Surface Finish Characterization and Measurement

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Outline

- Importance of Surface Finish
- Basic Terminology
- Assessment parameters
  - Geometrical
  - Statistical
- Measuring Instruments
  - Stylus based (2D)
  - Optics based (3D)

Importance of Surface Finish

Aesthetic

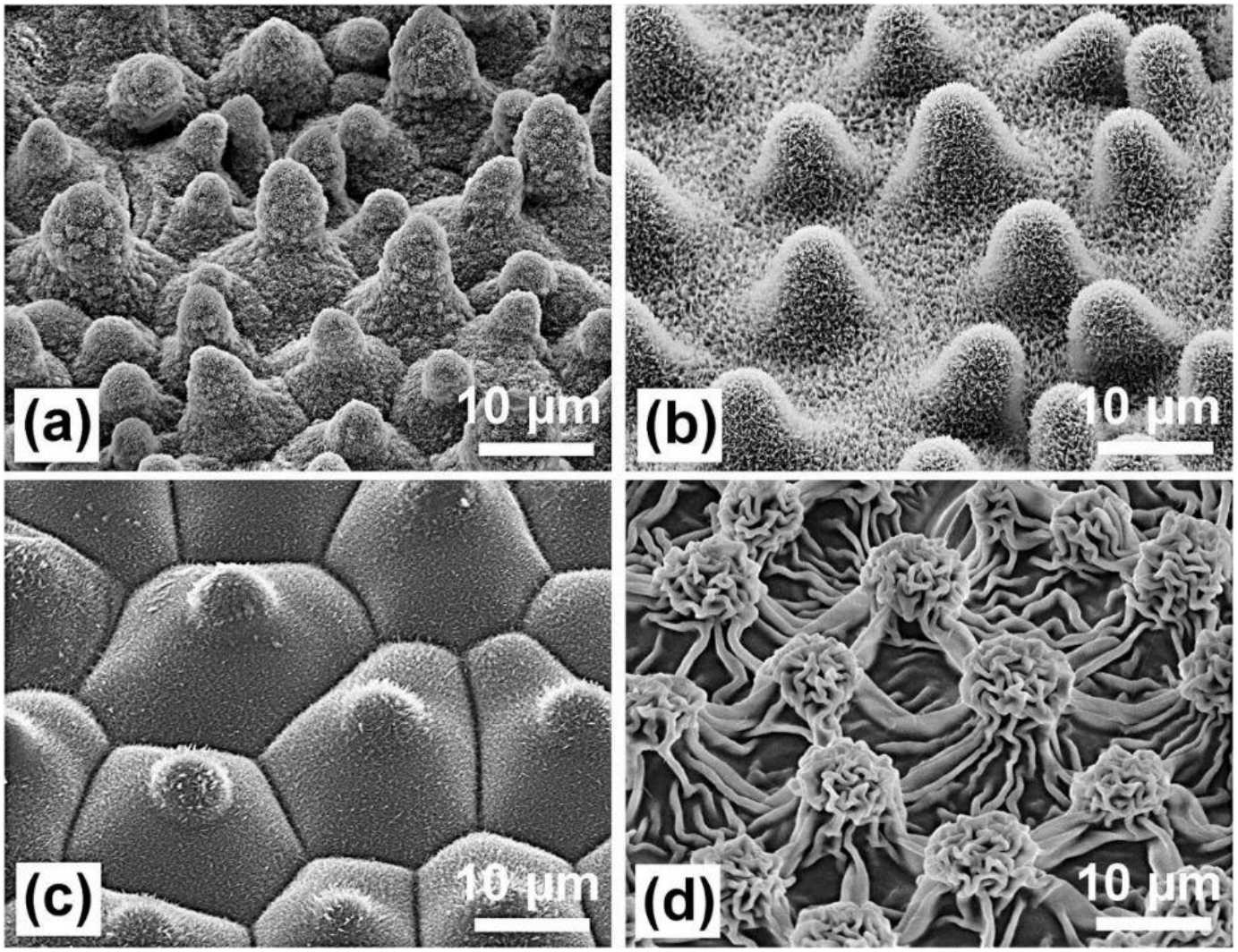
- Gloss, Appearance, Touch, Feel

Functional

- Friction, Lubrication and Wear
- Fatigue Life, Bonding Strength
- Assembly Performance
  - Clearance/ Interference
- Motion Behaviour
  - Slideways, Bearings

Lotus Leaf

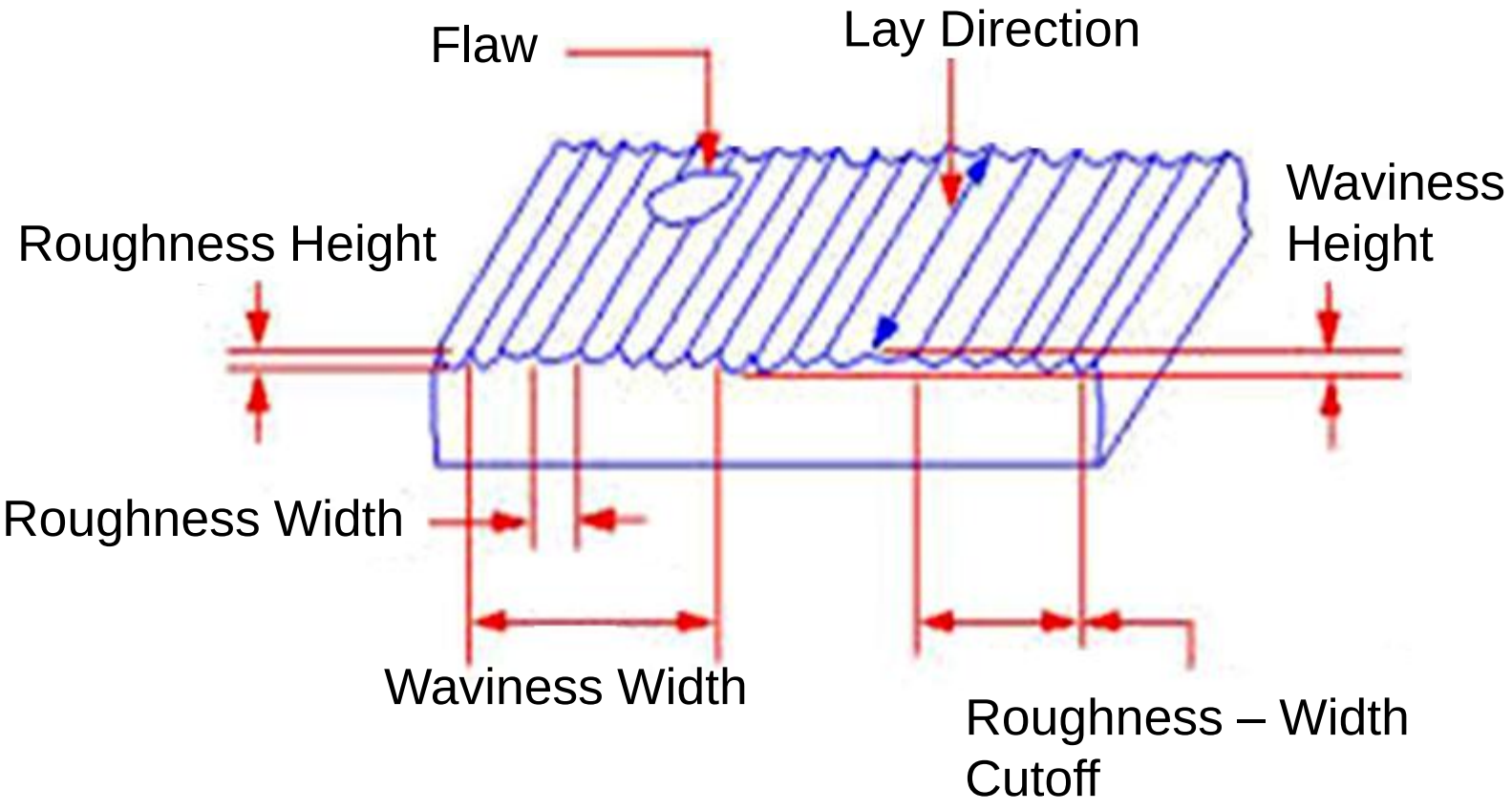
Surface Topography of Lotus Leaf



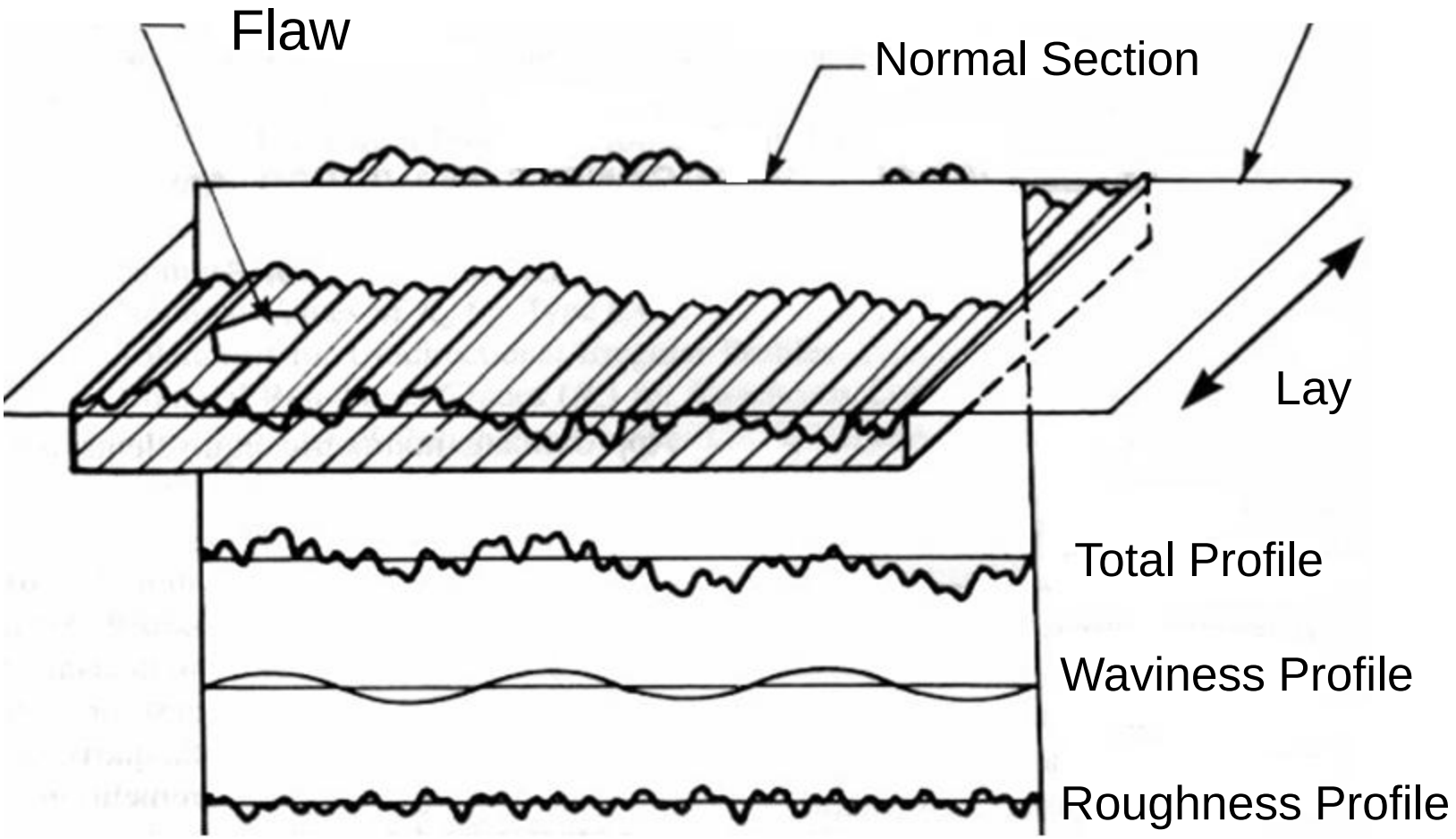
Surface Integrity

- Surface Topography
  - Surface Roughness Profile
- Surface Metallurgy
  - Sub surface material characteristics

Surface Roughness Nomenclature



Surface Topography

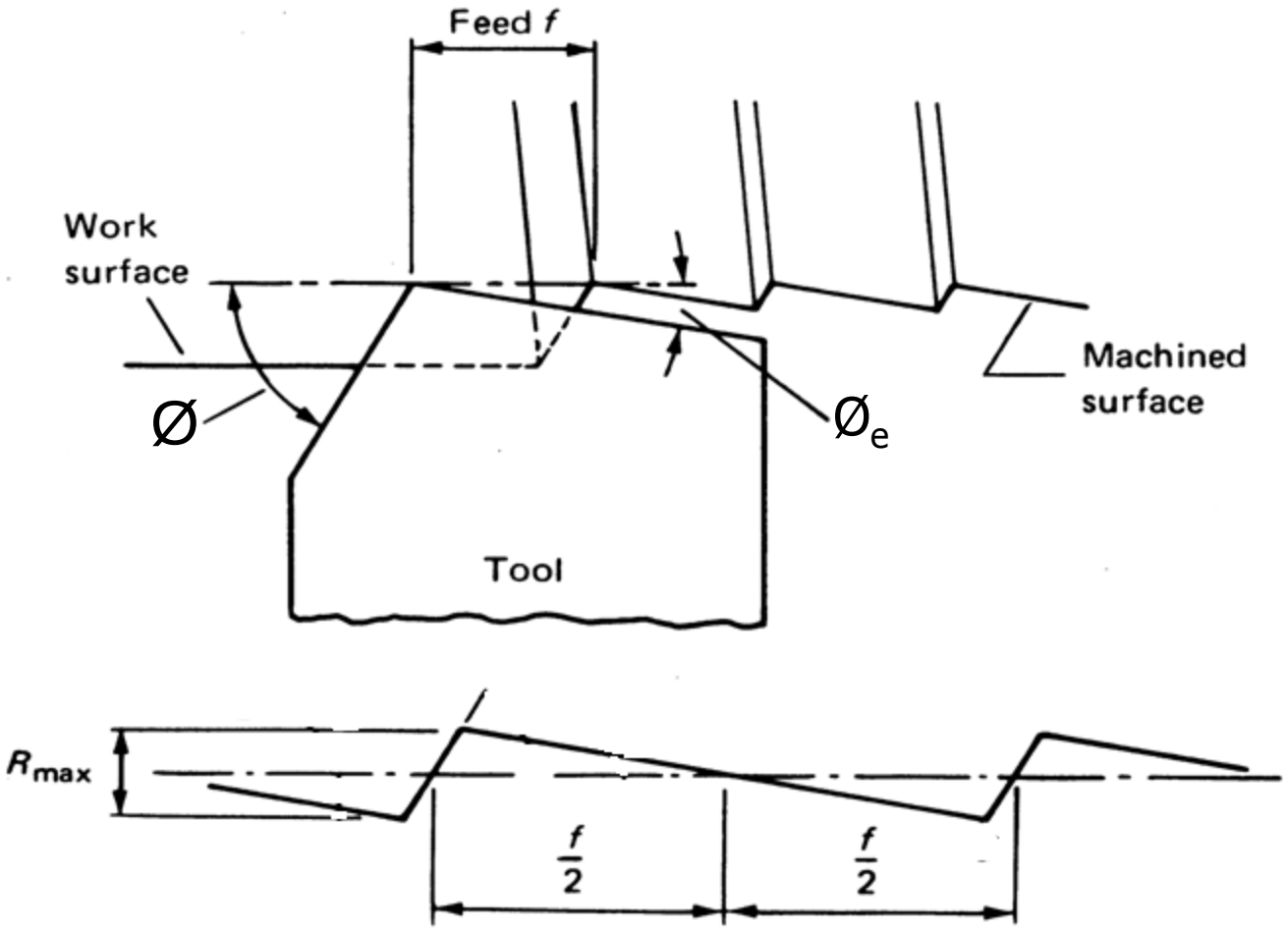


Surface Roughness Profile

Components and Causes

- Roughness – *Short wave profile*
  - Tool Feed marks, Cutting phenomena
- Waviness – *Long wave profile*
  - Axis errors, vibrations, run out
- Lay – *machining pattern*

Surface Roughness in Turning



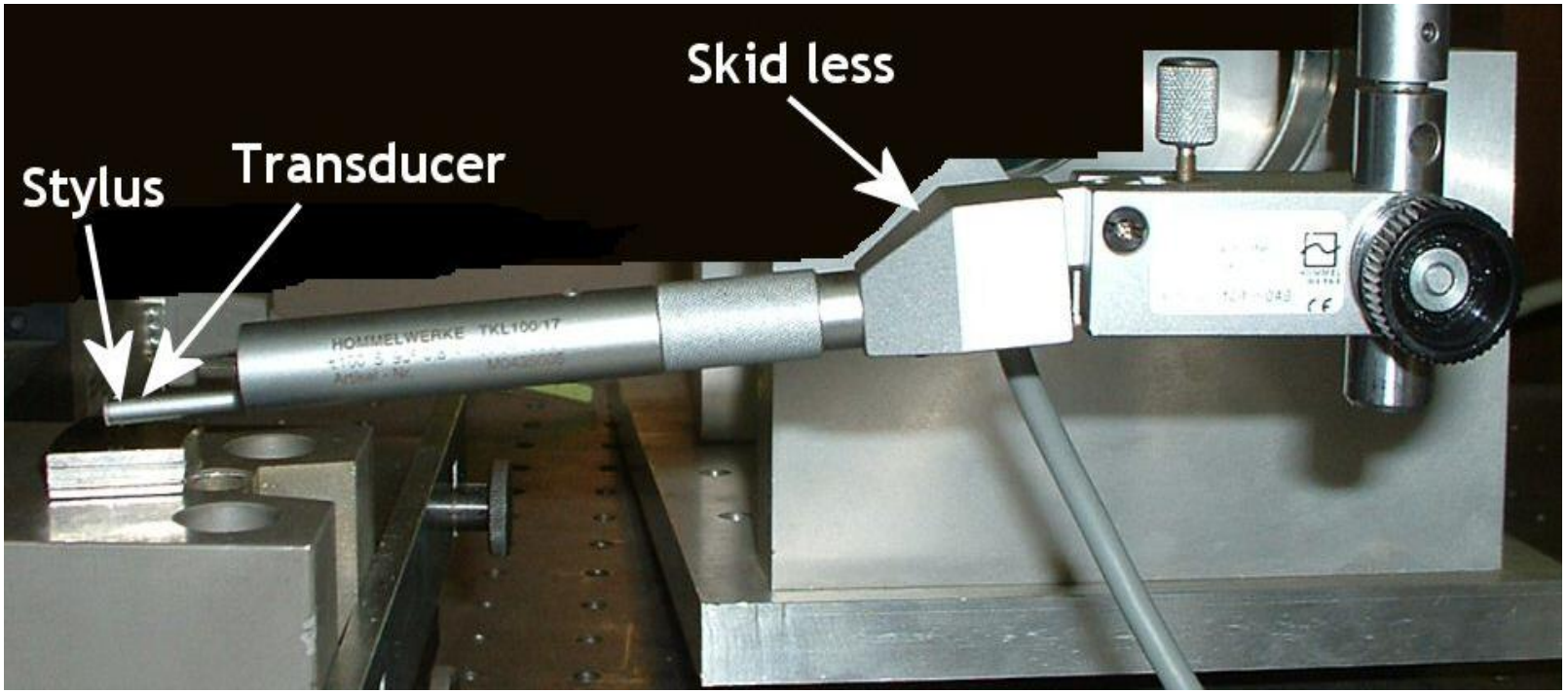
Assessment of Surface Roughness

Standards : ISO, BS, ANSI, DIN

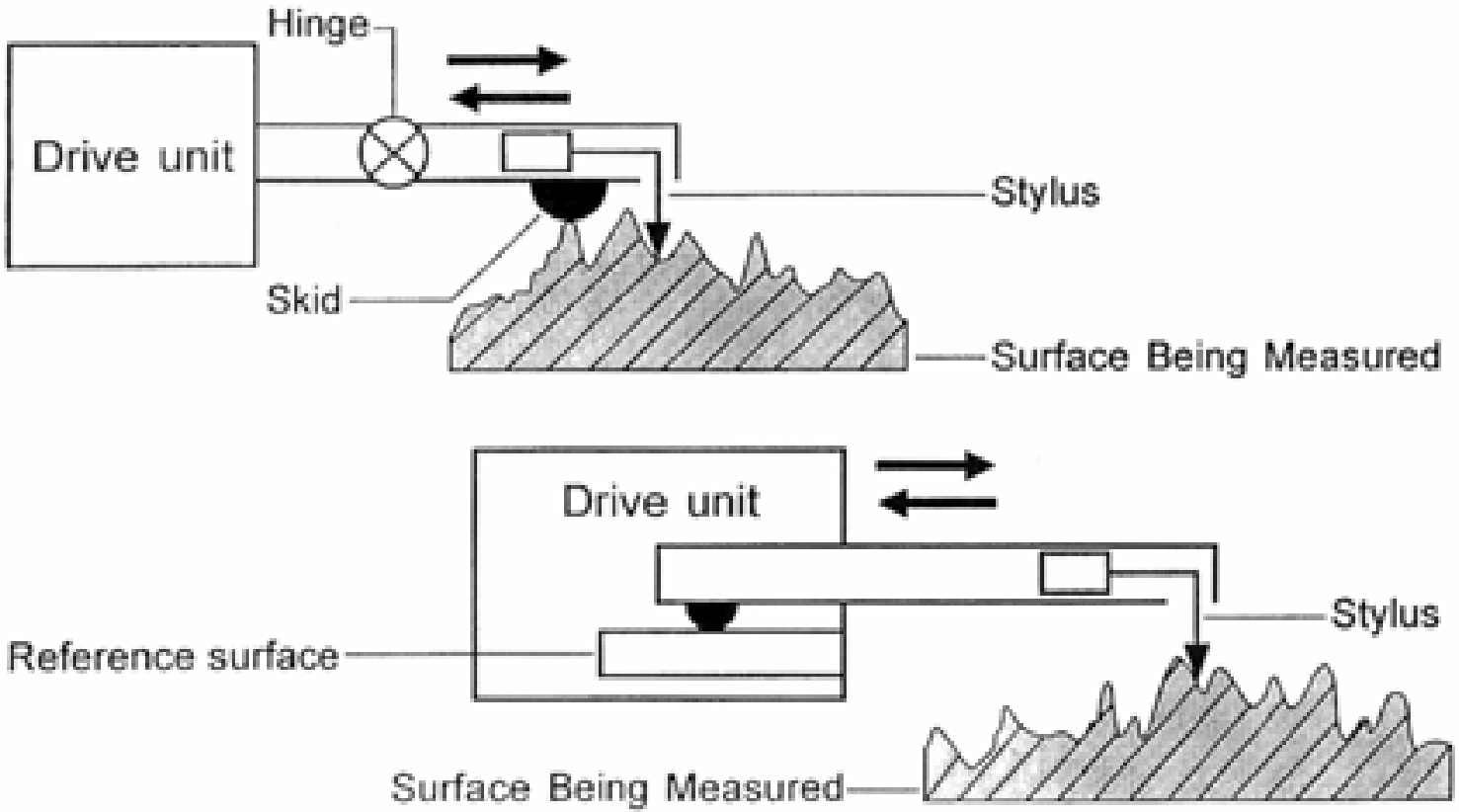
- 2D Parameters
  - Amplitude based
  - Wavelength based
  - Statistical measures
- 3D Parameters
  - Area based
  - Hybrid

Surface Roughness Measurement

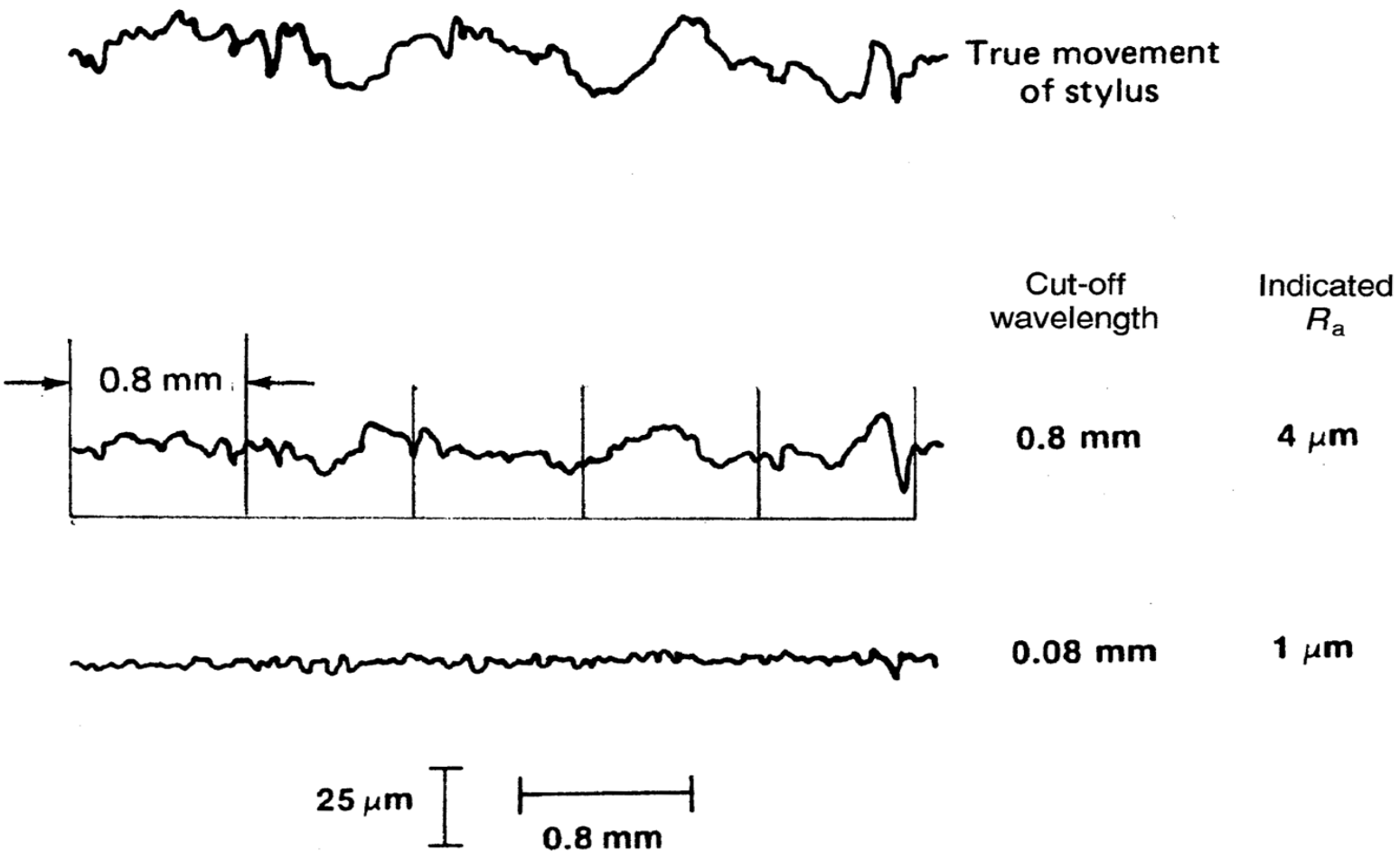
Stylus Instrument Probe



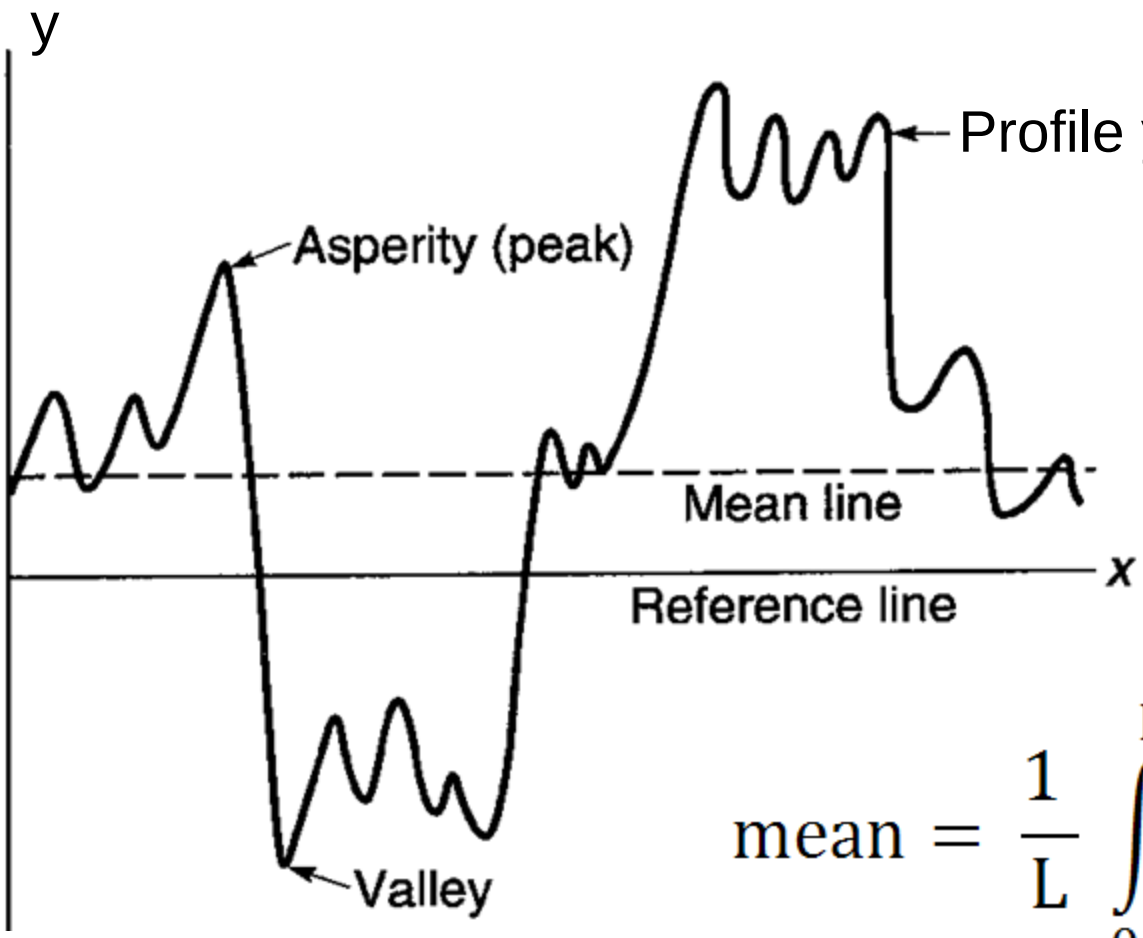
TalySurf - Stylus Instrument



Cut Off Length



Surface Roughness Profile



$$\text{mean} = \frac{1}{L}\int_0^L y(x)dx$$

Surface Roughness Parameters

Amplitude Based Parameters

R_a – Arithmetic Average (CLA)

R_q – Root Mean Square (RMS)

R_T – Peak to Valley

R_a – Arithmetic Average

y(x) = profile height from mean line

$$R_a = \frac{1}{L}\int_0^L |y(x)|dx$$

Digitized Profile

$$R_a = \frac{1}{N}\sum_{i=1}^{N} |y_i|$$

N = Number of points

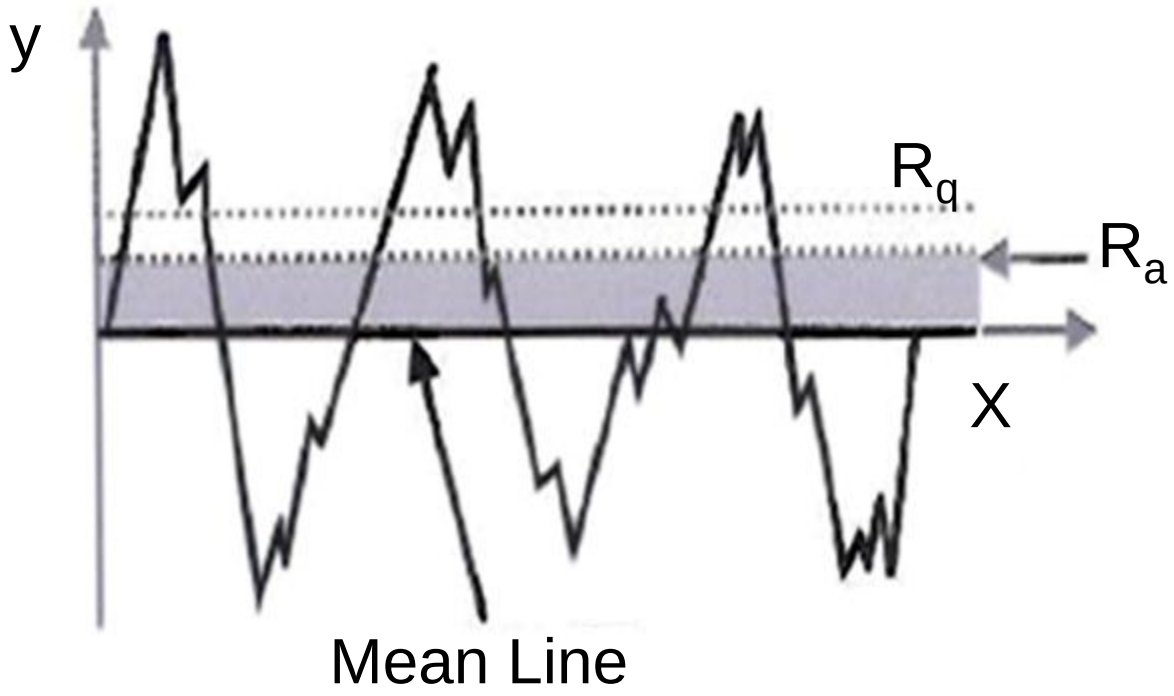
R_q – Root Mean Square (RMS)

$R_q = RMS = \sigma$

$$\sigma^2 = \frac{1}{L}\int_0^L (y(x))^2 dx$$

$$= \frac{1}{N}\sum_{i=1}^{N} |y_i{}^2|$$

Ra and Rq parameters



Sk - Skewness

$$Sk = \frac{1}{\sigma^3 L} \int_0^L (y(x))^3 \, dx$$

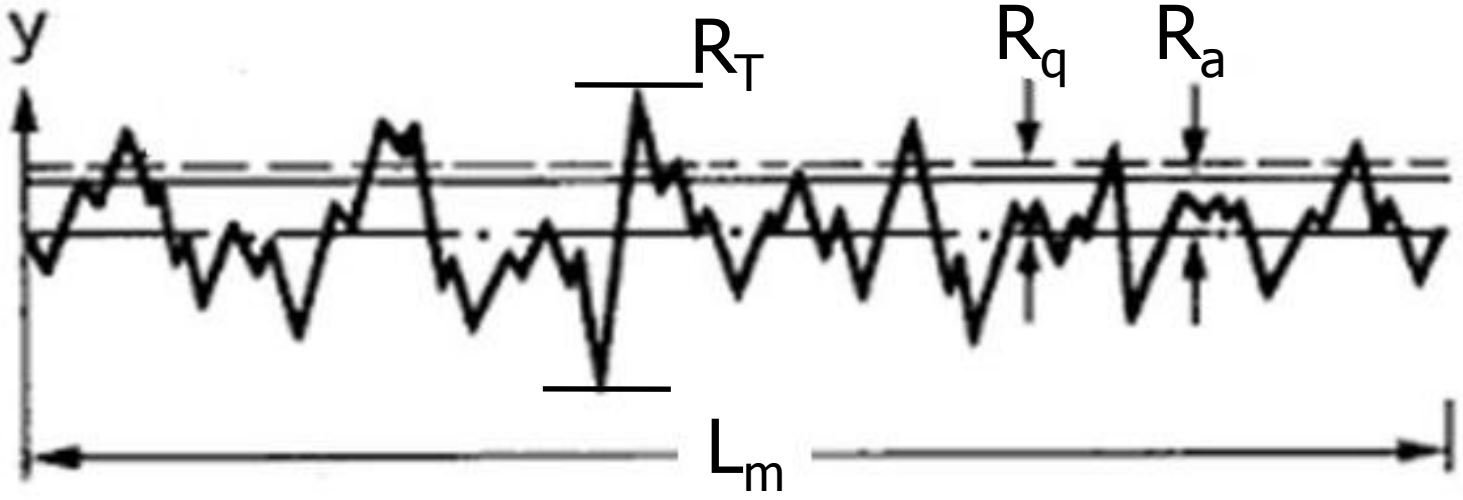
$$= \frac{1}{\sigma^3 N} \sum_{i=1}^{N} (y_i)^3$$

K - Kurtosis

$$k = \frac{1}{\sigma^4 L} \int_0^L (y(x))^4 dx$$

$$= \frac{1}{\sigma^4 N} \sum_{i=1}^{N} (y_i)^4$$

R_T – Peak to Valley measure

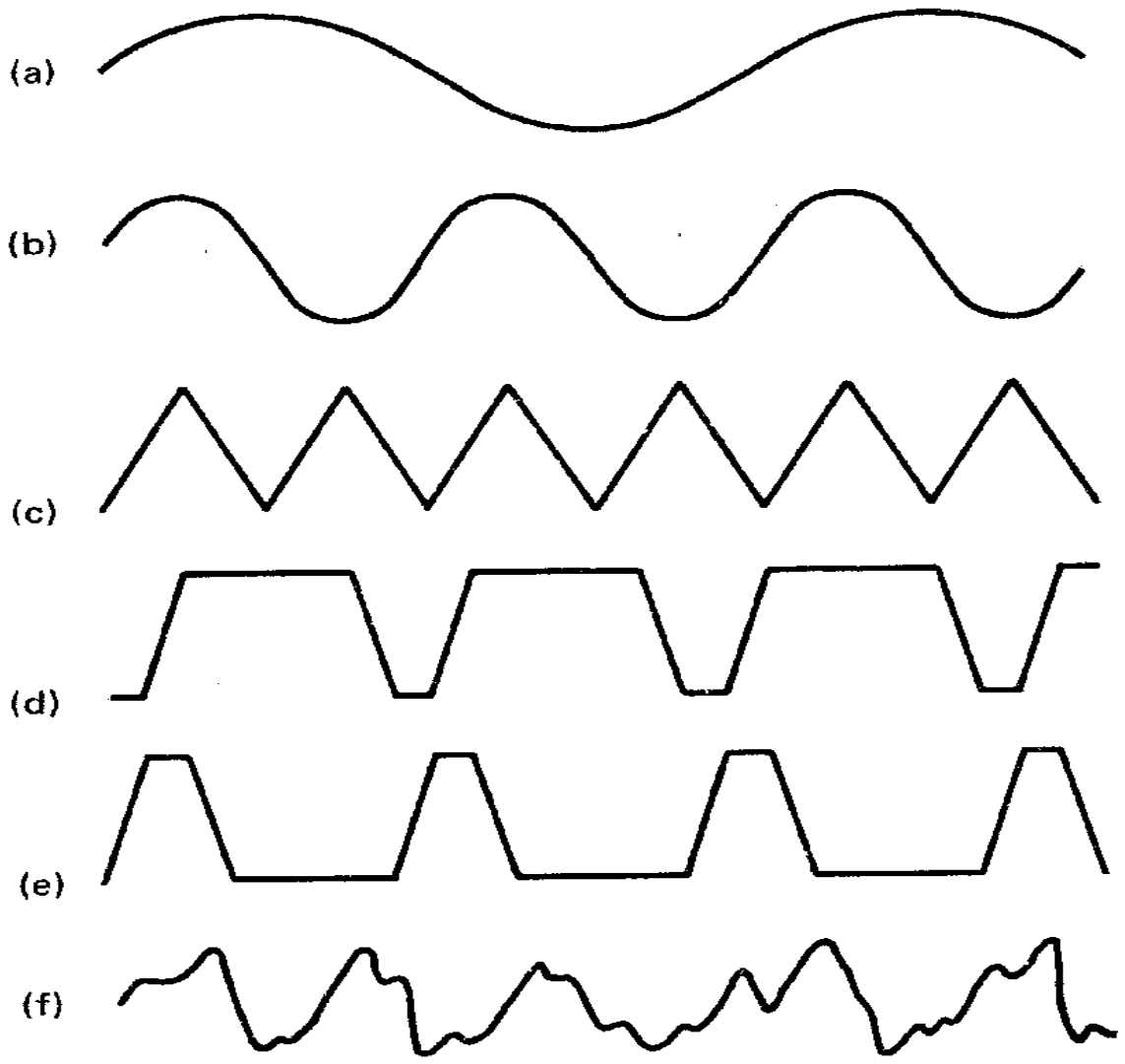


Amplitude Based Parameters

Limitations

- Focus on Profile amplitude only
- Profile wavelength is totally *ignored*
- Profiles can be completely *Different for the s*ame R_a value

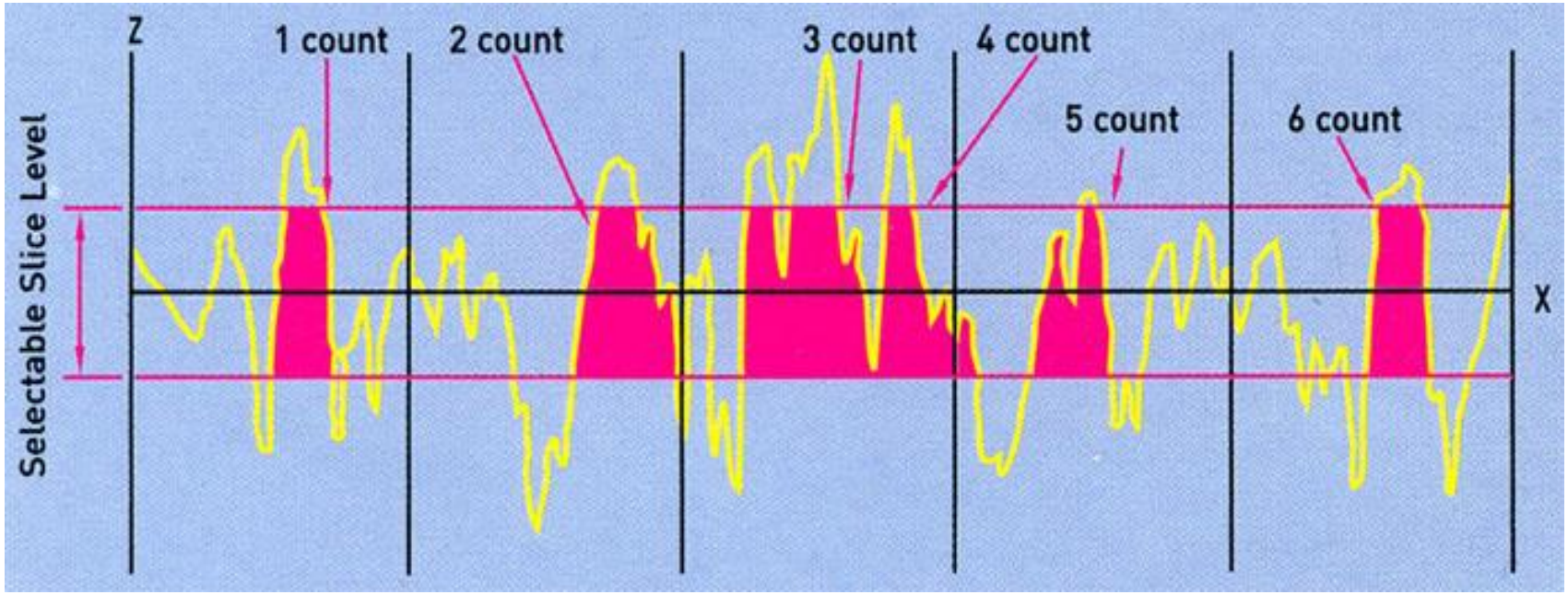
Different Profiles – Same Ra



Wavelength Based Parameters

- Average Peak Count
- Asperity Slope
- Auto Correlation function
- Power spectral Density/ Fourier Transforms

Average Peak Count



Amplitude Distribution function

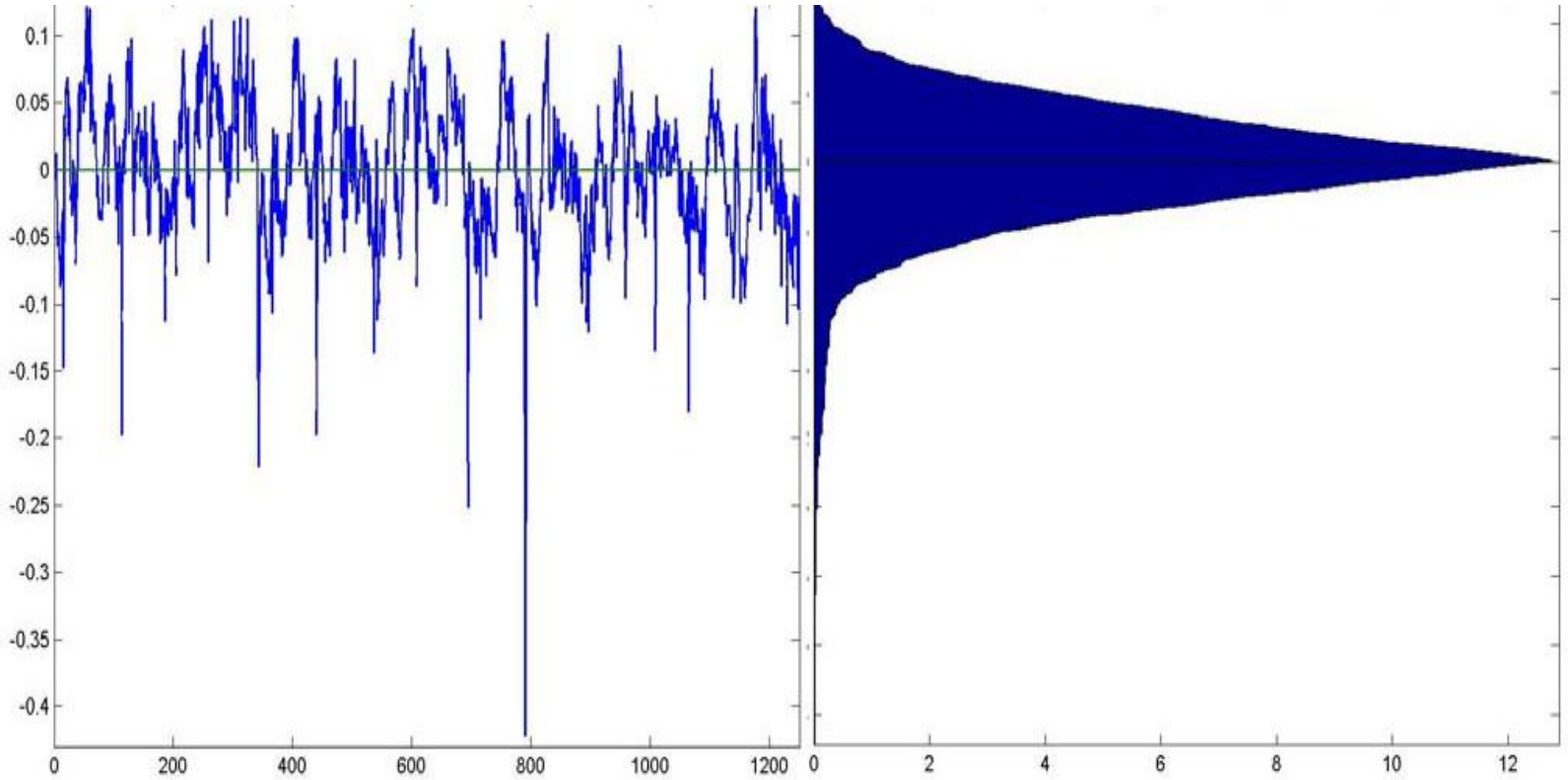
Amplitude Probability Distribution Function

$$p(y) = \frac{1}{\sqrt{2\pi}} e^{-y^2/2}$$

Normalized variable y

mean = 0 $\sigma = 1.0$

Profile Height Distribution



Moments of Distribution Function

Central moments are taken around the mean

$$R_a = \int_{-\infty}^{+\infty} |y| \, . \, p(y) dy$$

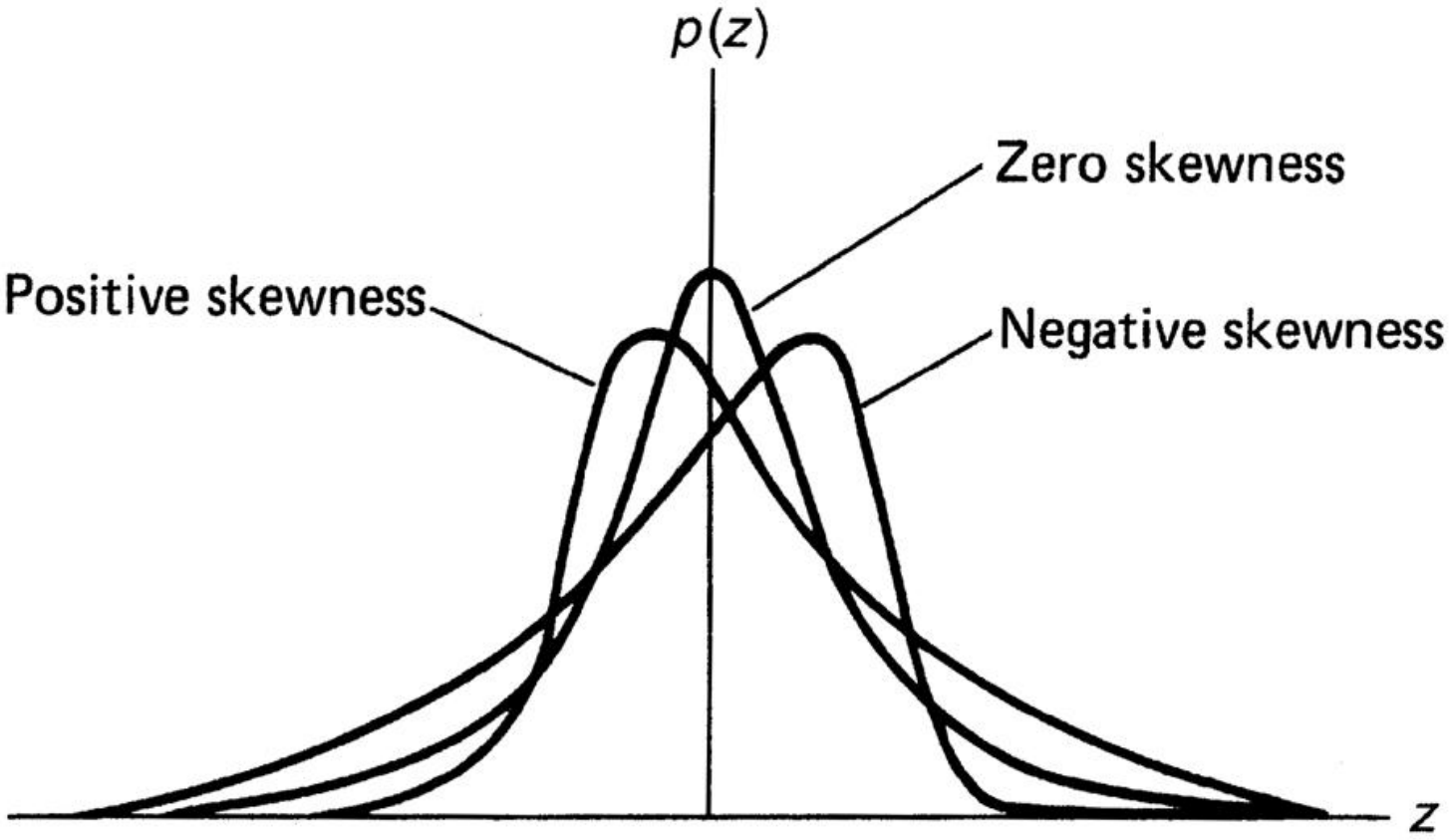
$$R_q{}^2 = \int_{-\infty}^{+\infty} y^2 \, p(y) dy$$

Moments of Distribution Function

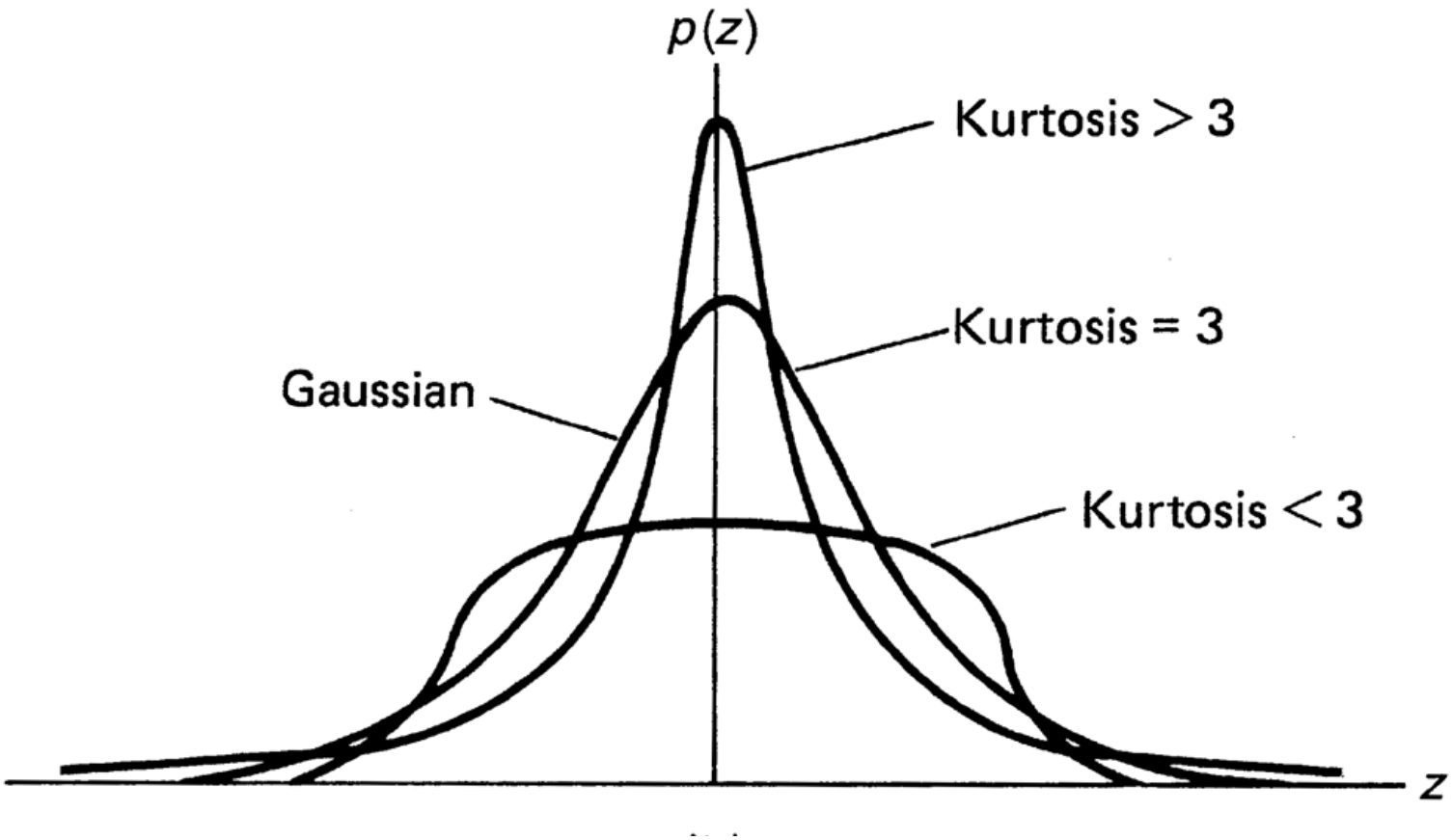
$$Sk = \frac{1}{\sigma^3} \int_{-\infty}^{+\infty} y^3 \, p(y) dy$$

$$k = \frac{1}{\sigma^4} \int_{-\infty}^{+\infty} y^4 \, p(y) dy$$

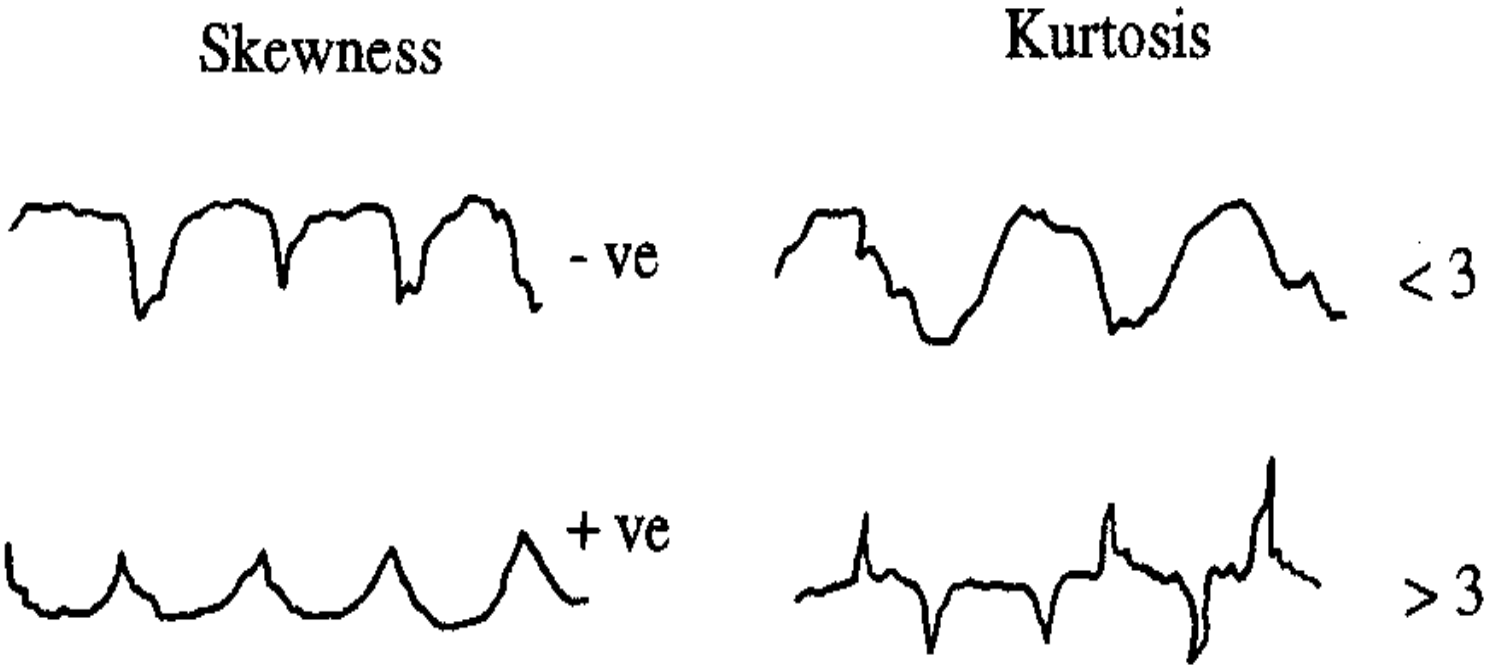
Skewness parameter



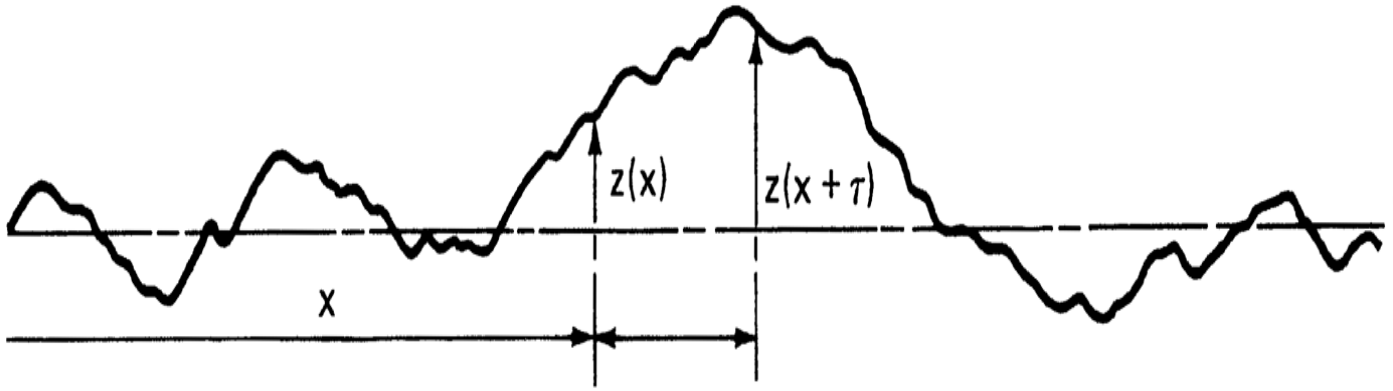
Kurtosis parameter



Classification of Surface Profiles



Autocorrelation Function Evaluation



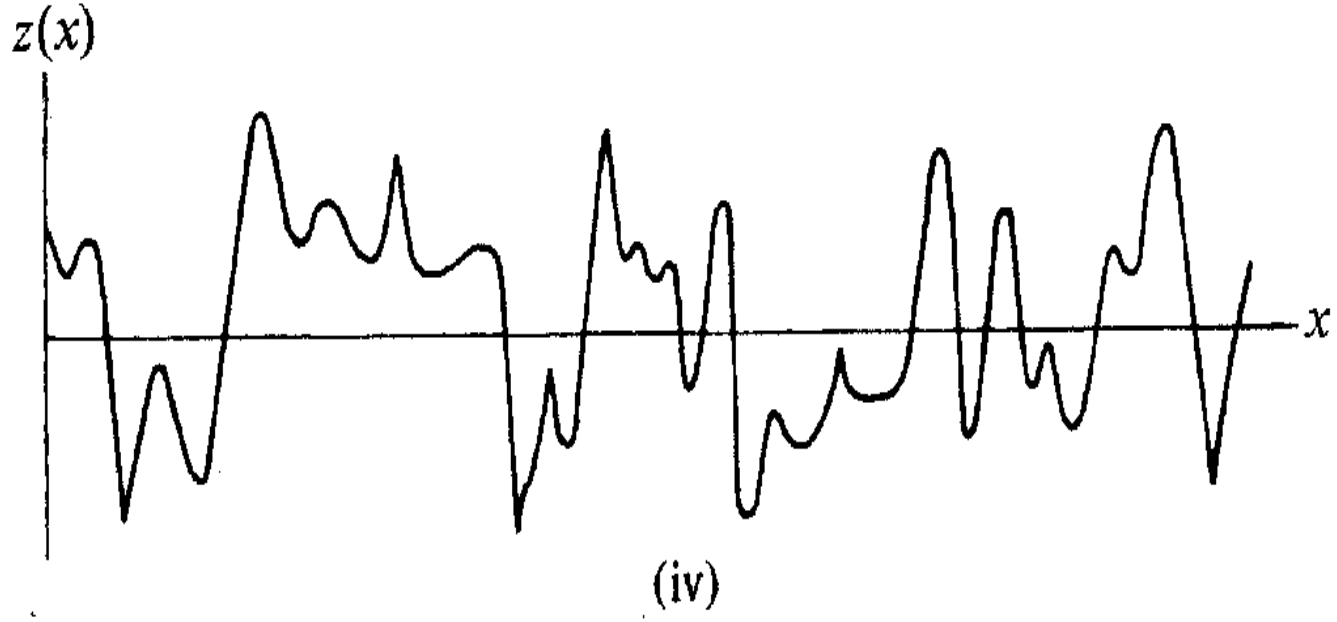
AutoCorrelation Function

Normalized form

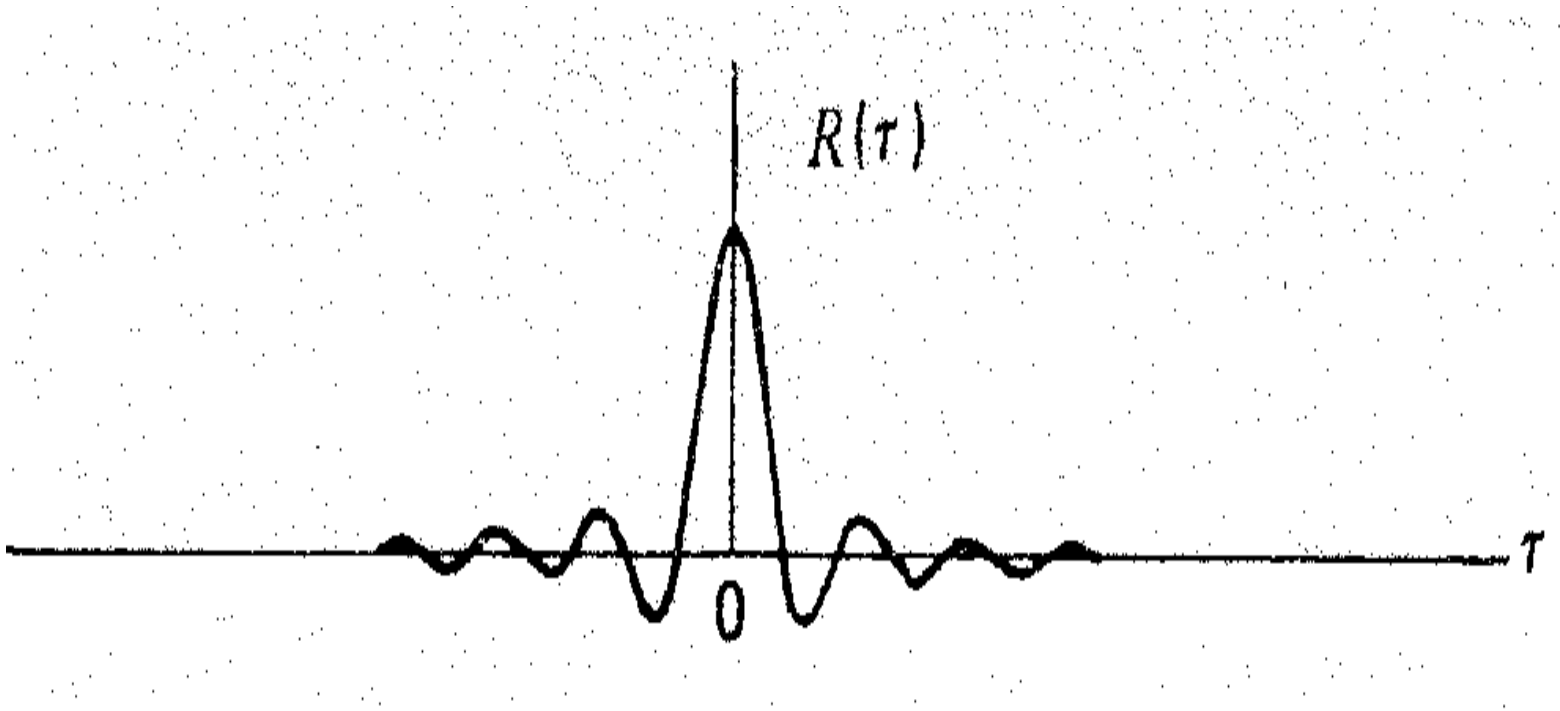
$$R(\tau) = \lim_{L\to\infty} \frac{1}{L.\sigma^2} \int_0^L y(x).y(x+\tau)dx$$

$$R(\tau) = R(-\tau)$$

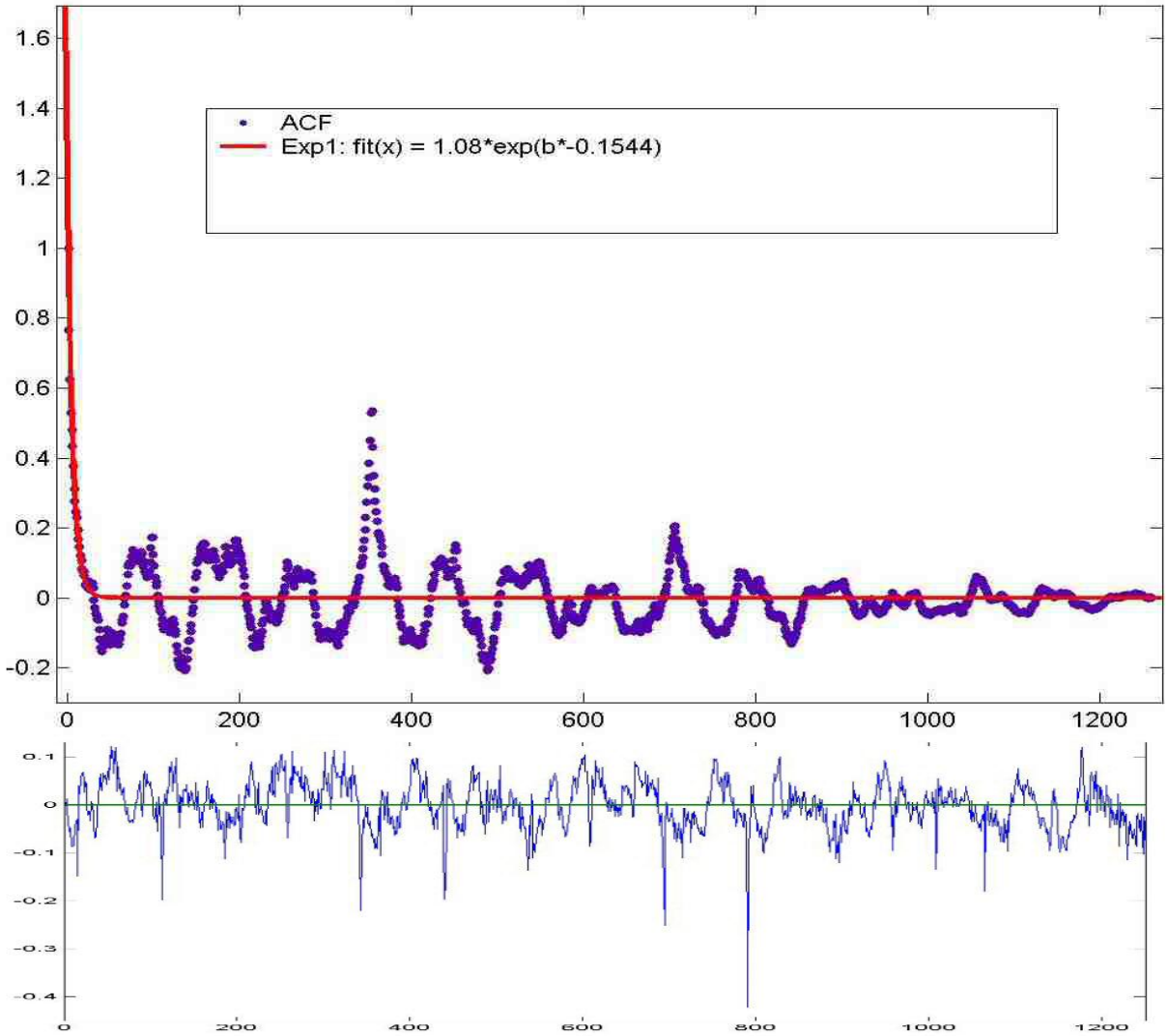
A typical surface profile



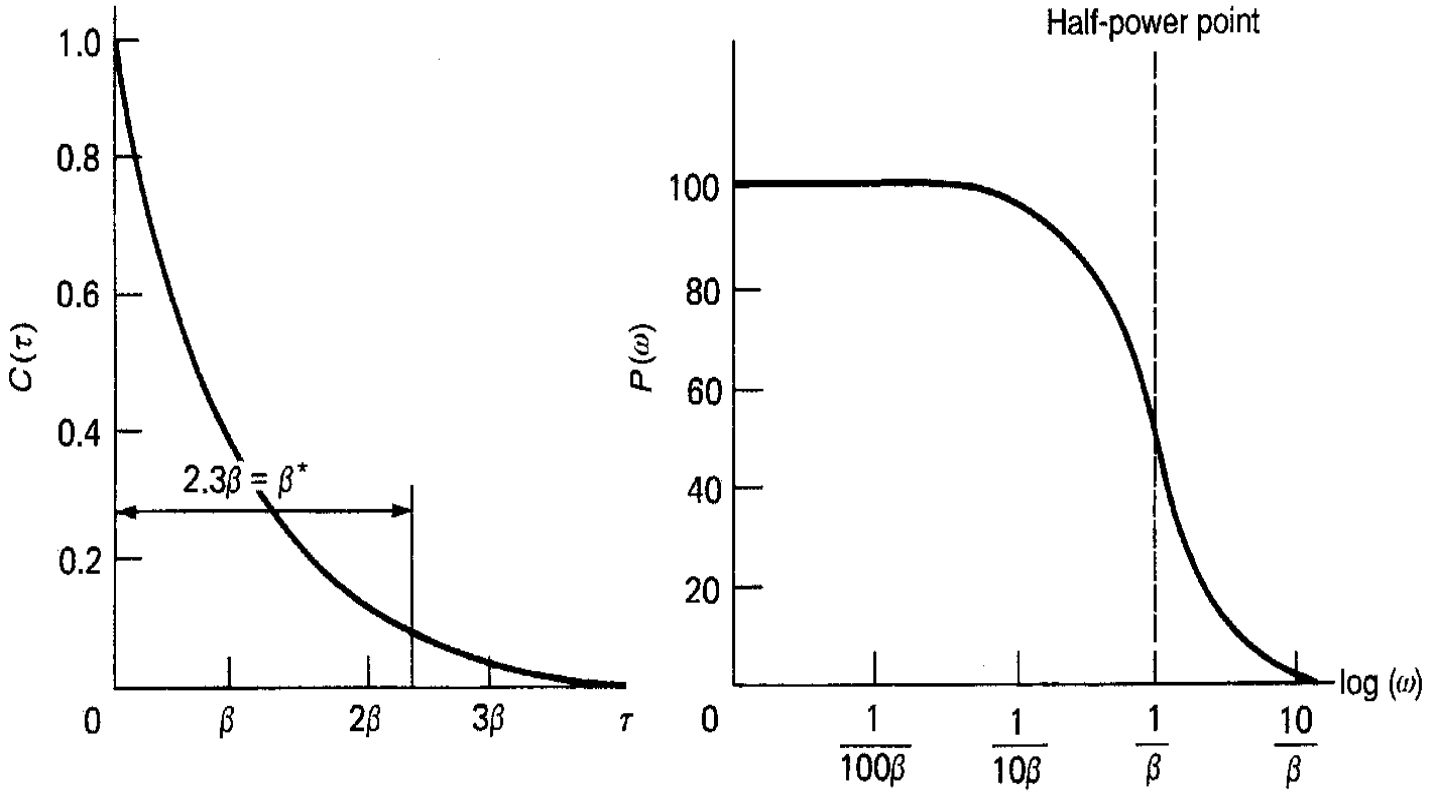
Autocorrelation Function



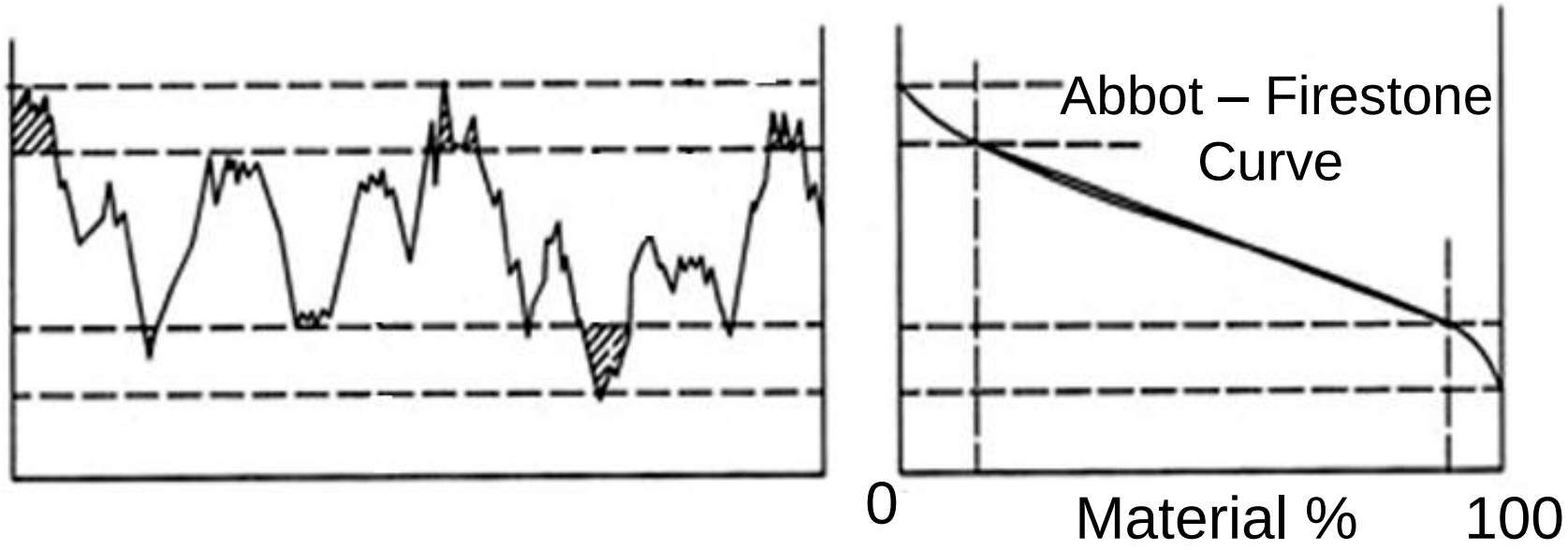
Real surface and Autocorrelation function



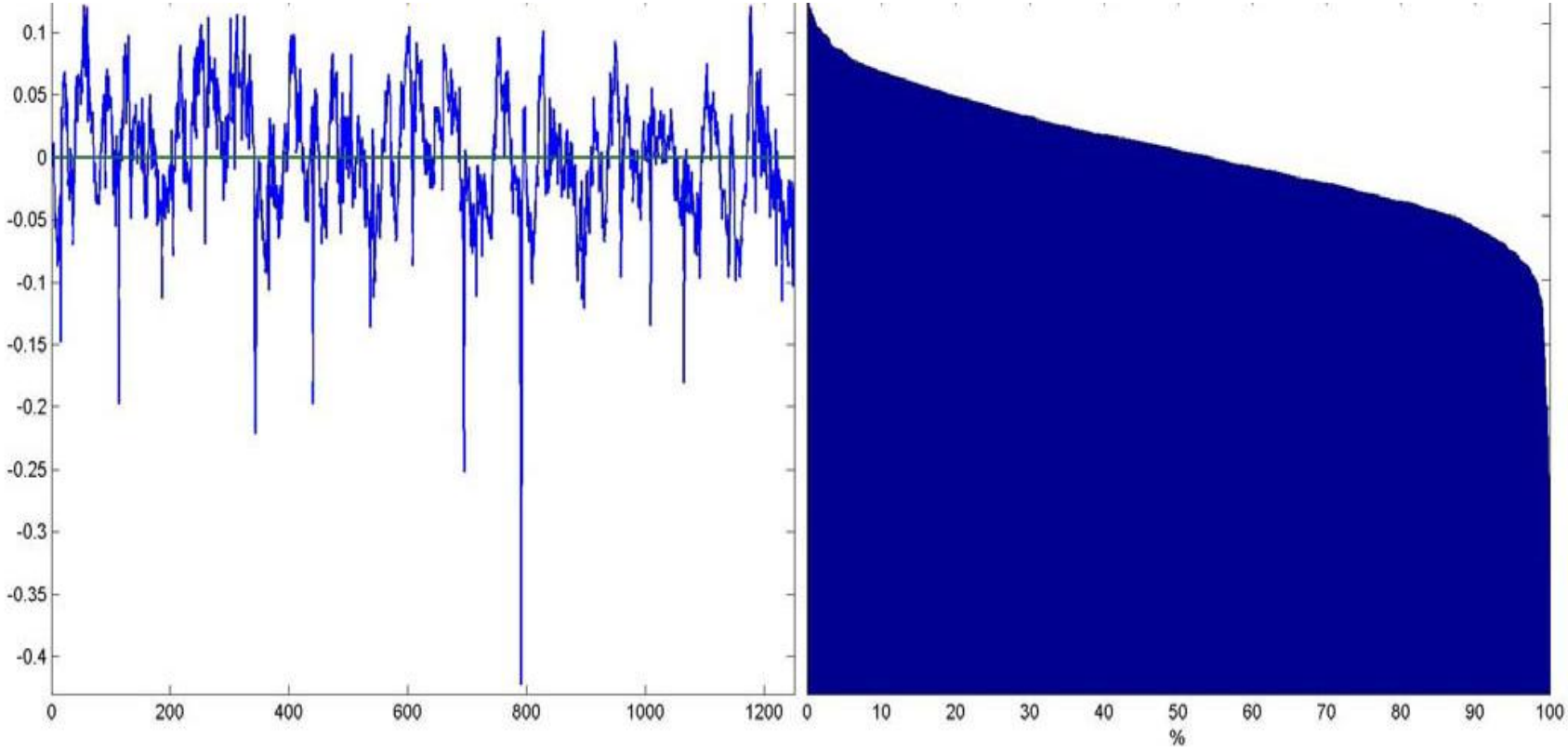
Autocorrelation function and Power Spectral Density Plot



Abbot's Bearing Area Curve



Surface Profile and Bearing Area curve

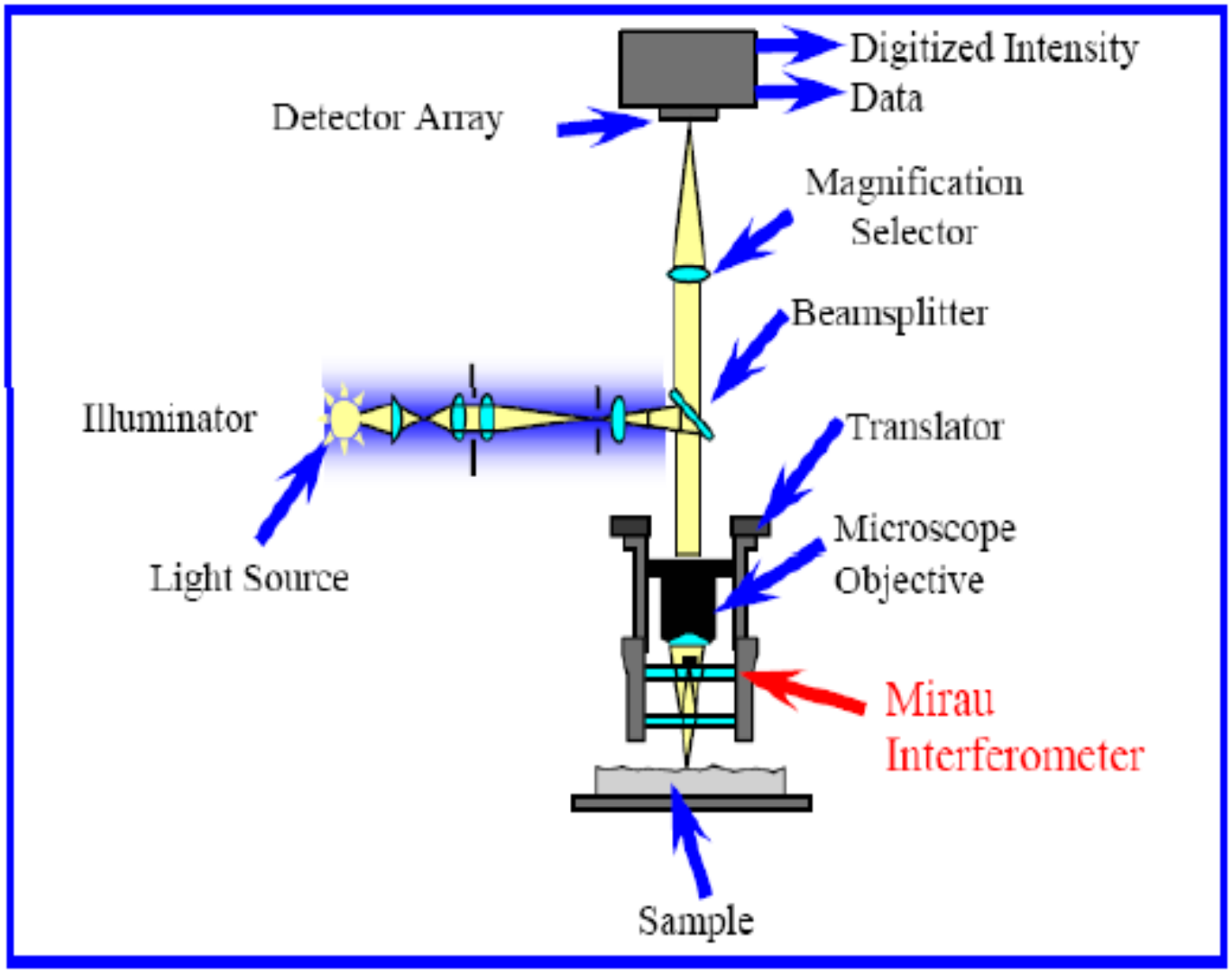


3D Surface Roughness Measurement

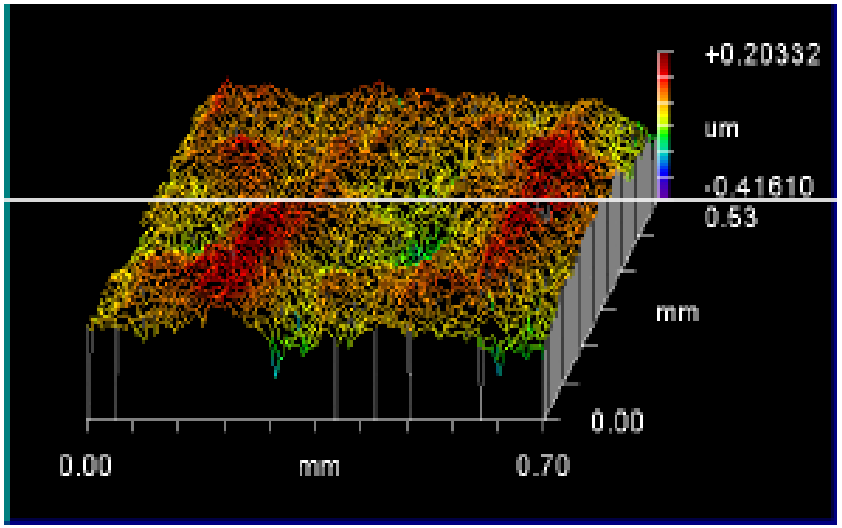
- Optical methods
- Capacitance based method
- Air flow measurement

White Light Interferometer

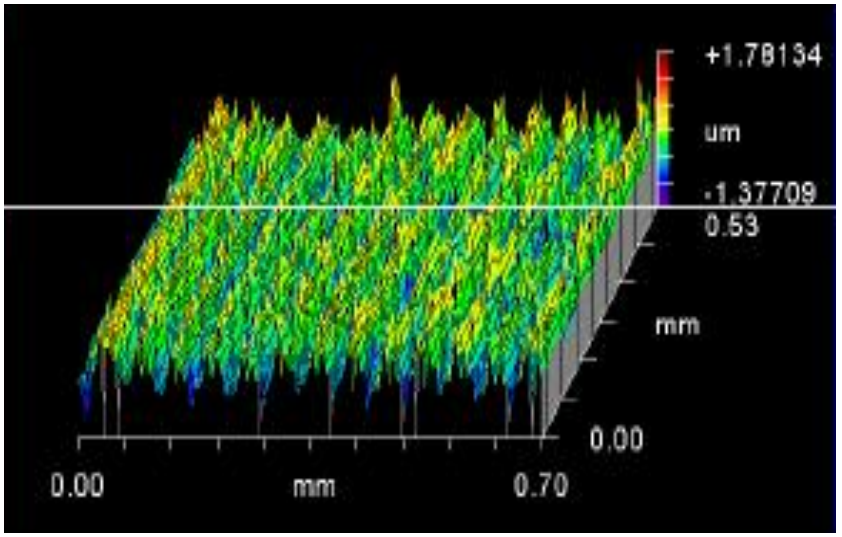
Principle of Interferometer



3 D surface plots



Isotropic - Random



Turned surface - Periodic