P21 – Traceable Calibration of Micro- and Sub-Micro-Newton Forces

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The Working Group Nanoforce Metrology for Tactile Sensors of PTB is engaged in determining the probing forces of stylus instruments and the stiffness of AFM cantilevers. In recent years different types of micro force sensors based on piezoresistive and electrostatic principles have been developed. The motivation for the development of force sensors in the micro- and sub-micro-Newton force range was micro-components with very low hardness. These lead to scratches and considerable measurement uncertainties when measured with stylus instruments with probing forces in the mN range. By reducing the probing forces it was, therefore, possible for the first time to measure soft surfaces non-destructively.
PTB has developed transfer standards to calibrate the stiffness of AFM cantilevers and the probing forces of stylus instruments.
A piezoresistive cantilever-type standard for the calibration of stiffness and force has been developed (Fig. 1). The cantilevers are manufactured by the Institute for Semiconductor Technology of Braunschweig Technical University. Metrological investigations have been carried out at PTB since 2002. For a detailed description of the calibration setup and the calibration procedure, see Doering et al. at the IMEKO Conference 2002.

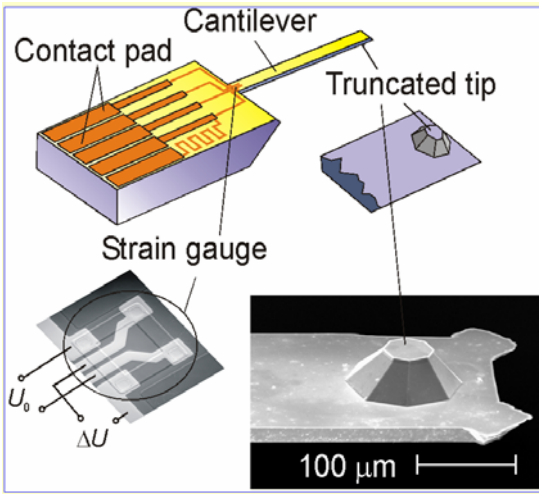


Fig. 1: Cantilever-type standard

Furthermore, an electrostatic comb-drive MEMS actuator with a multi-folded spring system has been developed for the measurement of AFM cantilever stiffness and probing force (Fig. 2). Details are published in TM 06/2009 by Gao et al. In the article the principle of measurement, the design, the manufacture, and the assembly of the MEMS as well as the first test results and the performance parameters achieved are described.

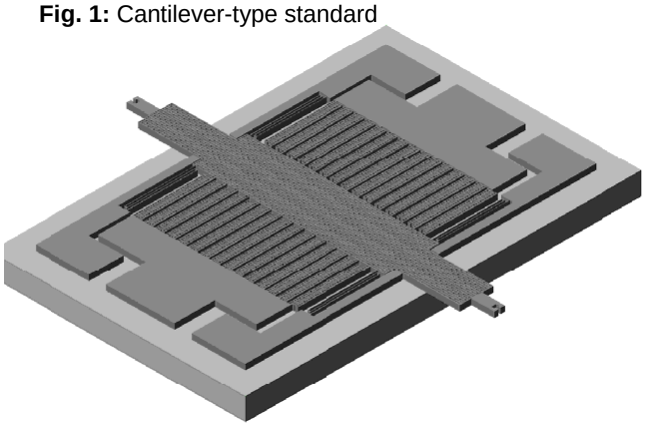
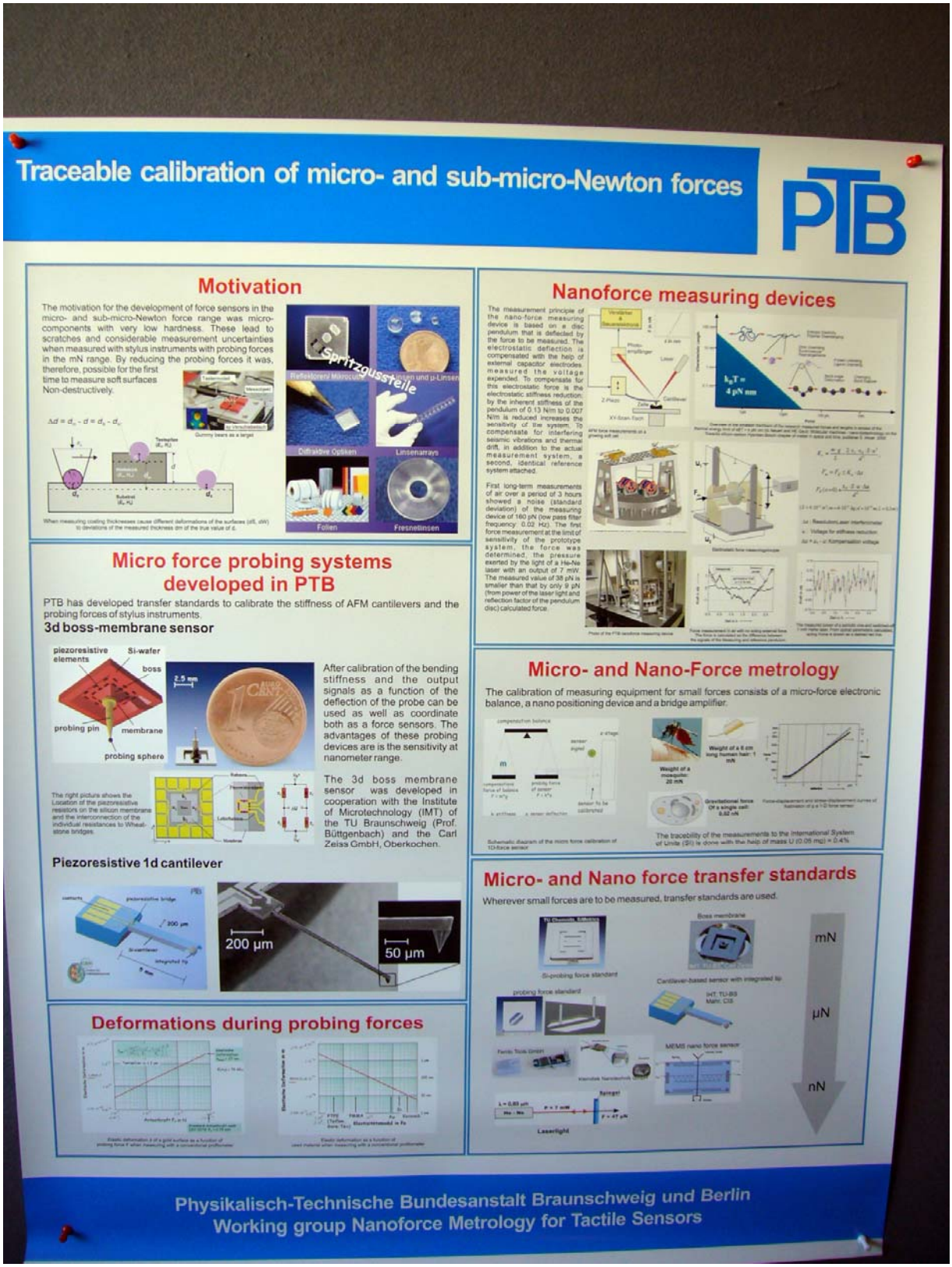


Fig. 2: Electrostatic comb-drive MEMS force

PTB is able to calibrate the sensors described in the nano- and -in future- also in the pico-Newton range. The sensors and the force and stiffness calibration set-ups are described in the poster.


Traceable calibration of micro- and sub-micro-Newton forces
PTB
Motivation
The motivation for the development of force sensors in the micro- and sub-micro-Newton force range was micro-components with very low hardness. These lead to scratches and considerable measurement uncertainties when measured with stylus instruments with probing forces in the mN range. By reducing the probing forces it was, therefore, possible for the first time to measure soft surfaces Non-destructively.
Spritzgussteile
Diffraktive Optiken
Linsenarrays
Folien
Fresnellinsen
Micro force probing systems developed in PTB
PTB has developed transfer standards to calibrate the stiffness of AFM cantilevers and the probing forces of stylus instruments.
3d boss-membrane sensor
piezoresistive elements
Si-wafer
boss
probing pin
membrane
probing sphere
2.5 mm
After calibration of the bending stiffness and the output signals as a function of the deflection of the probe can be used as well as coordinate both as a force sensors. The advantages of these probing devices are is the sensitivity at nanometer range.
The 3d boss membrane sensor was developed in cooperation with the Institute of Microtechnology (IMT) of the TU Braunschweig (Prof. Büttgenbach) and the Carl Zeiss GmbH, Oberkochen.
Piezoresistive 1d cantilever
200 µm
50 µm
Deformations during probing forces
Nanoforce measuring devices
Micro- and Nano-Force metrology
The calibration of measuring equipment for small forces consists of a micro-force electronic balance, a nano positioning device and a bridge amplifier.
Micro- and Nano force transfer standards
Wherever small forces are to be measured, transfer standards are used.
mN
µN
nN
Physikalisch-Technische Bundesanstalt Braunschweig und Berlin
Working group Nanoforce Metrology for Tactile Sensors