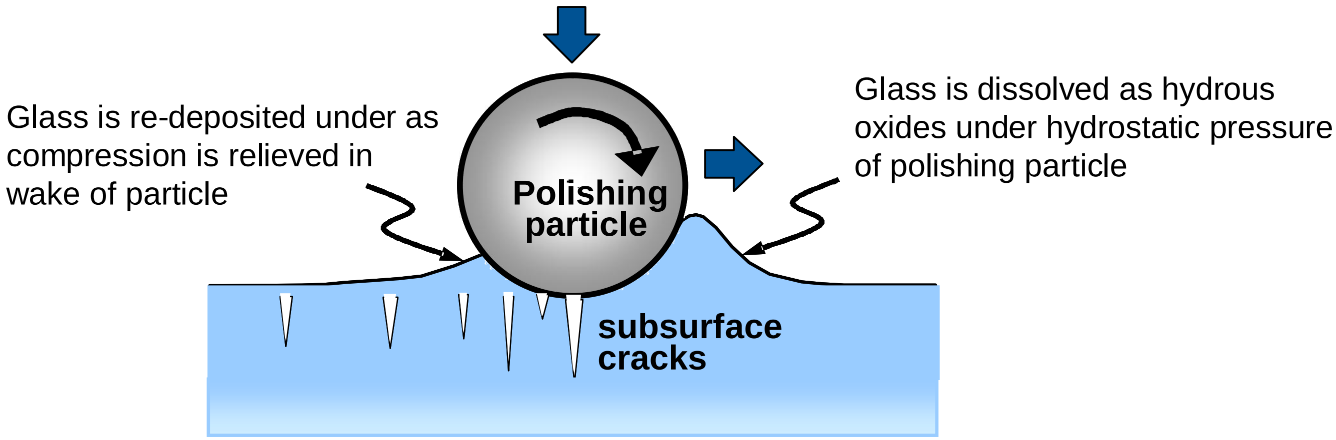
FACT: Fusion surface is smooth & featureless

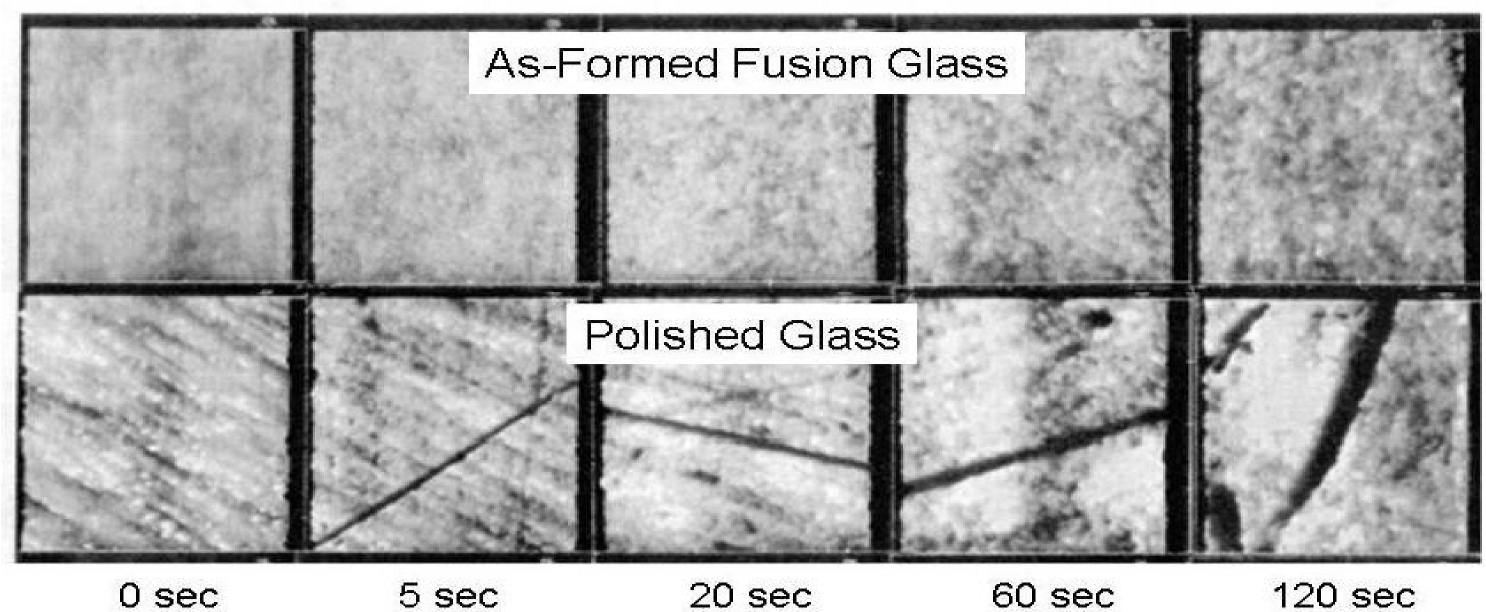


Roughness Measurement Results

RMS	**0.29 nm**	**1.46 nm**
Ra	**0.23 nm**	**1.13 nm**
Z-Range	**4.23 nm**	**33.7 nm**

Etching reveals subsurface damage in polished glass that is not in fusion glass.





Etch time in 1:5 Buffered HF

Conclusion

- Glass is a versatile and robust material with a track record & enormous future potential as an enabling material in electronics
- Corning's capabilities in flat glass in aluminosilicate family are an excellent foundation for the development of glass for advanced semiconductor packaging
- The key attributes to be delivered are in the areas of flatness, surface quality, thermal behavior, thin & strong.
- An open & deep collaboration across the value chain is the best path to mutual success: the right product with optimized value will not be "off the shelf".

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