

LER/LWR Measurements

Patrick Naulleau

Lawrence Berkeley National Laboratory

University at Albany

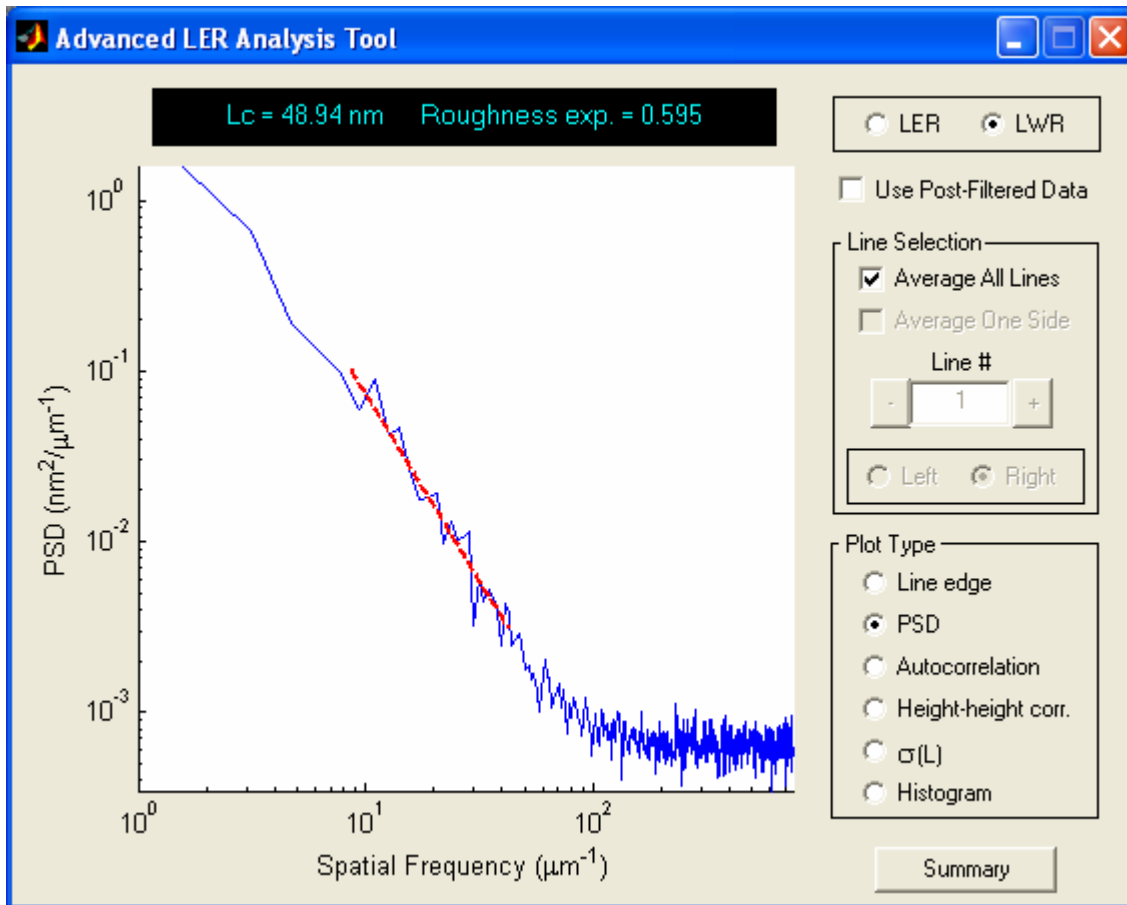


- ITRS breaks up LER into two frequency bands: low and high frequency
 - Low: $T = \text{Node Pitch} \rightarrow 2\text{-m}\mu$
 - High: $T = 0 \rightarrow \text{Node Pitch}$
- Only LWR_{hf} is specified
 - Measurement length should be $\geq 2 \mu\text{m}$
 - Sample spacing along length should be $\leq 4 \text{ nm}$
 - Orthogonal sample spacing not defined
 - To get reasonable pixel spacing across edge, ITRS spec implies requirement for rectangular pixels

ITRS LER/LWR Specification

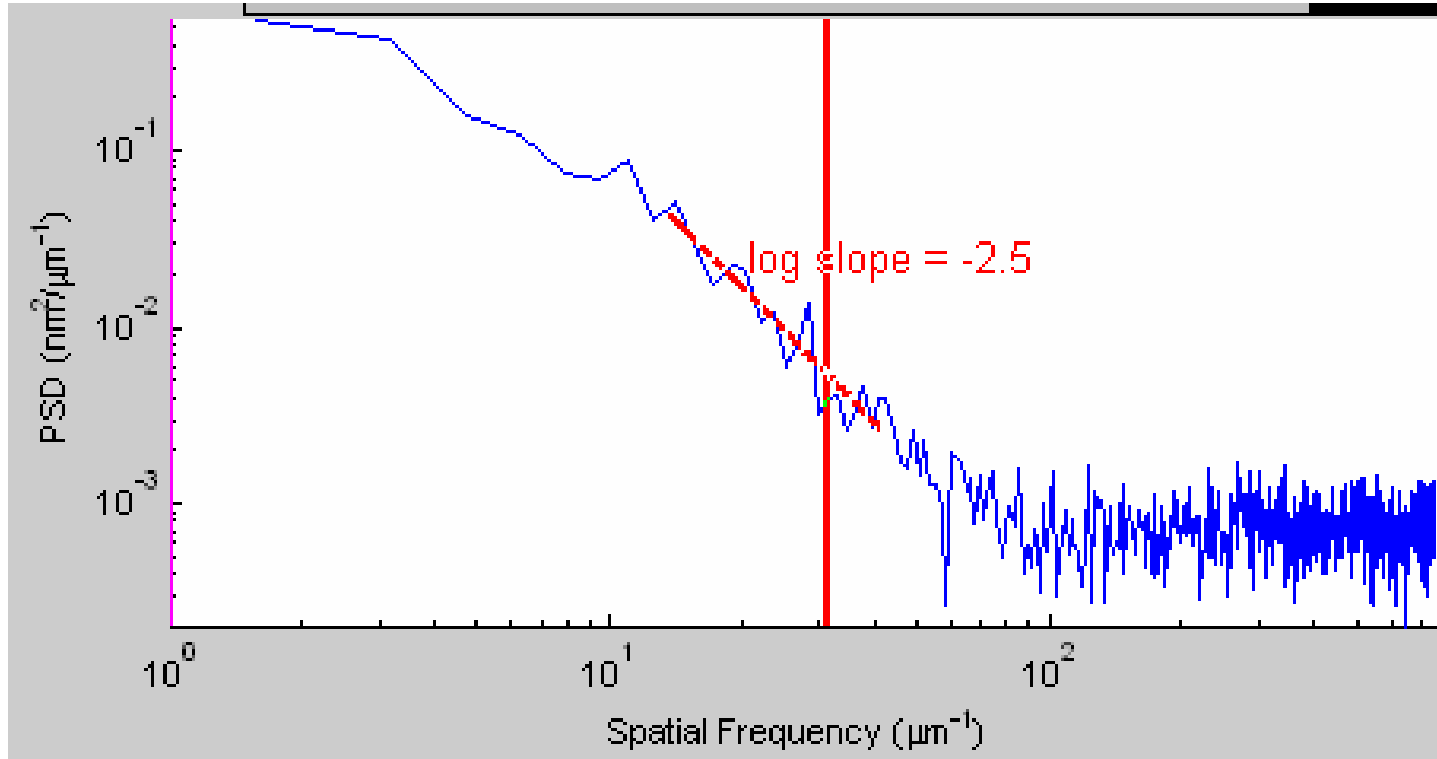


- ITRS also states that the measurement should be “biased” (corrected for SEM noise)

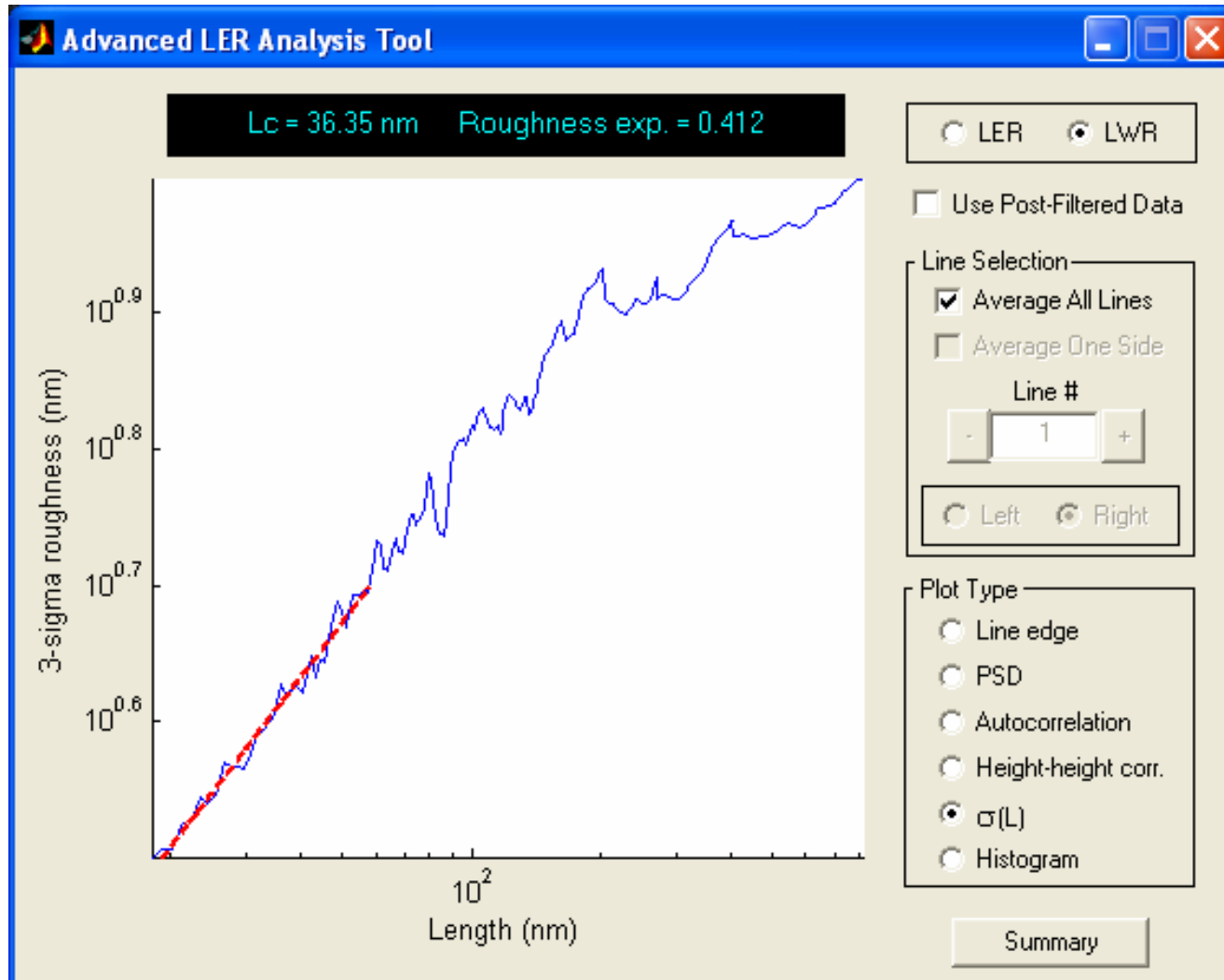


- Determine noise floor
- Assume noise to be white
- Bias entire PSD down to remove noise effect
- SEM must be clean enough for noise floor period to be $<$ Node Pitch

Cut-off period for 32-nm node

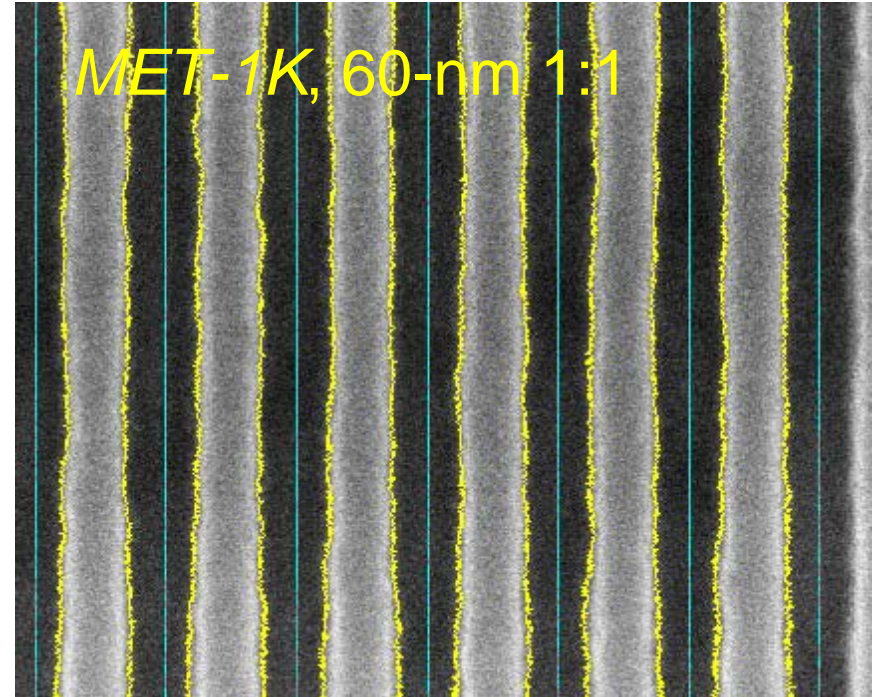


Effect of length on LER



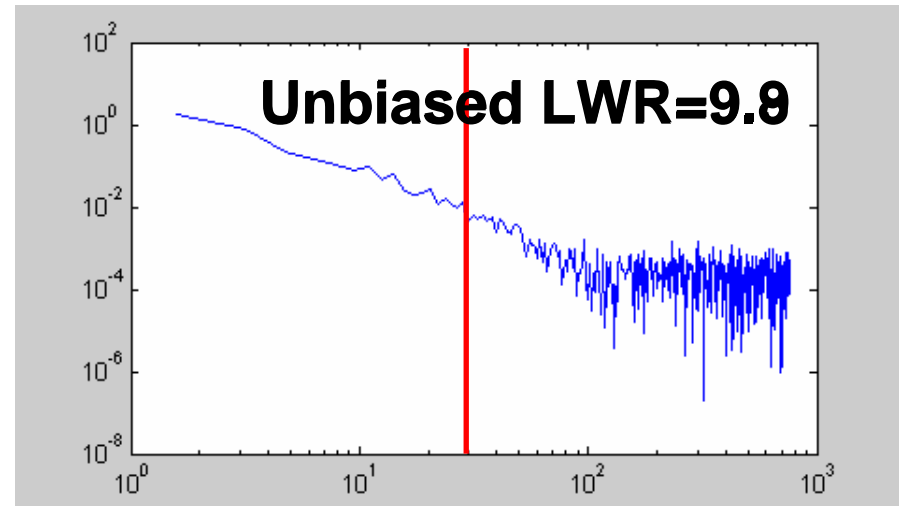
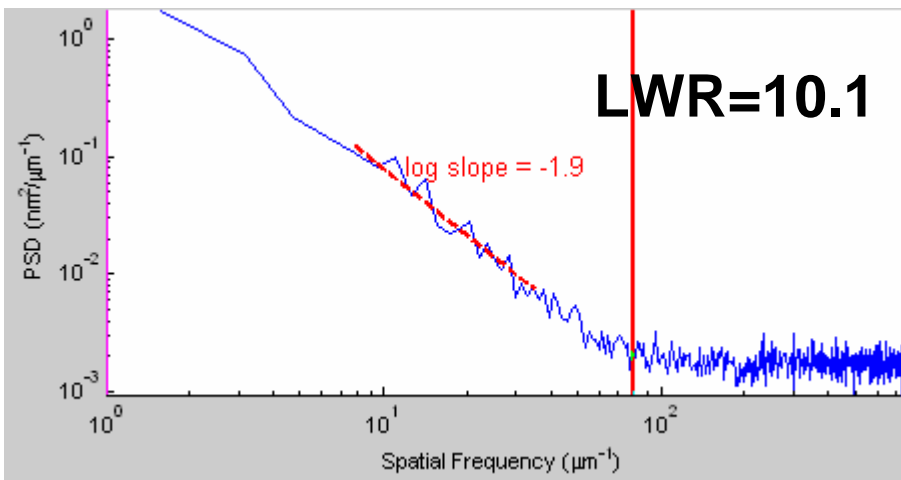
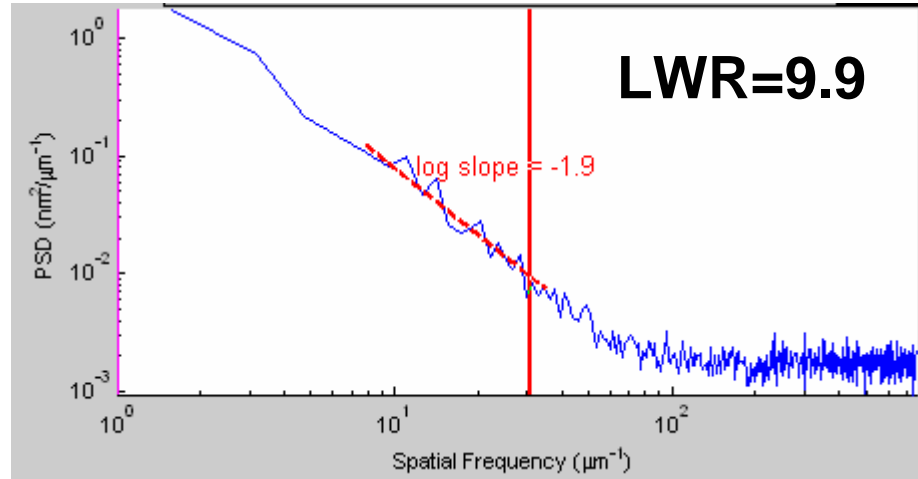
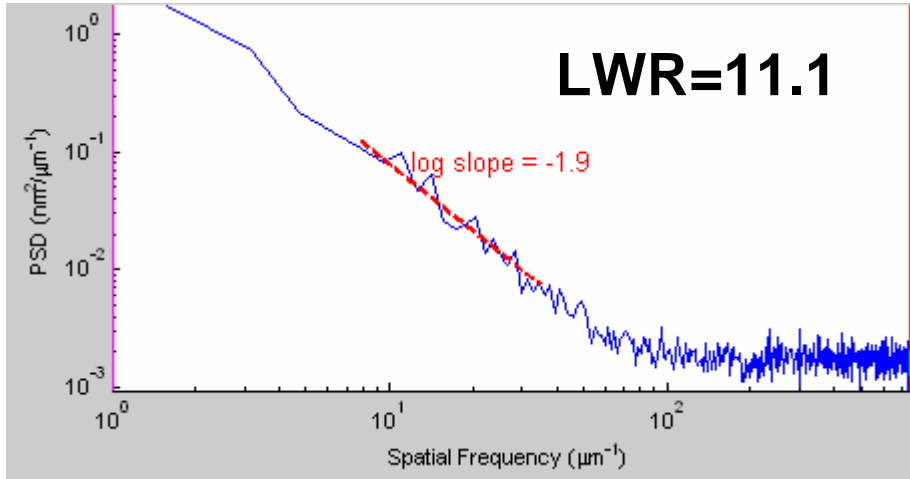
- Reason for 2 μm length is that it has been shown that at that level the sigma no longer increases with length
 - $\sigma_{2\mu\text{m}} = \sigma_{\infty}$
- It has also been shown that σ_{∞} can be statistically determined by measuring several shorter lines instead of one long line
 - Constantoudis et al., J. Vac. Sci Technol. B 22, 1974 (2004)
 - $\text{Var}_I = \text{Var}(W) + \text{Var}(\text{CD}) + \text{Var}(\sigma_W)$

MET-1K, 60-nm 1:1



- *MET-1K*
 - Raw LWR: 11.1 nm
 - Unbiased in-band LWR: 9.8 nm
 - Infinity unbiased in-band LWR: 10.8 nm

Effect of SEM noise



- MET-1K
 - LWR = 9.4 ± 2.1 nm
(assuming single line measurement)

