

Inclusions Within ULE[®] Glass

2nd International Workshop on EUV Lithography
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Dondi Brewer, Ken Hrdina and Sue Kenney

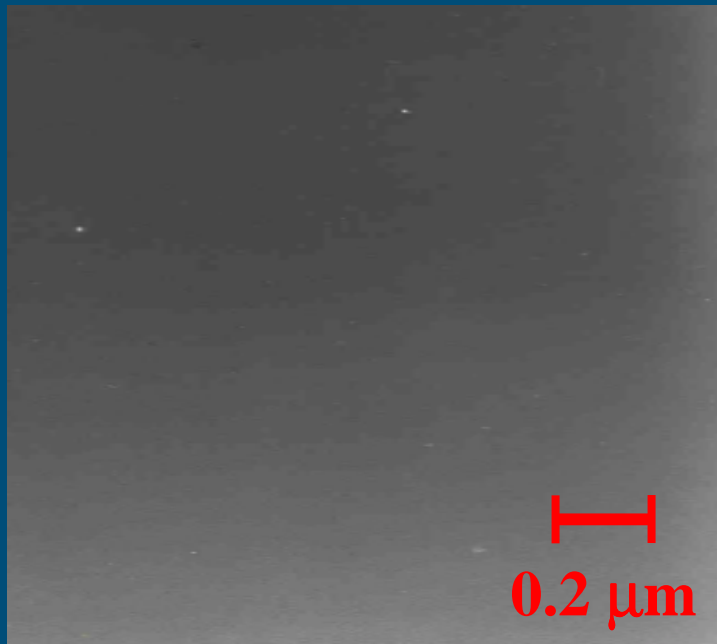
Corning Incorporated



Defining ULE[®] Glass

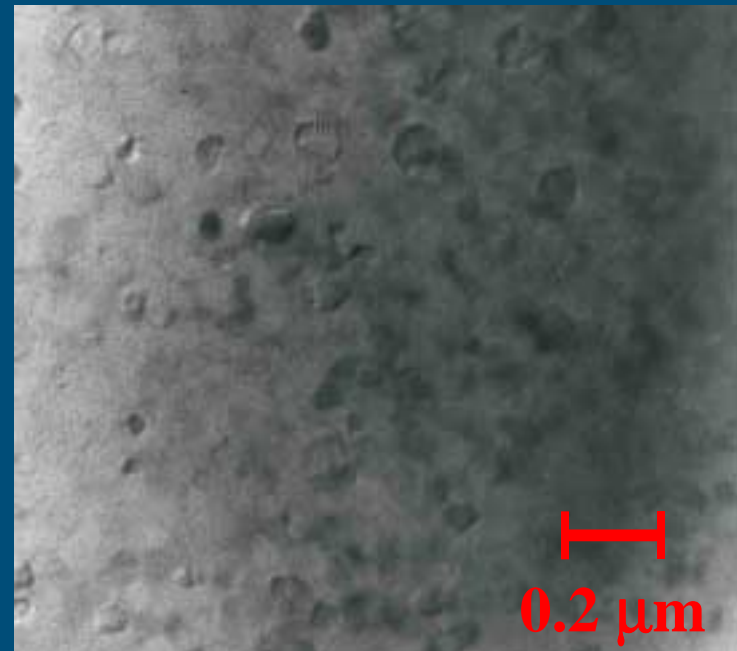
TEM micrographs

ULE[®] Glass



Single phase: no
crystals

Corning's low expansion
glass ceramic



Crystalline phase
and glass phase

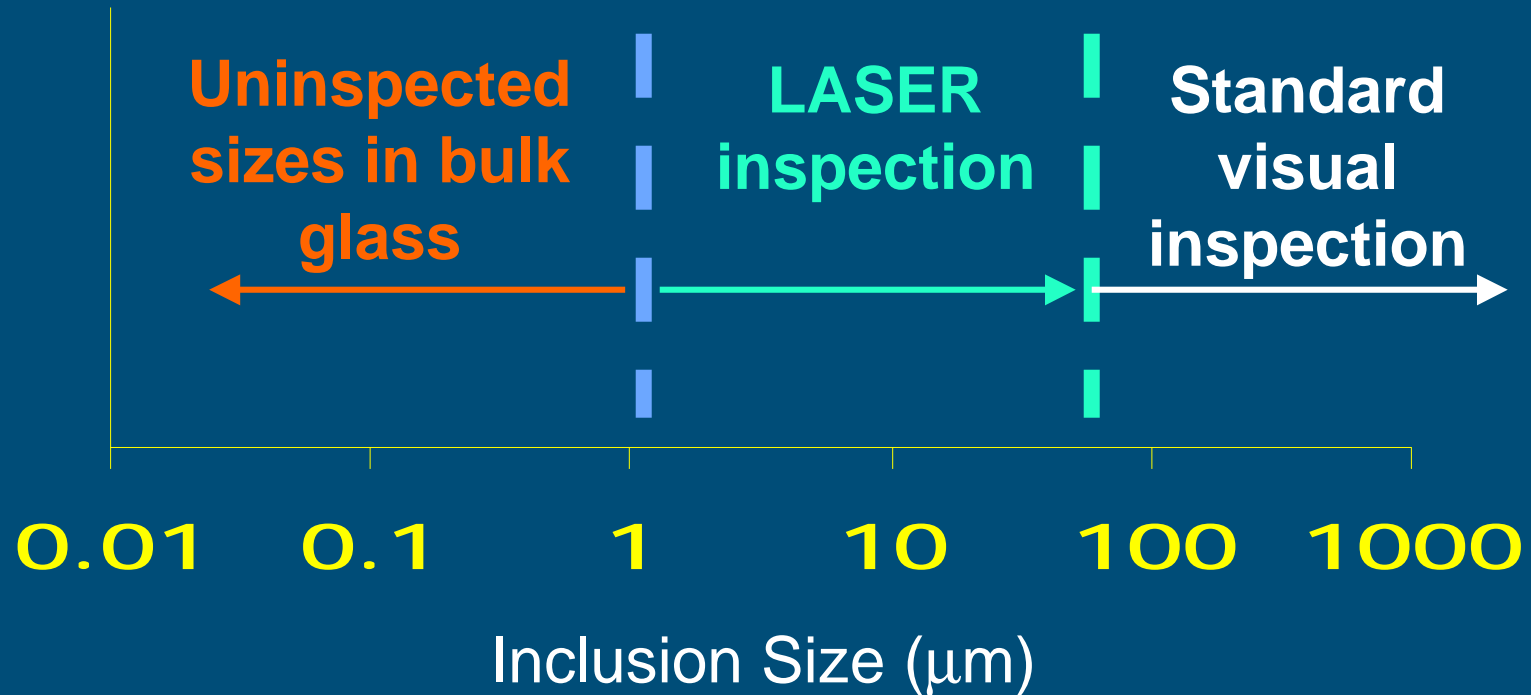


Inclusion vs. Defect

Inclusion: A feature in bulk glass.

Defect: A feature on surface of photomask.

Inclusion Metrology Used in Bulk Glass at Corning



Note: (1) LASER inspection is non-standard.

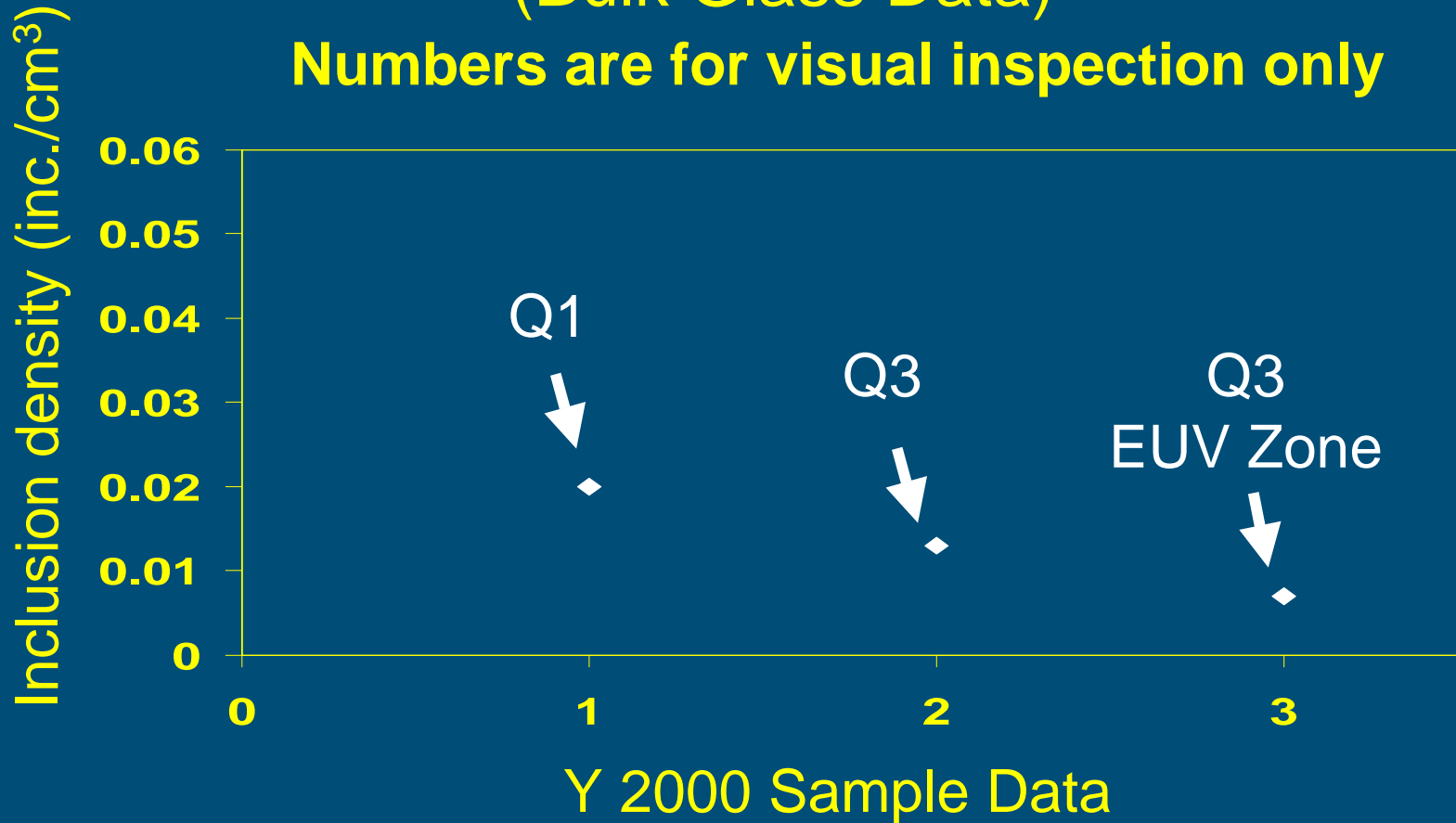
(2) Inclusions less than 1 μm not detected.



Inclusion Reduction

(Bulk Glass Data)

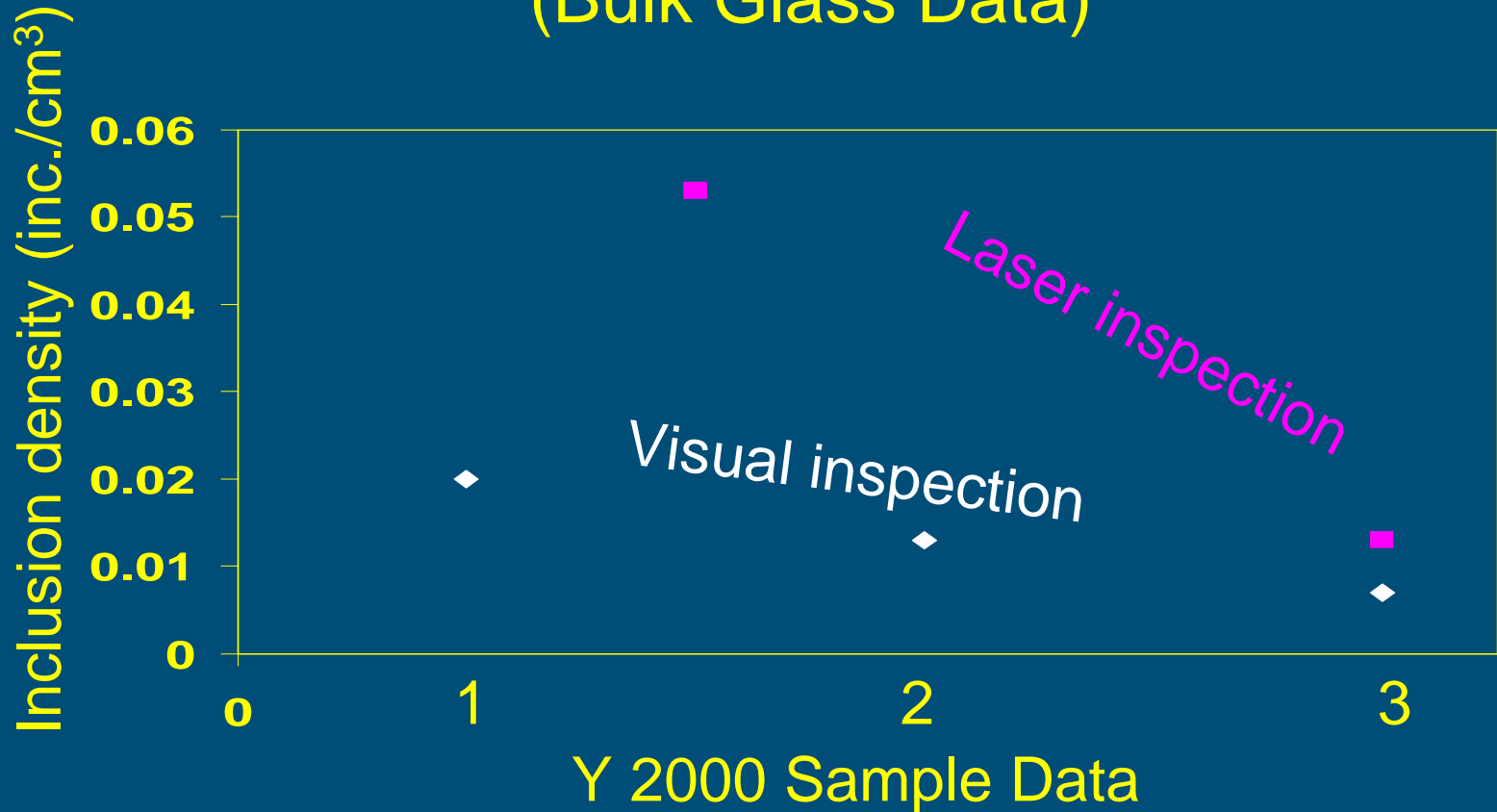
Numbers are for visual inspection only



Inclusion level being reduced (~2x)



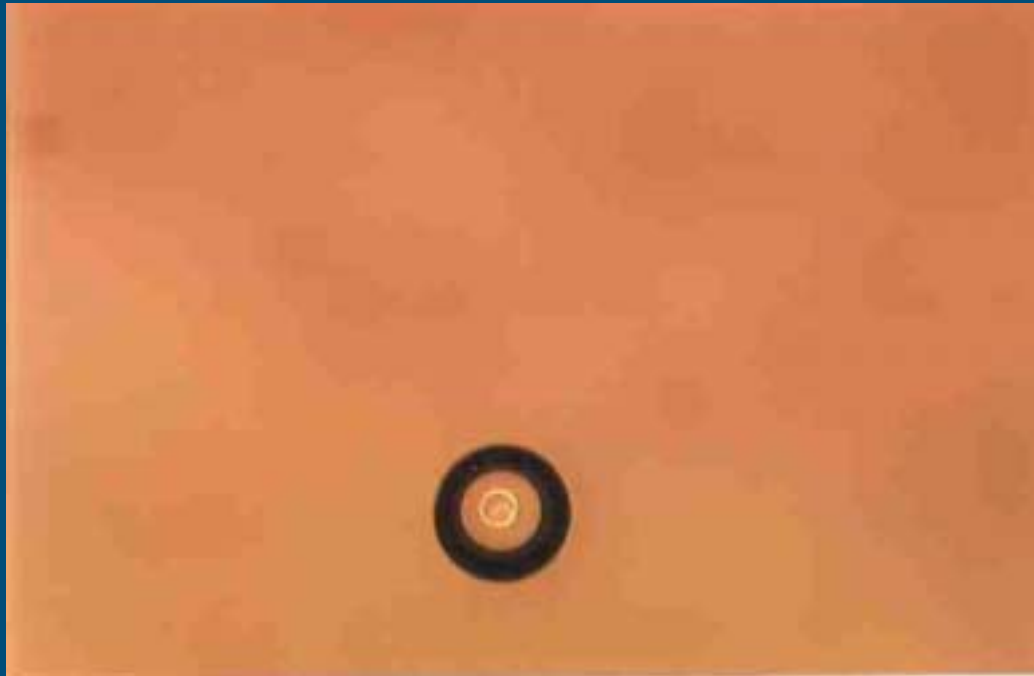
Comparison Visual Inspection vs Laser Inspection (Bulk Glass Data)



**Inclusions reduced regardless of
inspection technique**



Typical Composition of Inclusion



Optical micrograph ~ 200X

>95% of inclusions are gaseous

Defect Predictions

Probability of internal inclusion showing up on glass surface (as a defect)*

$$P = N_v * D_v * A$$

Where: N_v = Inclusion density

D_v = Diameter of spherical inclusion

A = Area exposed (203 cm²)

Assumptions:

Spherical inclusions

Randomly located

Does not account for undetected inclusions. <1 um

*Reference: Dehoff & Rhines, *Quantitative Microscopy*



Defect Criteria for EUV Photomask as Defined in SEMI Draft Document 2848

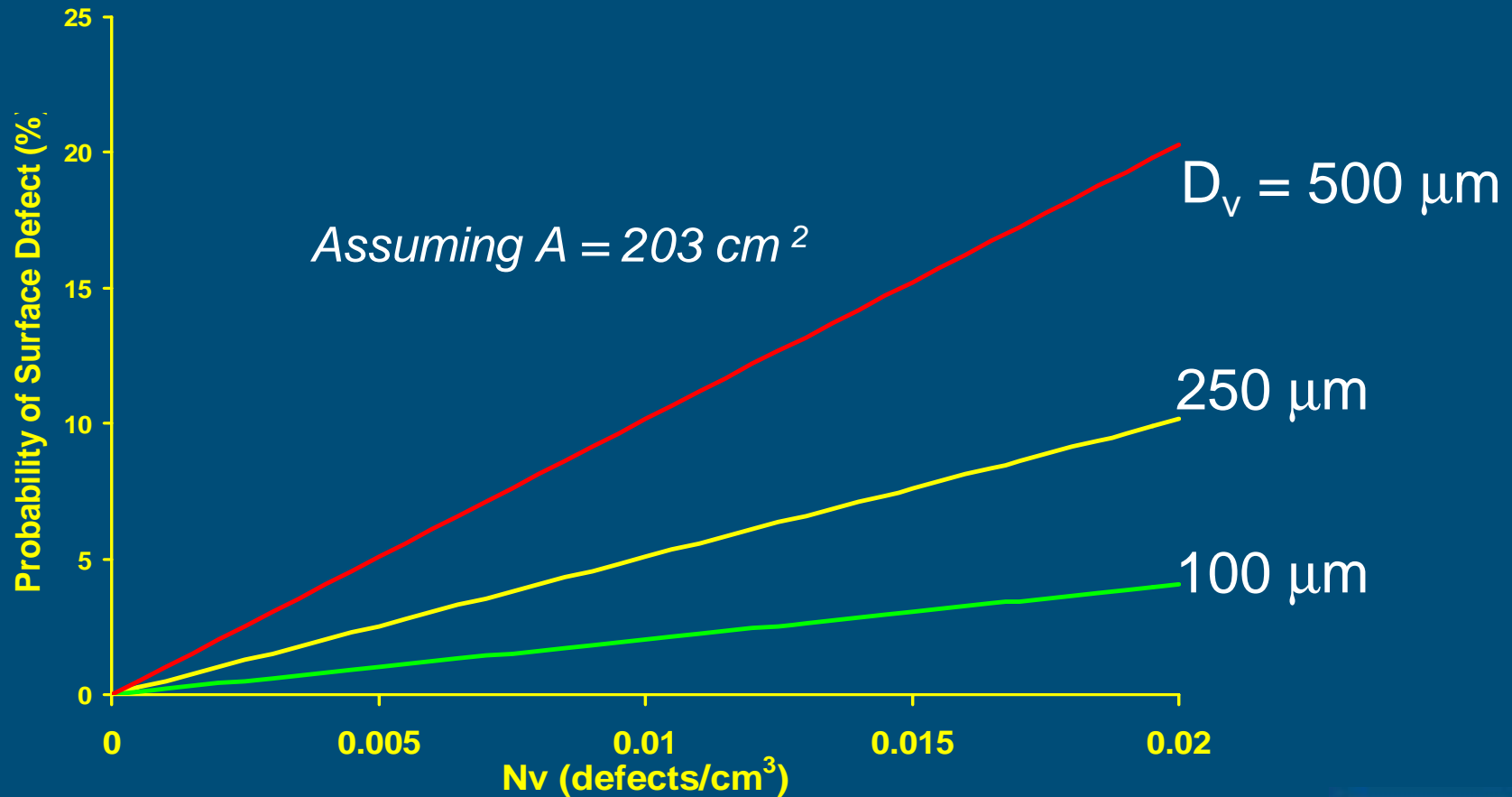
Photomask

Front side
only

Area ~ 203 cm²



Equation Prediction



Small inclusions have a small chance of appearing on the surface



Defect Predictions...

Continued

Probability of surface defect

Quarter 1 EUV zone = 2 to 9%

Quarter 3 EUV zone = 1 to 2%

Conclusions: Equation showing small chance of seeing defect.



Summary

- Inspected bulk glass down to 1 μm
- Inclusion level reduced ~ 2x
- Typical inclusion... gaseous
- Probability of surface defect low
 - Quarter 1 EUV zone ~ 2 to 9%
 - Quarter 3 EUV zone ~ 1 to 2%

Acknowledgements

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