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:70μm)
Encoder scale
(L20 × W15 × T5mm)
Reading head
Piezo-resistive cantilever

Realize a measurement range of several tens μm
Align along the same axis
Zero Abbe error
Measure displacement of piezo actuator and compensate non-linearity
Don’t need optical system
Simple and compact structure

**Results**

Displacement of piezo actuator

- Displacement: 53μm/160V
- Maximum linearity error: Approximately 6μm

Measurement of 3D micro-structured surface

Sinusoidal surface (design value)
- Amplitude: A=1μm
- Wavelength: λ=150μm

Without compensation
- Average amplitude: 1.625μm ± 0.028μm (3σ)

With compensation
- Average amplitude: 0.987μm ± 0.021μm (3σ)

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