# Statistical Analysis of Endpoint Detection in CMP

6.780 Term Project

Kyungyoon Noh and Zil Lyons

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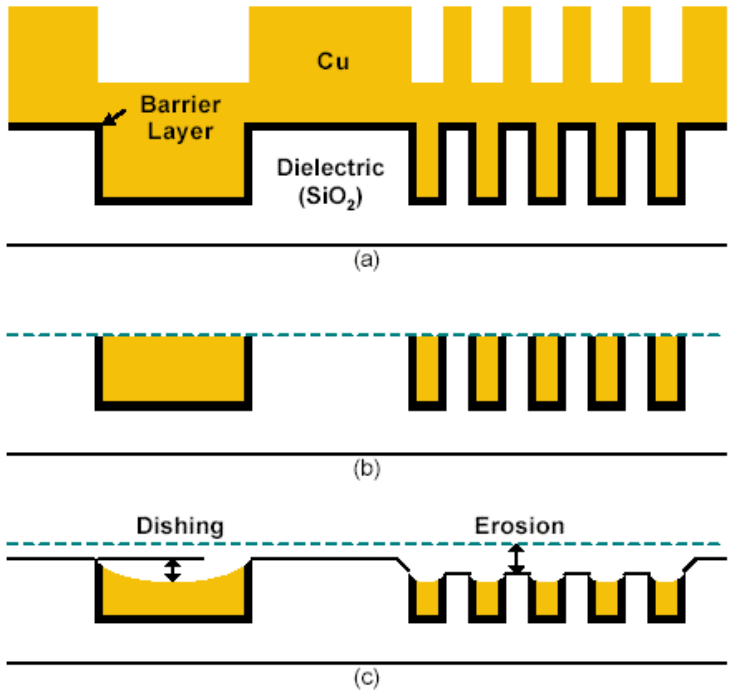
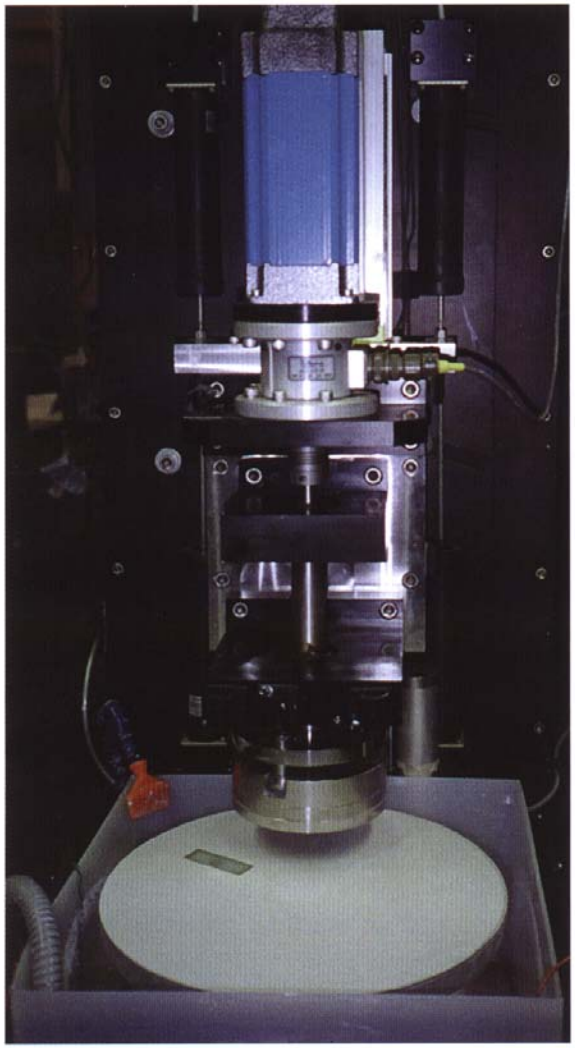
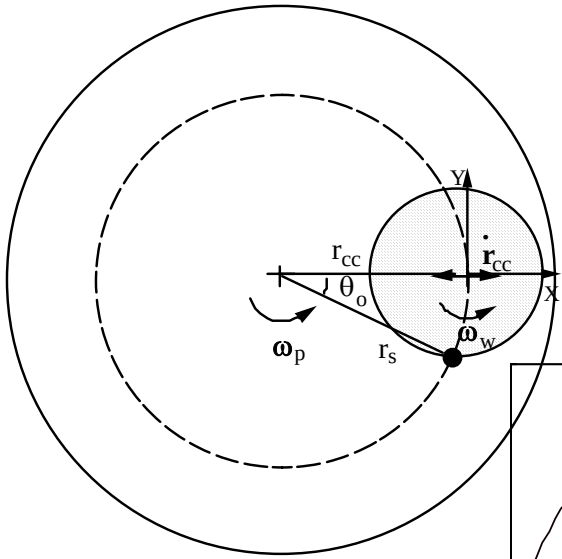
# Introduction: CMP Process
## (Chemical Mechanical Polishing)

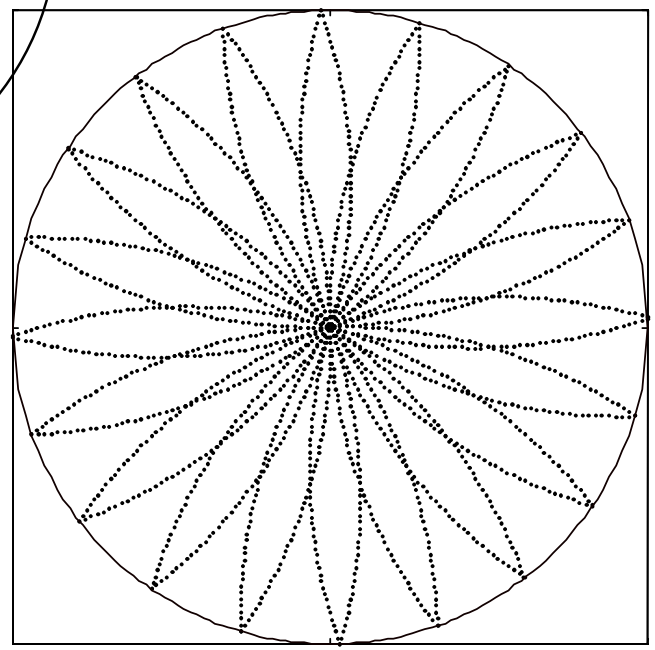
- Removes material from uneven topography on wafer surface, planarizing.
- Primarily for the interconnect structure of the chip
- Critical for fabricating copper-based semiconductors.
- Overpolishing can cause problems: dishing and erosion.



# Detecting Endpoint with Reflectance





# Endpoint detection: Ideal

Clears at edges first.

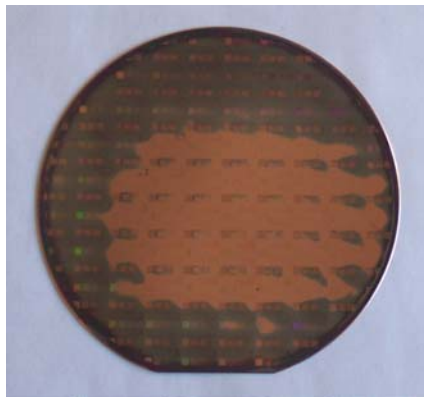
Average Reflectance drops sharply once areas begin to clear

Easy to declare finish point!

# CMP Process

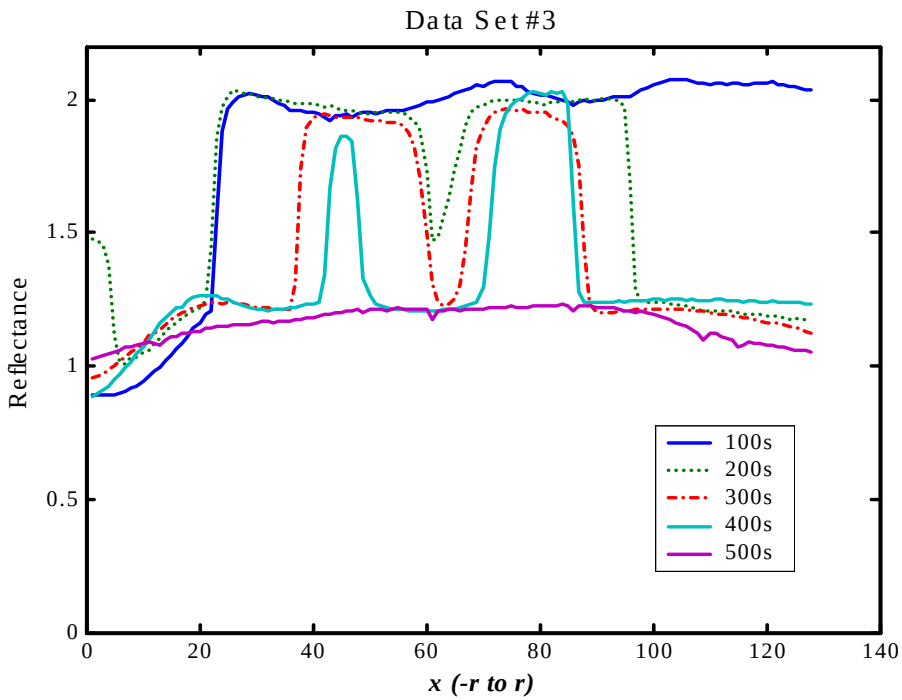
Time evolution of a blanket Cu wafer (t=2, 3, 4 min)

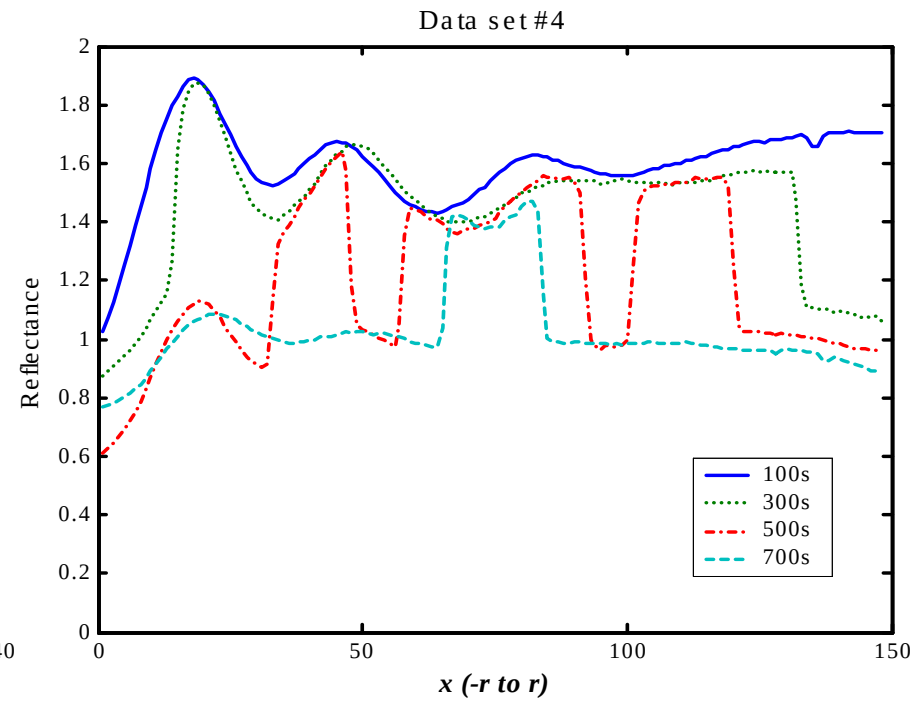
Effect on a patterned wafer



# Endpoint detection: Nonideal

Reflectance profiles for two wafers do not resemble the ideal profile!



# Variance Analysis

$$R_{ij} = \mu + W_i + D_{j(i)}$$

$j = 1,\ldots,m \quad (m = \#\,of\ dies\ in\ one\ path)$

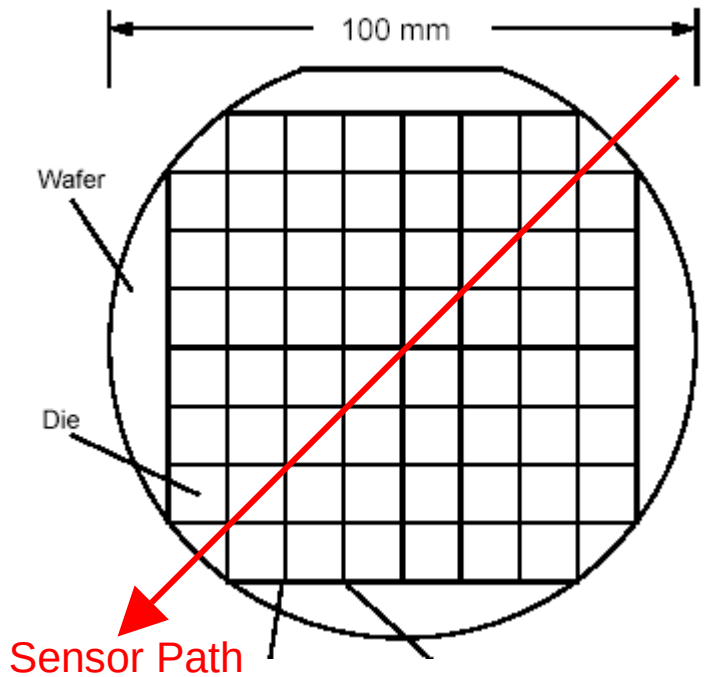
$i = 1,\ldots,n \quad (n = \#\,of\ measurement\ in\ one\ die)$

$$\sigma_T^2 = \sigma_W^2 + \sigma_D^2$$

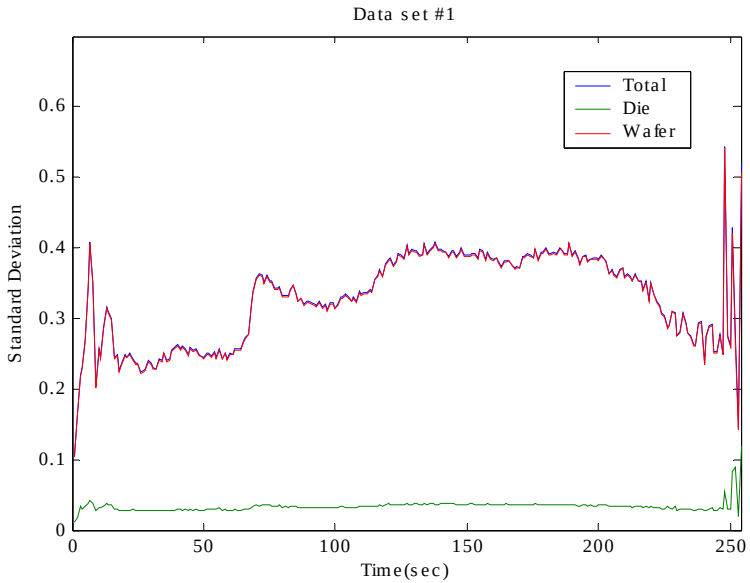
$$S_D^2 = \frac{1}{m}\sum_{i=1}^{m}\sum_{j=1}^{n}\frac{(x_{ij} - \bar{x}_i)^2}{n-1}$$

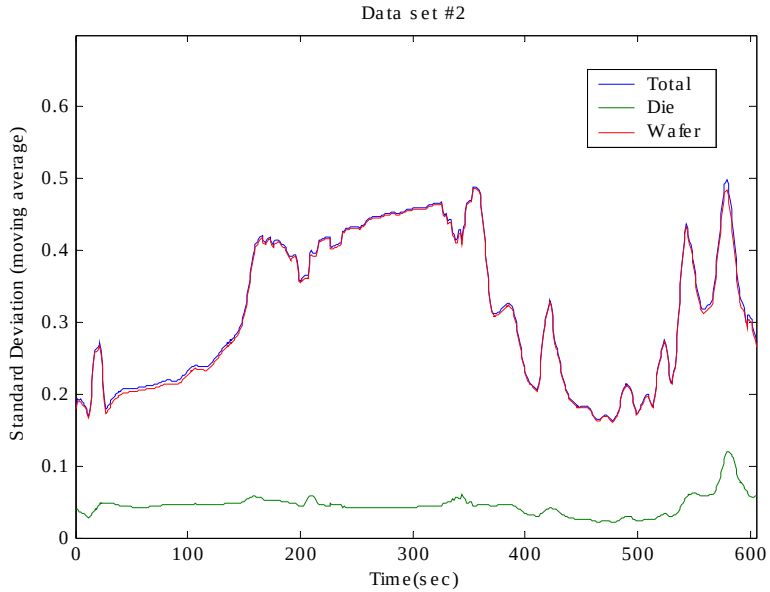
$$\sigma_{\bar{W}}^2 = \sigma_W^2 + \sigma_D^2 / n$$

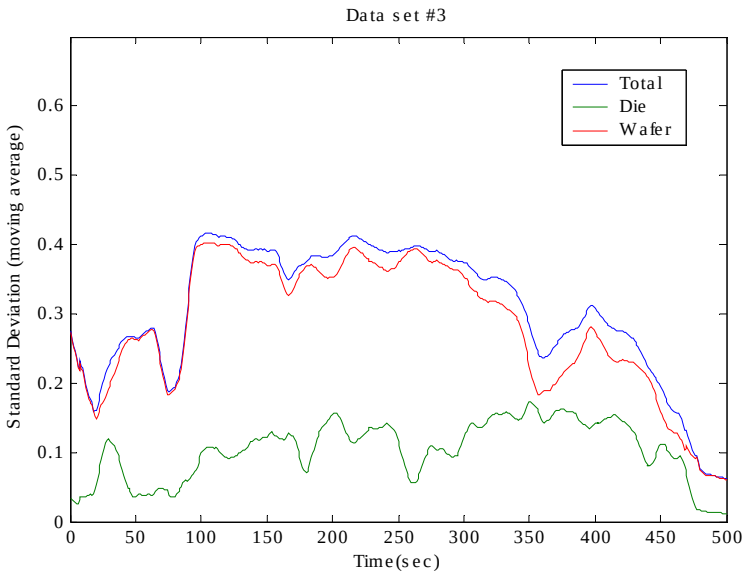
$$S_{\bar{W}}^2 = \sum_{i=1}^{m}\frac{(\bar{x}_i - \hat{x})^2}{m-1}$$

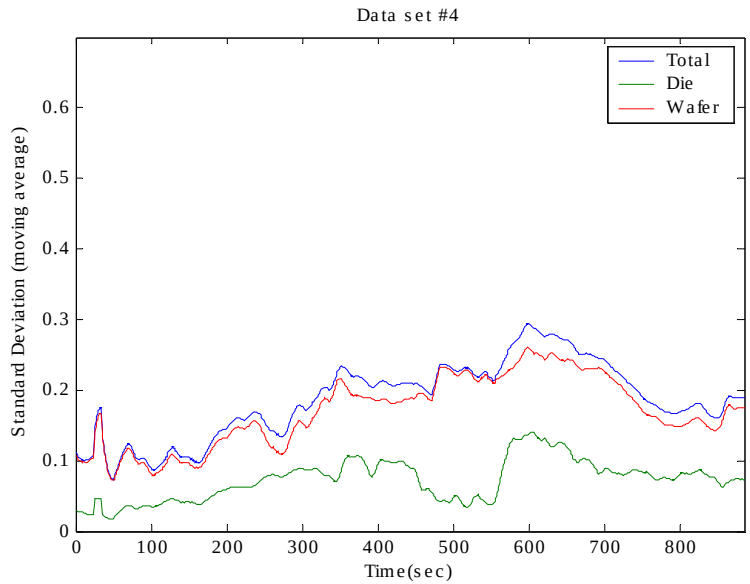


# Variance Analysis - Results

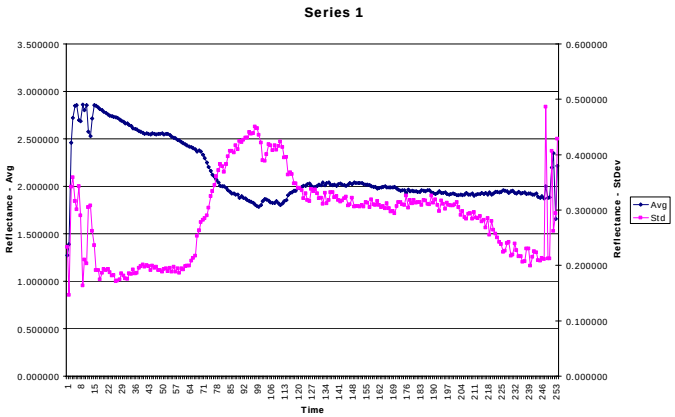


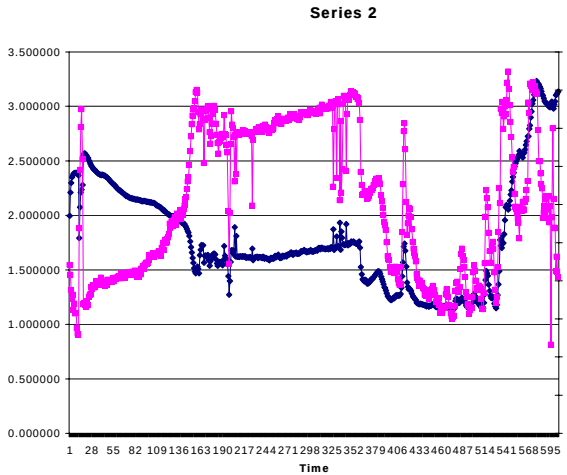



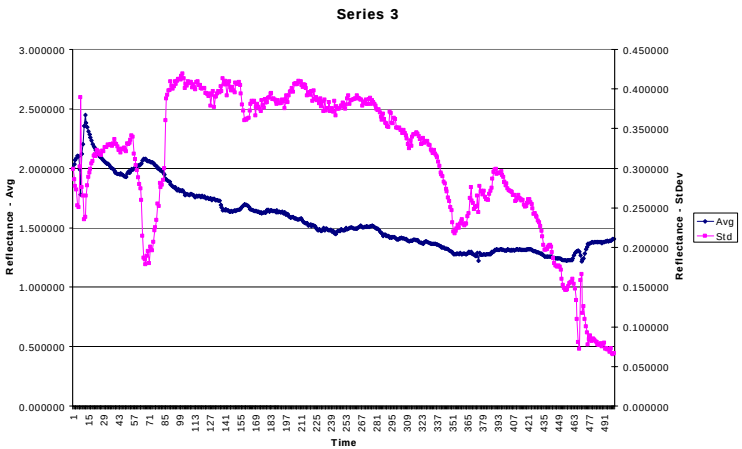



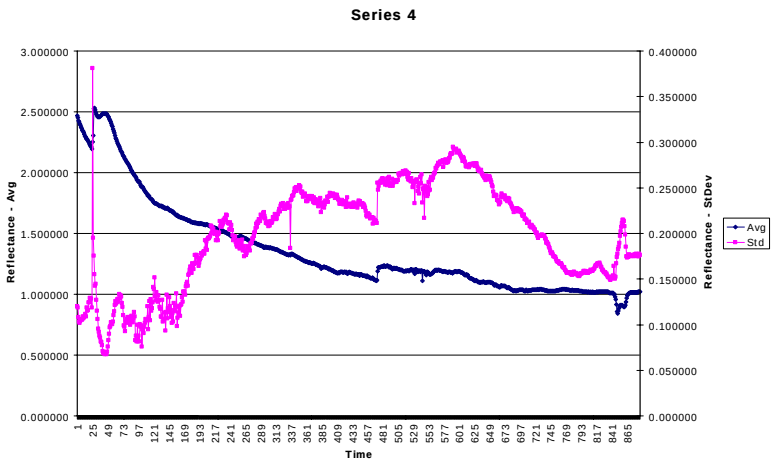



# Wafer Polishing Data:
# **Average**, **Standard Deviation**

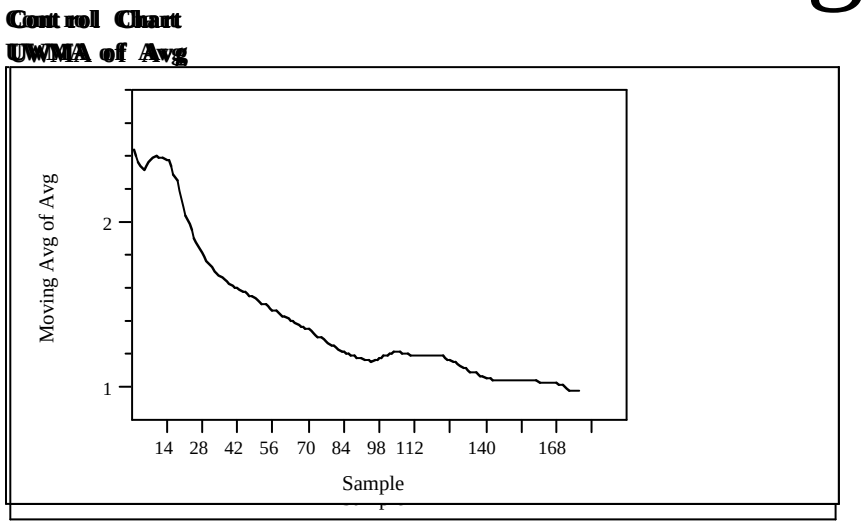


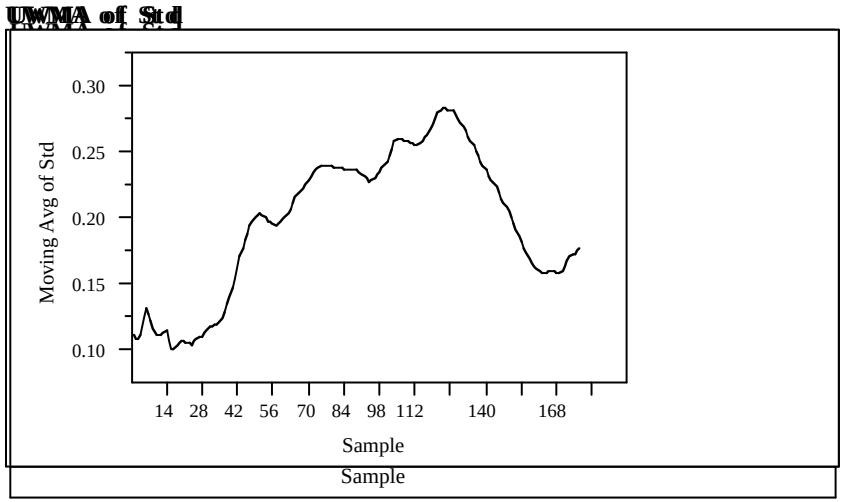



# Wafer Polishing - Refined Data

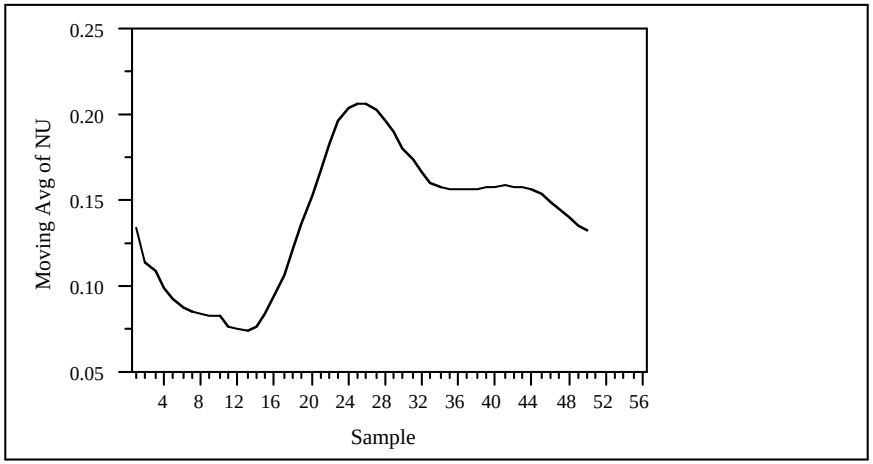


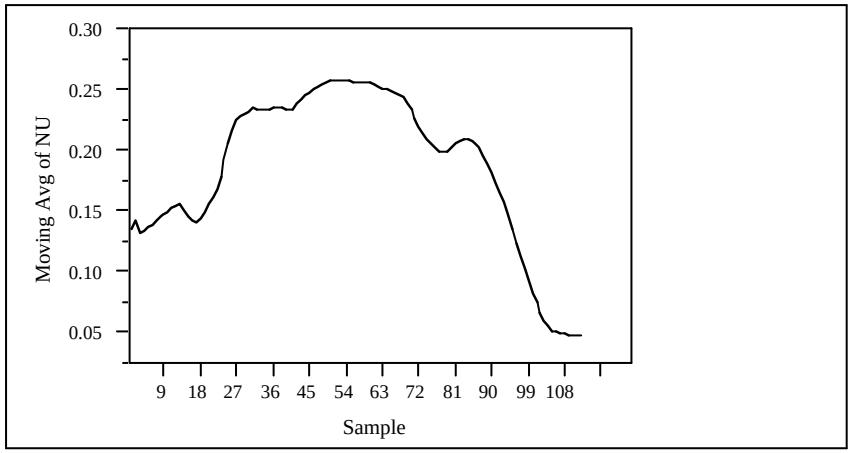

- Moving Avg Charts of Average, StDev
- Average not ideal
- Initially: StDev of 0.4
- Doesn’t work for all sets

# Signal To Noise Ratio

**Cont rol Chart**
**UWMA of NU**




**Cont rol Chart**
**UWMA of NU**

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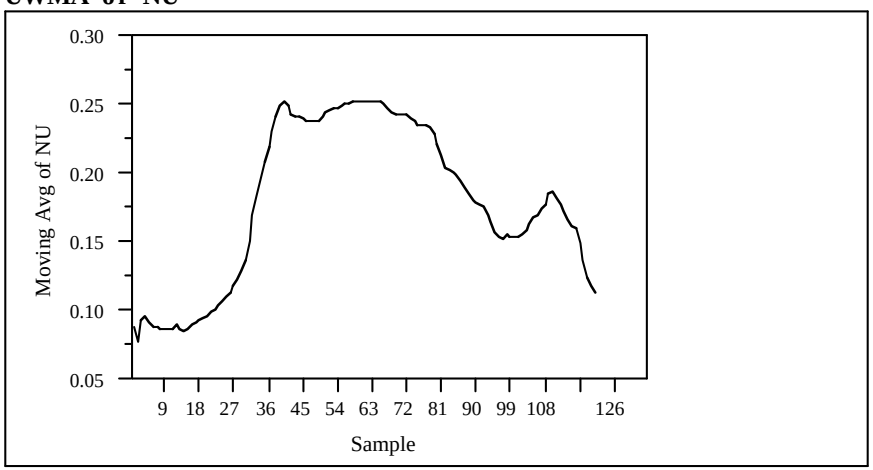
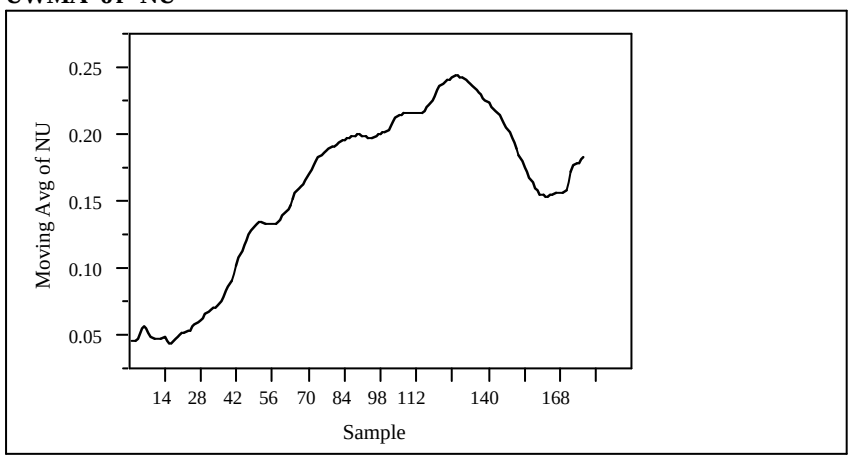



**Cont rol Chart**
**UWMA of NU**



# Conclusion

- Endpoint best measured with standard deviation, although this metric is vulnerable to shifts, especially with off-center data.
- NU, average not reliable criteria
- More sophisticated analysis techniques might improve detection algorithm - possibly multivariable.