

A precision AFM probe-unit for measurement of high aspect micro-structured surfaces

Background

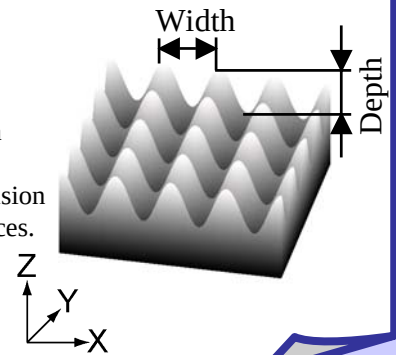
High aspect ratio micro-structured surfaces can be found in a wide variety of products.

Examples: Optical waveguide, Metrology artifacts etc.
Shape: Width (XY): several μm – several hundreds μm
Depth (Z): sub-micron – several tens μm

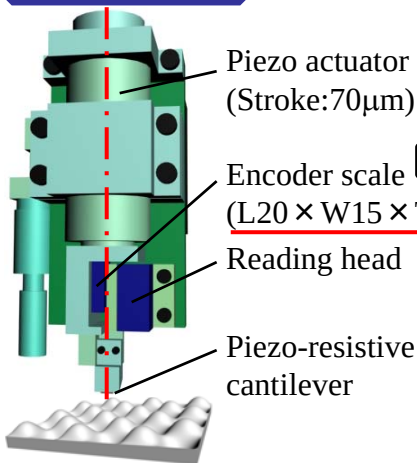
Nanometrology of such surface profiles is an important task for precision fabrication of the surfaces.

Interference microscopes and scanning electron microscopes are not proper.

A precision AFM probe-unit for measurement of high aspect micro-structured surfaces was developed.



Principle



Piezo actuator
(Stroke: 70 μm)

Realize a measurement range of several tens μm

Encoder scale
(L20 $\times$ W15 $\times$ T5mm)

Small

Measure displacement of piezo actuator and compensate non-linearity

Reading head

Piezo-resistive cantilever

Don't need optical system
Simple and compact structure

Align along the same axis

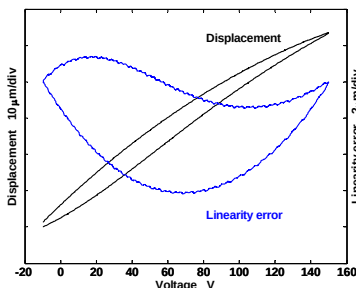


Zero Abbe error

Be able to measure displacement high precision

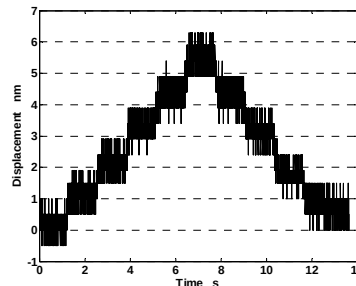
Results

Displacement of piezo actuator



Displacement:
53 $\mu\text{m}/160\text{V}$
Maximum linearity error:
Approximately 6 μm

Resolution of the AFM probe-unit



Linear encoder was able to detect the step of approximately 1nm.

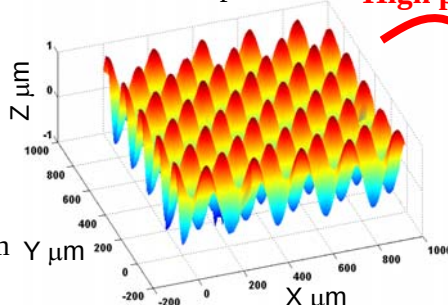
Resolution: 1nm

Realize large dynamic range of 94dB

Measurement of 3D micro-structured surface

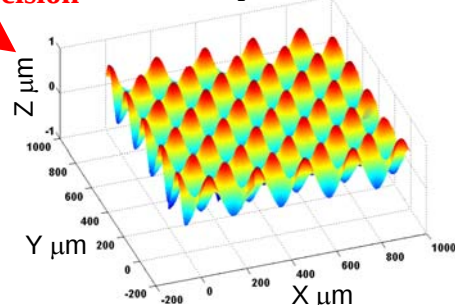
Sinusoidal surface
(design value)
Amplitude: $A=1\mu\text{m}$
Wavelength: $\lambda=150\mu\text{m}$

Without compensation



High precision

With compensation



Average amplitude: $1.625\mu\text{m} \pm 0.028\mu\text{m}(3\sigma)$

$0.987\mu\text{m} \pm 0.021\mu\text{m}(3\sigma)$