



**Status of Mask Blank Development:  
Flatness & Thickness Data, and Project  
Summary Data**

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Acknowledgement

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*SEMI Standards Meeting Santa Clara 2/22/04*

# Outline

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- Quick project overview
- Front-surface flatness isn't the whole issue
- Summary

# Sematech LITH-141 project does neutral benchmark measurements of LTEM substrates & blanks

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## Sematech LTEM Projects Overview:

- Earlier LITH-111 project (1999-2002): flatness, roughness, defectivity on ~215 *substrates*. Six manufacturers, 3 materials (some none-6025 formats)
- Recent LITH-141 project (2003): flatness, roughness, defectivity, ML reflectivity on ~50 *blanks*. Five manufacturers, 4 materials, all 6025 format.

## 1997

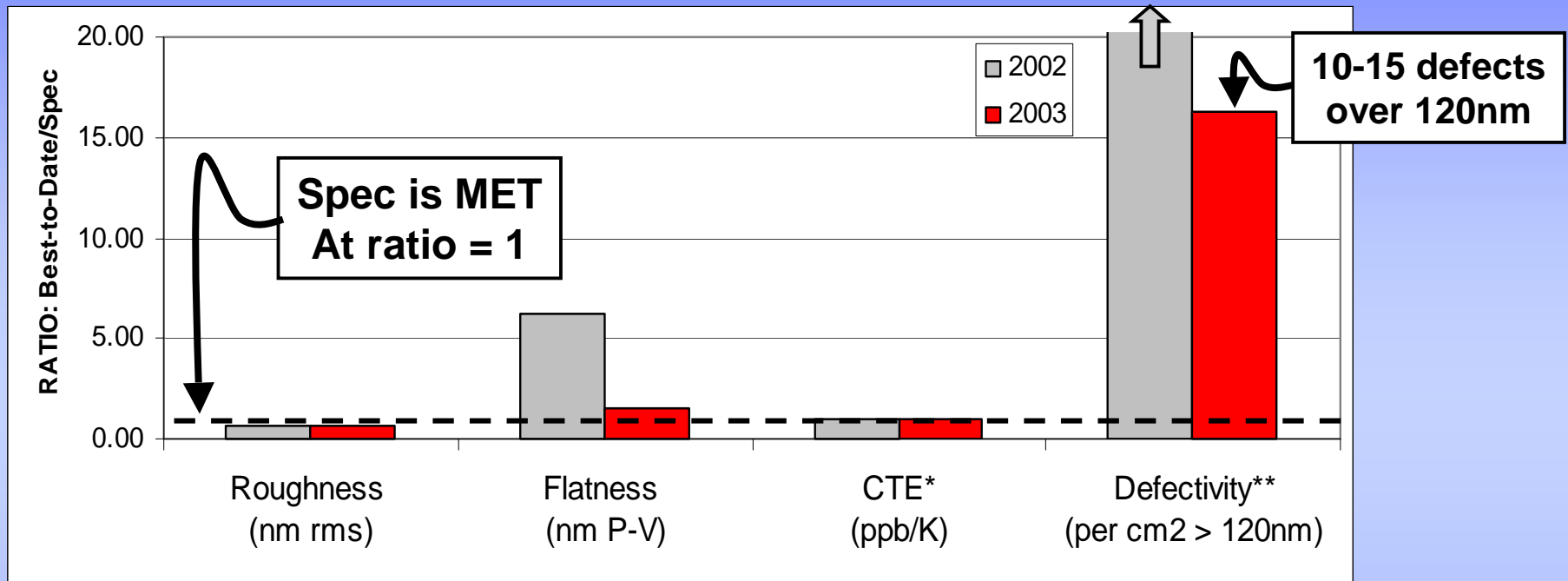
- Thermal expansion identified as issue at VNL
- Pilot program begun with early ISMT participation: buy LTEM materials in 6025 format.

## 2004

- SEMI standards adopted for substrates (P-37) and blanks (P-38)
- 6 suppliers have produced standard-format LTEM substrates
- 2-3 suppliers offer ML-coated substrates (reticle *blanks*)
- One tool vendor engaged to commercialize low-defect ML coatings
- EUVL mask facility and toolset being commissioned at ISMT-N.

# Previous summary showed progress on flatness; identified defectivity as risk standing out

Comparison of supplier “best to date” capability to specs (P-37 and P-38):



Conclusion: Roughness, flatness and CTE capability have been demonstrated within 1.5X of specification and making progress, and metrology exists. Defect reduction is still the most important concern.

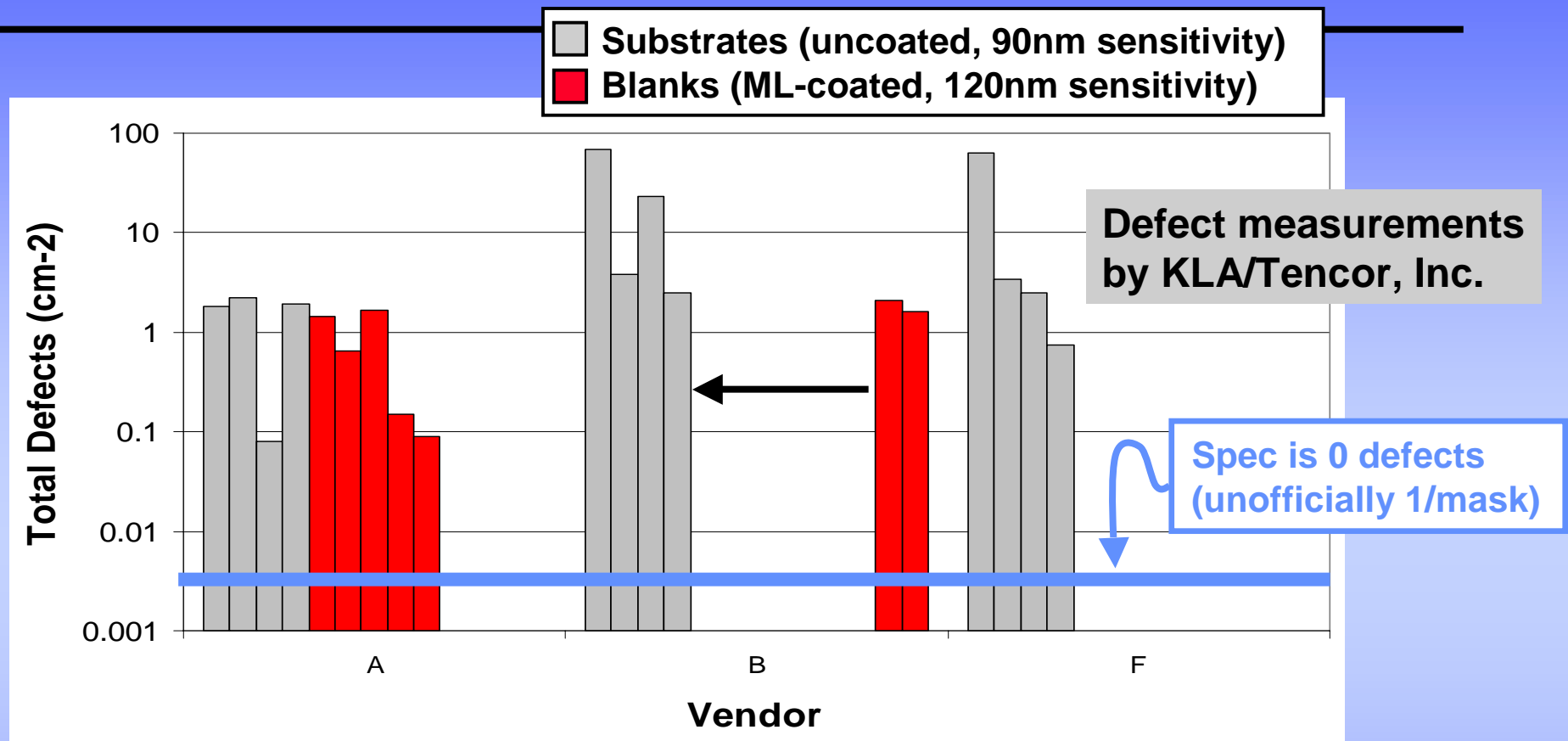
(best-to-date over all suppliers; results on different substrates.)

(\*CTE for ULE measured indirectly, through strong correlation to refractive index: Hrdina KE, *Proc. SPIE*, vol.5037, 2003, pp.227-35.)

(\*\*Specification is for >25-60nm size; inspection capability is >120nm)

(\*\*Specification is zero defects; unofficially 1/blank = 0.008cm<sup>-2</sup> usually tolerable)

## Blanks now available at total defects $\sim 0.1\text{cm}^{-2}$ ( $> 120\text{nm}$ )



- One manufacturer now offers ML-coated *blanks* at defect levels comparable to best *substrates* offered earlier
- Considerable improvement in defect levels and inspection sensitivity still needed to meet SEMI P-38 specification. Benchmarking optical tools against new actinic tool at LBNL will provide valuable feedback.

# Adopting, and achieving, combined flatness and thickness spec is a current risk

Specification is 50nm P-V on the blank as purchased, but:

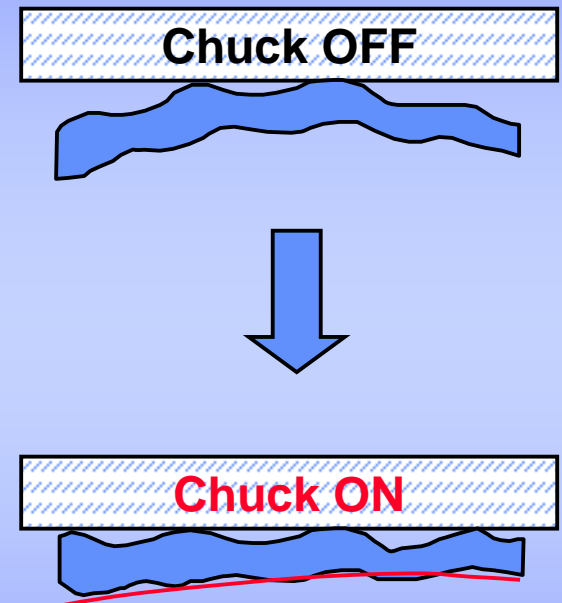
- a) Distortion from fixturing during flatness measurement can change figure 50-100nm
- b) Typical Mo/Si ML film stress will curve plate ~ 500nm

Current SEMI approach to as-chucked flatness:

- Electrostatic chuck will flatten low-order Legendre modes; these modes now covered by thickness spec
- Flatness spec will cover only high-order Legendre modes.

Risks still to be addressed

- Flattening may not be reproducible or predictable due to trapped friction
- Particles under the mask may cause extra distortions
- Manufacturability of combined thickness and flatness spec needs to be demonstrated.



# P-37 specification provides for backside flatness and thickness variation as well as front flatness

Table 4 Flatness, Wedge and Surface Roughness

## FLATNESS ERROR IN FLATNESS QUALITY AREA

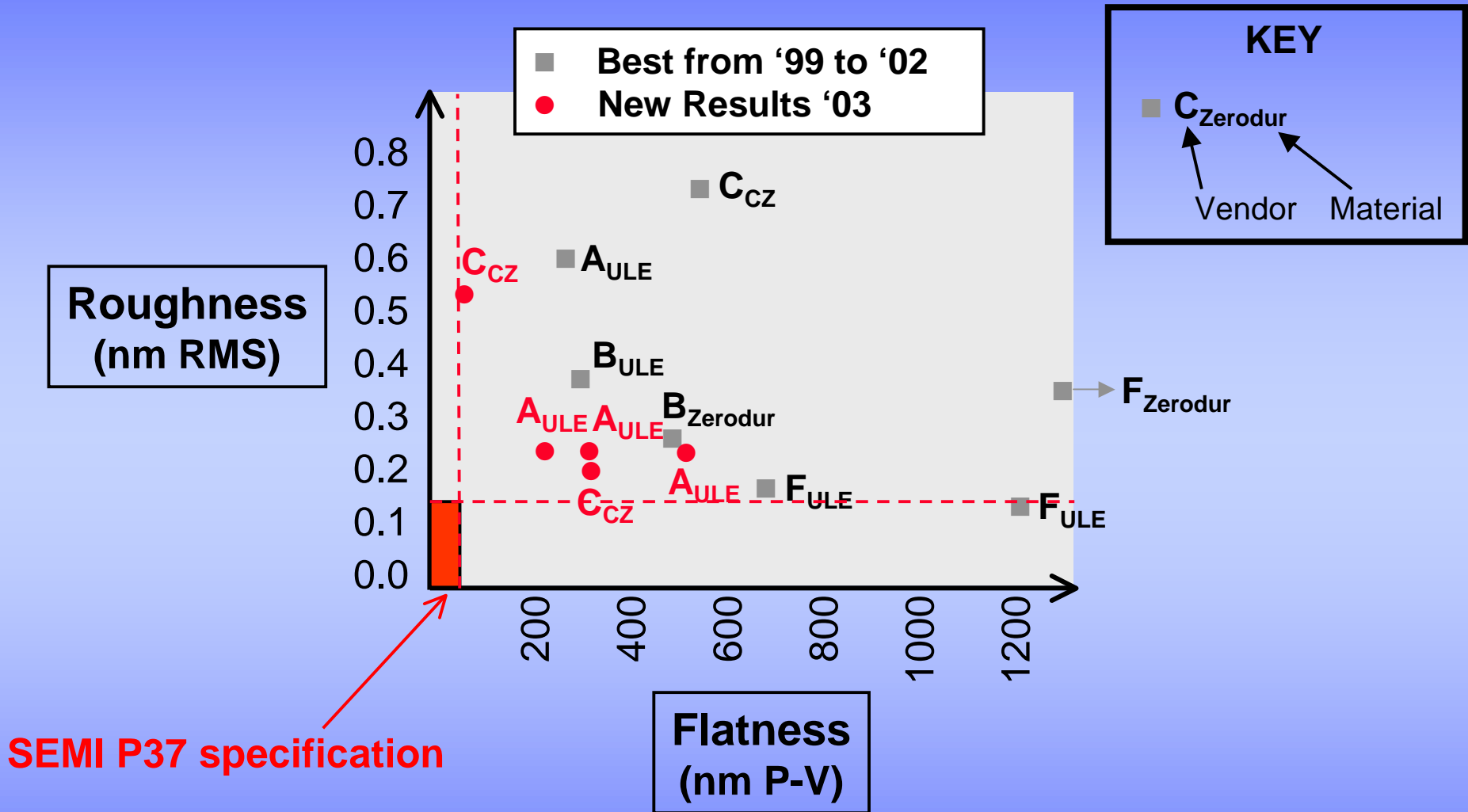
<i>Frontside Flatness, within Flatness Quality Area</i>	<i>Backside Flatness, within Flatness Quality Area</i>	<i>Low Order Thickness Variation (LOTV), within Flatness Quality Area (See Note 2.)</i> $\lambda_{\text{spatial}} > (\text{edge length})$	<i>Units</i>
50 peak-to-valley	50 peak-to-valley	50	nm

NOTE 1:  $\lambda_{\text{spatial}}$  is the spatial period of the flatness error.

NOTE 2: Evaluated after removing wedge angle.

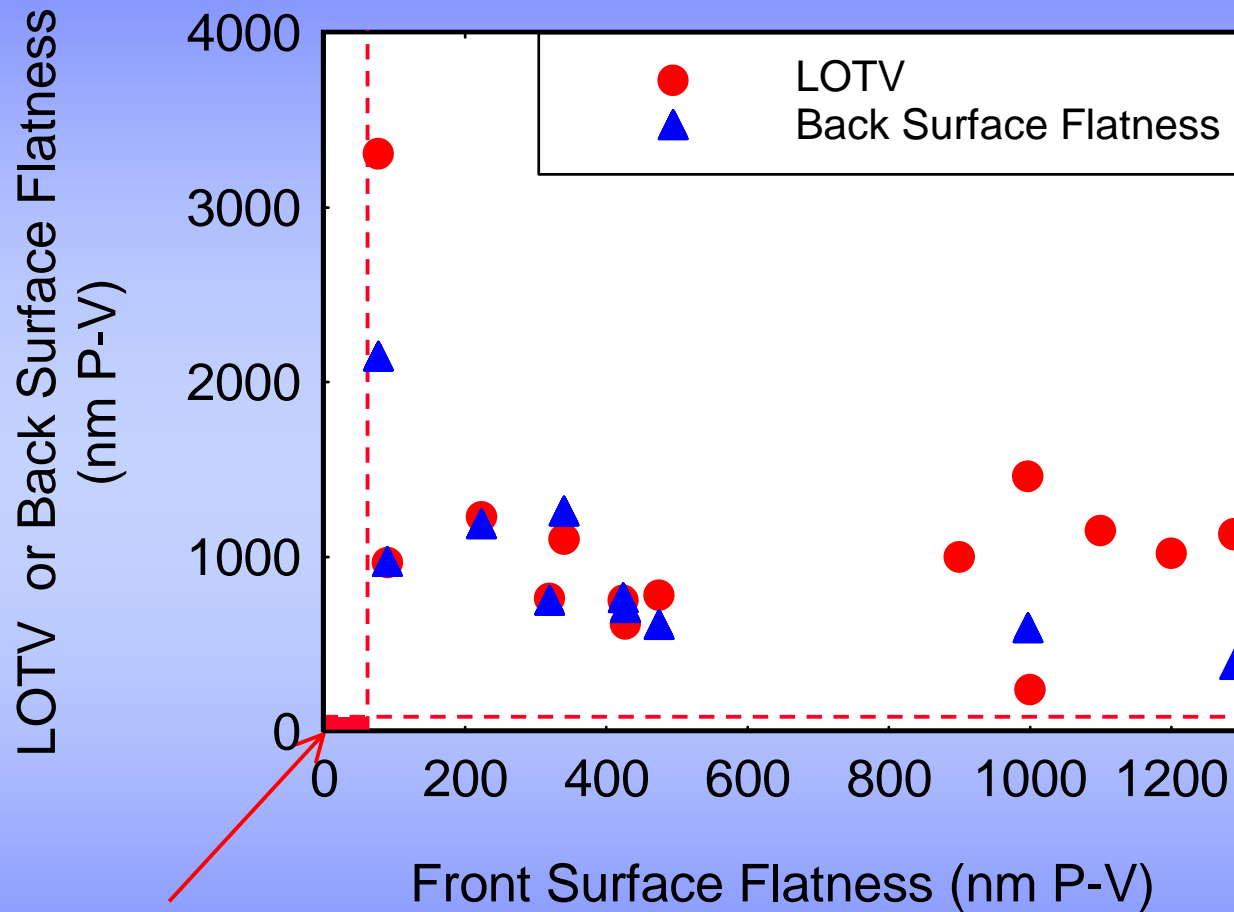
Previous reports from LITH-111 and 141 projects have concentrated on frontside flatness....

# Manufacturers show recent progress toward achieving front-side flatness and roughness together.



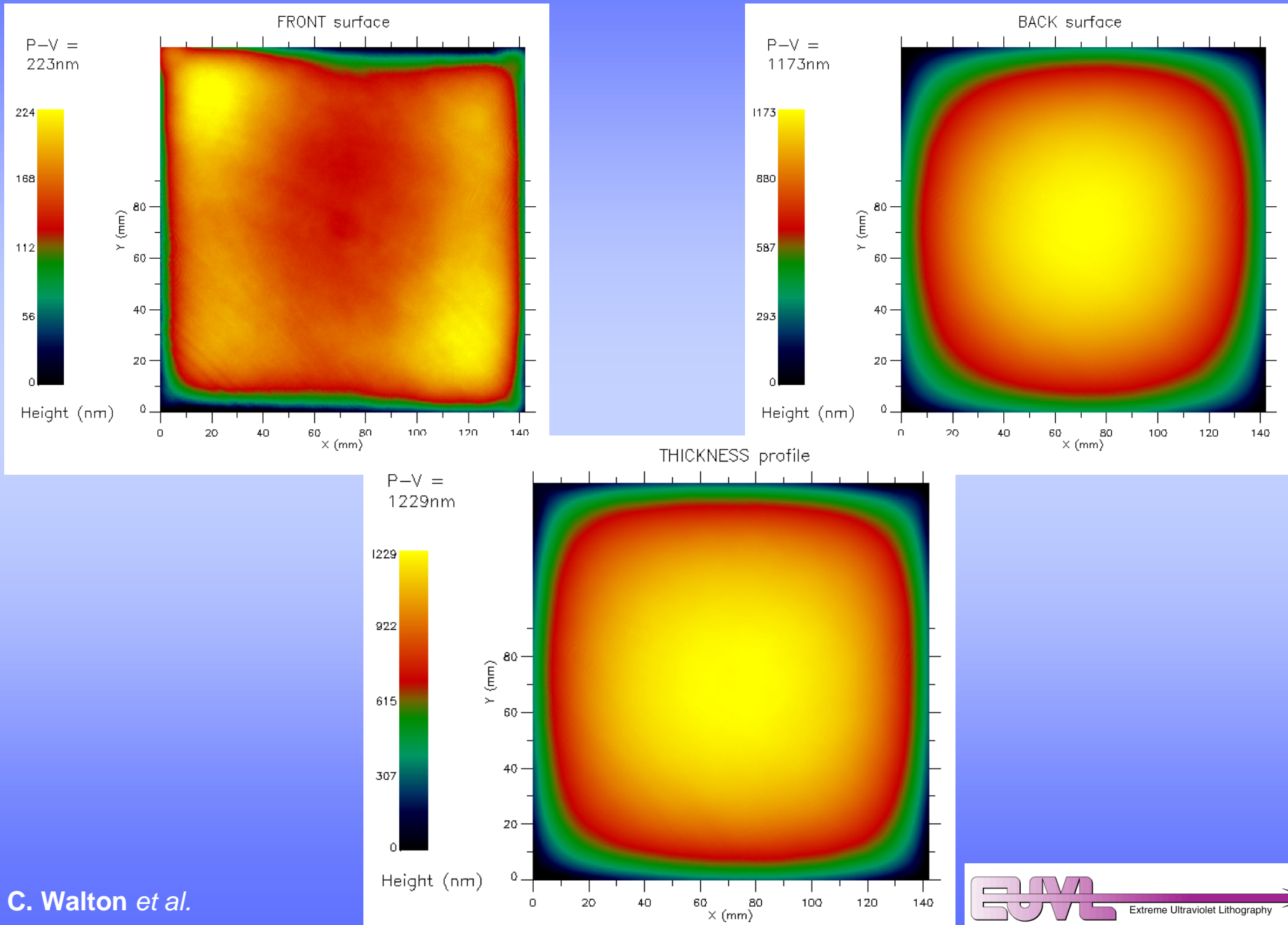
☞ **Still a need to examine progress on thickness variation.**

# Thickness/LOTV is ~5X above spec on best specimens



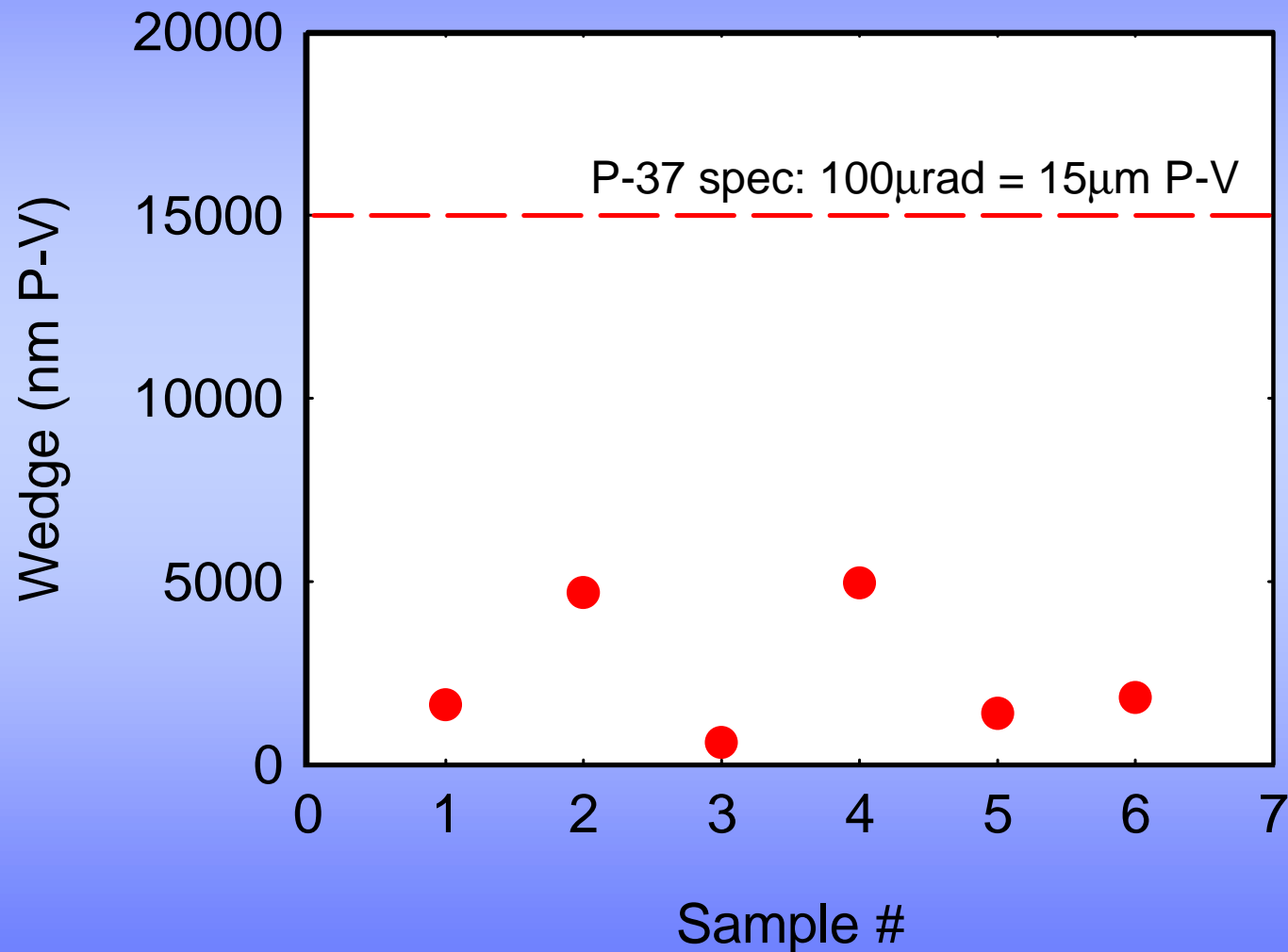
**SEMI P37 specification**

# Plates with best front-surface flatness typically poor on backside



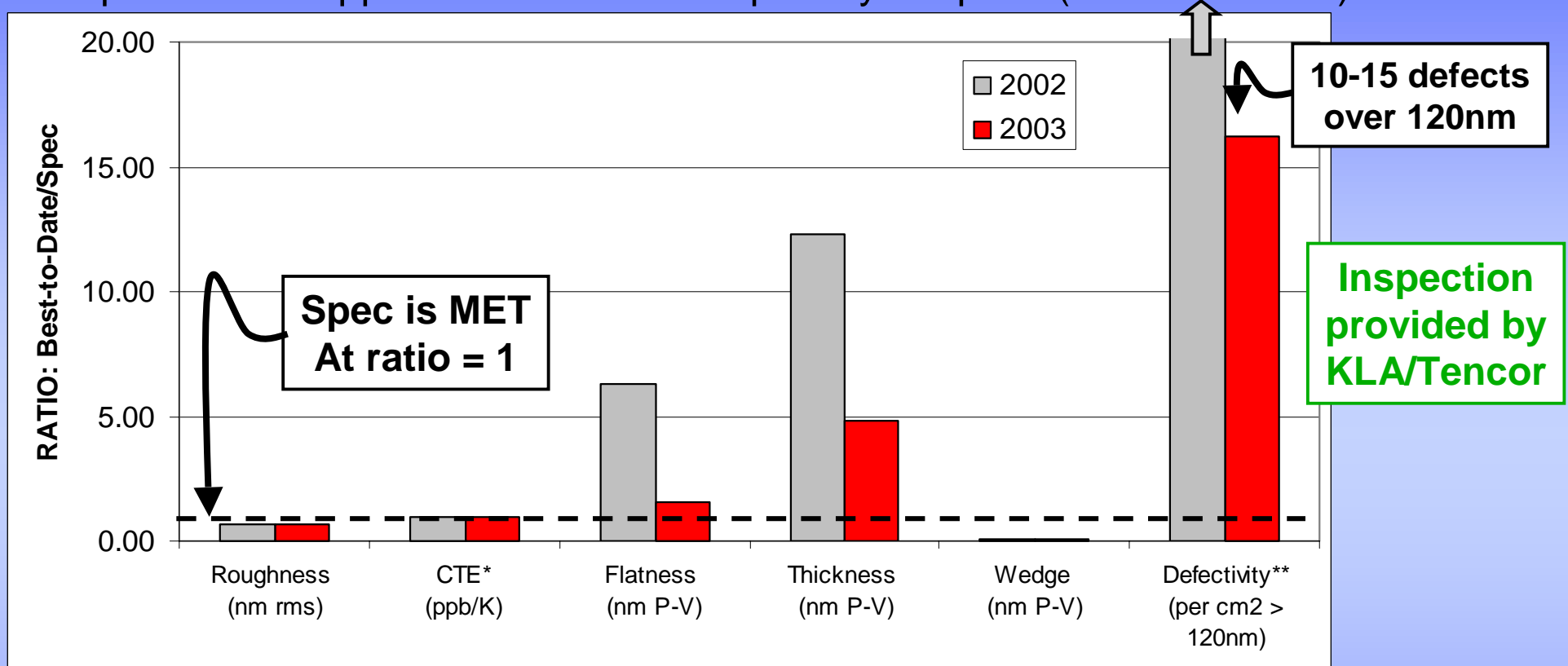
# Wedge requirement in P-37 appears not to be a challenge

Upper-limit approximate wedge values for small sampling (2 manufacturers):



# Summary of relative status shows thickness and defects are top *single* issues.

Comparison of supplier “best to date” capability to specs (P-37 and P-38):



Thickness based on 5 samples through 2002, 15 samples in 2003 for which full data available.

**Conclusion:** Roughness, flatness, CTE, and wedge have been demonstrated within 1.5X of specification, but thickness/LOTV and defectivity need significant progress.

(best-to-date over all suppliers; results on different substrates.)

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# Summary

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- Industry is within a factor of 1.5 of spec on roughness, flatness, CTE, and wedge
- Still 30X from spec on defectivity, and inspection tools sensitive to 40-50nm spec levels not widespread: substantial improvement needed
- Thickness is also 5X above spec; achieving combined flatness & thickness & roughness also needs substantial improvement.

## Acknowledgement

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