Understanding the Role of Scanning Electron Microscope Image Noise in the Measurement of Pattern Roughness

FRACTILIA

Austin, Texas
info@fractilia.com
www.fractilia.com

Chris A. Mack, Fractilia, LLC

Introduction

Measuring Roughness is Hard

- SEM images contain both random and systematic errors that bias our results
  - Random noise in the image produces white noise
  - Systematic field variations (intensity, distortion) increase the apparent low-frequency roughness
  - Standard measurements today are *biased*
- We need to measure these SEM errors in order to subtract them out and obtain the *unbiased* roughness
  - Unbiased measurements at small feature sizes has proven difficult using alternate approaches

The goal is to provide consistent, accurate, unbiased estimates of roughness parameters that are comparable across materials, processes, and most measurement conditions

- Move from precision to accuracy

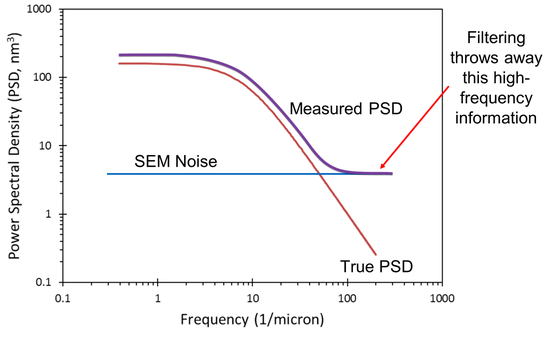
Experiment and Methods

Vary Measurement Conditions:

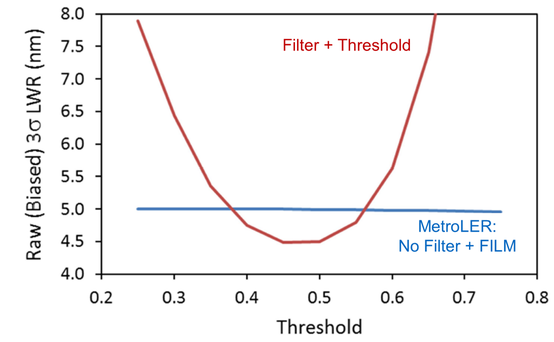
- Change algorithm settings, pixel size, magnification, number of frames (electron dose), and voltage

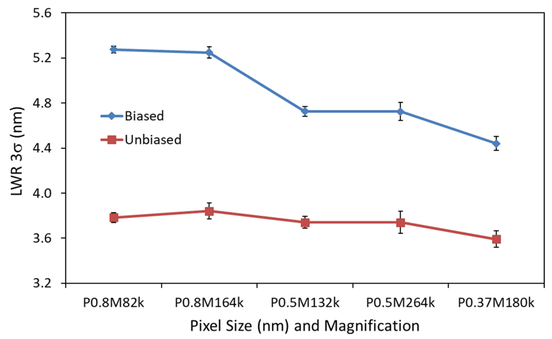
Compare Biased and Unbiased Linewidth Roughness (LWR)

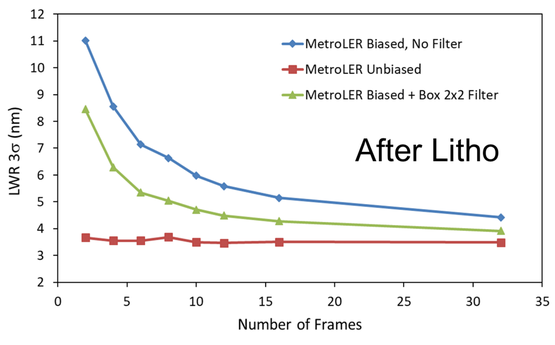
- Use Fractilia's MetroLER for all roughness measurements
- The Fractilia Inverse Linescan Model (FILM™) enables robust edge detection without filtering, allowing noise measurement and removal

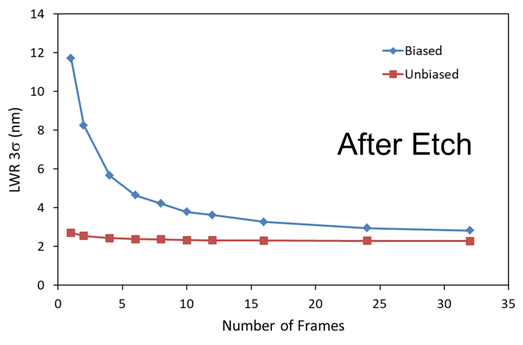


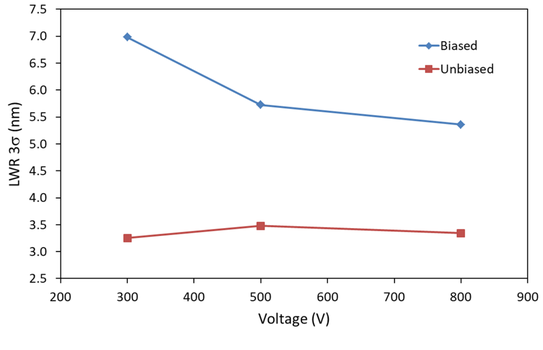
Results – Biased versus Unbiased Roughness Measurement

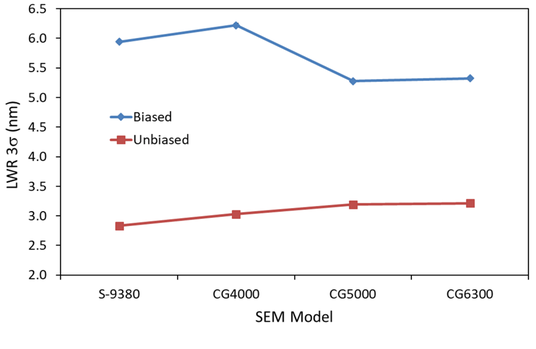












- Biased roughness can vary by > 100% when changing SEM settings
- MetroLER's unbiased roughness varies by only a few percent

Conclusion

Bias due to SEM noise increases the apparent roughness, and bias is not constant – it varies significantly as a function of:

- SEM measurement conditions:
  - SEM pixel size, magnification
  - SEM voltage
  - Electron Dose (# of fames of averaging)
  - SEM model
- Materials:
  - Feature material
  - Underlayer material
- Feature Size and Shape:
  - CD and pitch
  - Sidewall angle, profile shape

Only *unbiased* measurements have the possibility of enabling accurate and useful roughness measurements

References

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Acknowledgements

Thanks to imec for collaboration and for providing all images used in this study