

3TU • Metrological Atomic Force Microscope Stage

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Introduction

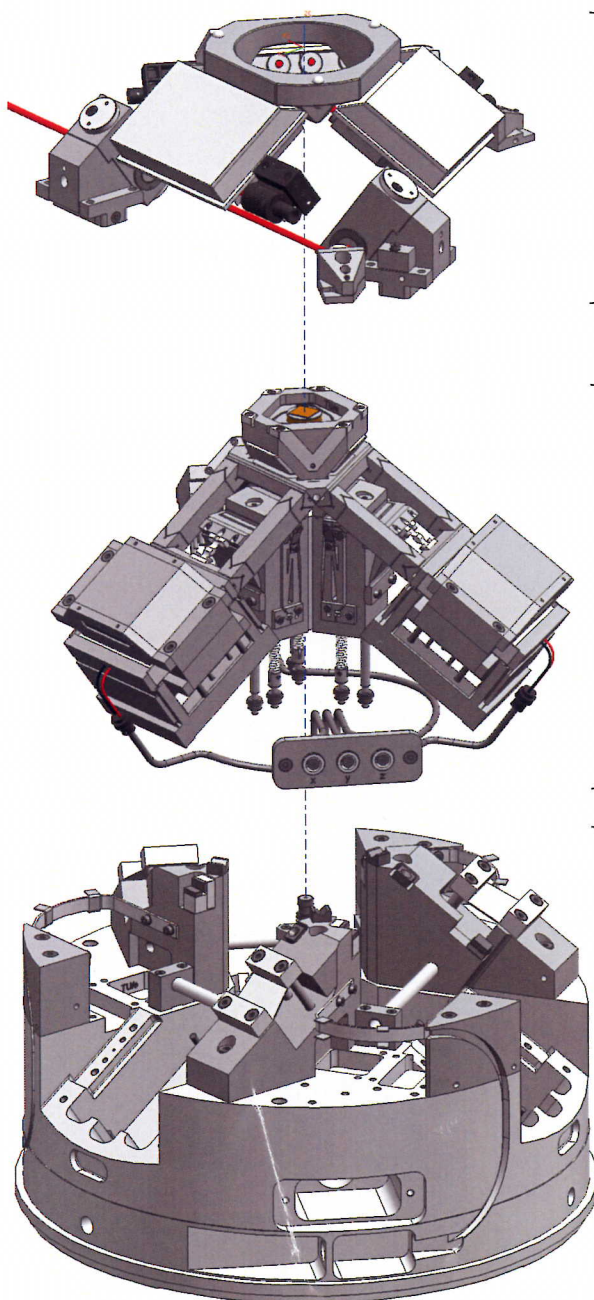
Instruments capable of dimensional measurements at the nanometer scale, such as atomic force microscopes (AFM's), are often calibrated using step height standards and 1D or 2D gratings. These calibration samples are, in turn, calibrated using traceable metrological AFM's.

In this project a metrological AFM is being developed for the Dutch Metrology Institute (VSL). Compared to most current metrological AFM's this new instrument has an increased scanning range, 1 x 1 x 1 mm, while maintaining sub-nm position resolution and nm-range uncertainty.

The instrument consists of a low-hysteresis elastic translation stage and a dedicated, kinematically mounted AFM measurement head. To minimize the Abbe error, the stage is used to translate the sample while the AFM head remains stationary.

The translation stage is constructed from three identical axes which are aligned symmetrically around the vertical. This parallel setup results in improved dynamical behavior over stacked designs, resulting in better environmental disturbance attenuation.

The thermal stability of the stage is maximized by aligning its thermal centre of expansion with the AFM measurement tip.



Displacement measurement system

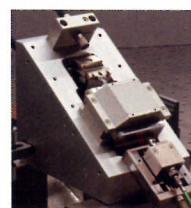
Three differential interferometers are used to measure the translations of the sample. The sample table contains the measurement mirror while the reference mirror is connected to the AFM, resulting in a favourably short measurement loop.

- Zerodur® mirrors
- heterodyne double pass, resolution 0.15 nm
- custom interferometers (58 x 48 x 10 mm)
- commercial optical signal processing
- integrated laser beam delivery optics

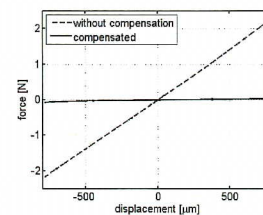
Straight guiding and actuation

The sample table is suspended by three identical and orthogonally oriented elastic guides. These guides, each consists of two struts on one leafspring parallelogram, allow the sample table to translate while three rotations are suppressed.

Lorentz-type motors actuate the stage. To minimize the heat generated by these actuators, weight and stiffness compensation mechanisms are included.



Prototype actuation



stiffness compensation

- First eigenfrequency stage 1.4 kHz
- Actuator force constant K_f 57 N / A
- Maximum dissipation < 1 mW

Instrument base

