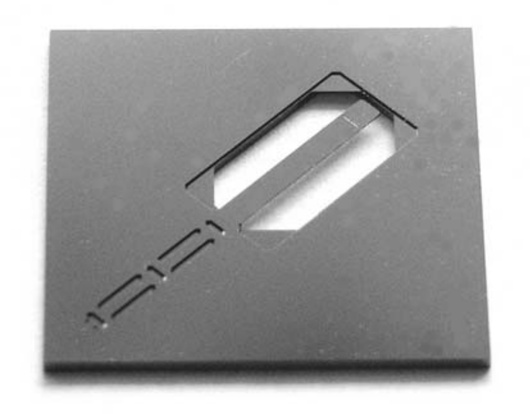
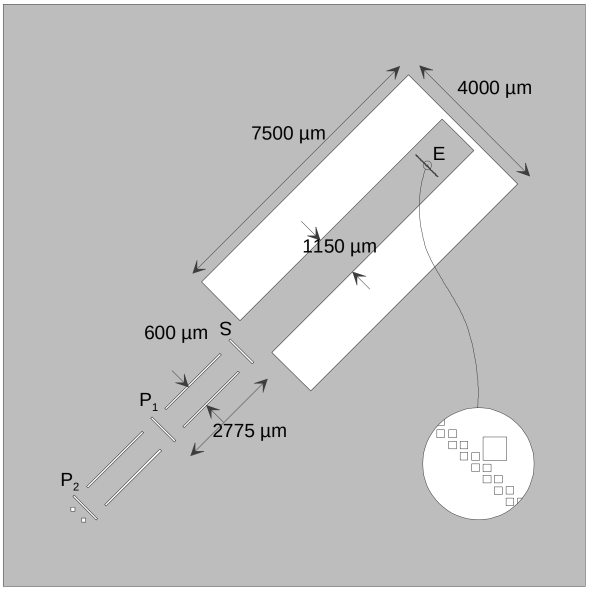


Force Standard
Type FS-C

1. Structure



Force standards of type FS-C are bending beams (“**c**antilever”) with a rectangular cross section fastened at one end inside a frame of a {100}-silicon chip.
The direction of the beam is parallel to the <100>-direction of the silicon. The cantilever is anisotropically wet etched from a monocrystalline silicon wafer with a thickness of 525 µm.
The chip size of the standard is 15 mm x 15 mm.

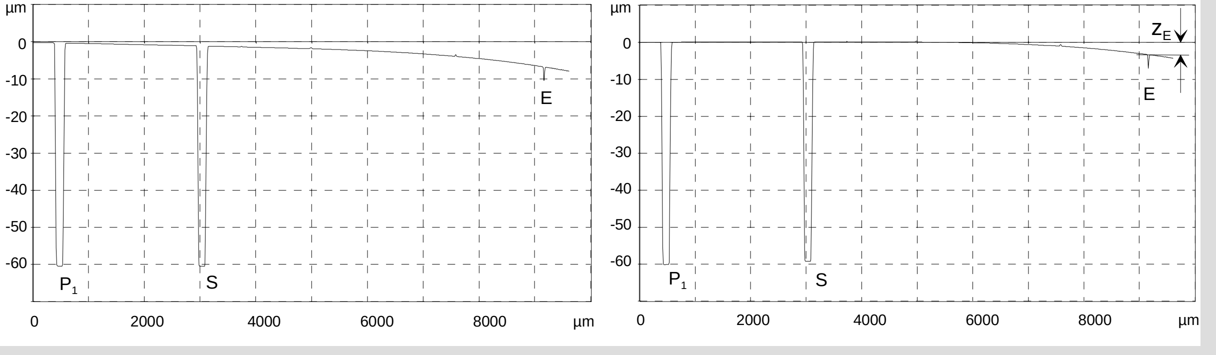
The marks S, P_1 and P_2 and the guiding marks between them are grooves situated in front of the cantilever. They support the adjustment of the scan. The dimensions of the rectangular cross section of the grooves depend on the thickness of the cantilever. The end mark E defines the position of loading during the calibration procedure. This mark consist of two arrays of quadratic deepenings (width $\geq$ 10 µm) which are diagonal to the direction of the cantilever. The deepenings build pyramidal etch pits with a depth far below the thickness of the cantilever. A larger quadratic pit marks the middle of the width of the cantilever (middle mark).
The weight of the cantilever and internal stresses produced by the surface machining cause a deflection z_o of the cantilever (“zero load bending”) relative to the chip frame. This deflection must be measured by an optical method.
The stiffness k_E (spring constant) by loading at the endmark E and the zero load bending z_o at this point are stable characteristics of the force standards which can be certified.

J. Frühauf, H. Trumpold: Silicon Standards for Assessment and Calibration of Stylus Probes, Annals of the CIRP Vol. 51/1/2002, p. 475
U. Brand et al.: Neue taktile Sensoren für die Mikro- und Nanomesstechnik. tm – Technisches Messen 76, 6, 2009, p. 323

2. Process of Calibration

The measurement of the probing force is based on a scan along the cantilever of the force standard analogous to the common use of tactile instruments.
Starting in front of the mark P_1 und crossing the start mark S the cantilever will be increasingly bent with increasing distance of the tip from S because of the probing force of the stylus tip. A scan results which consist of an even plateau between the marks P1 und S and a curved region with a drop corresponding to the end mark.
The probing force F can be calculated from the measured profile by multiplication of the difference between the level z_P of the plateau in front of the cantilever and the deflection z_E in front of the end mark E with the here effective stiffness k_E :
$F = k_E * (z_P - z_E)$
For the determination of the level z_P and the deflection z_E the profile must be rotated creating a horizontal region between the marks P_1 and S. As the value of deflection the profile depth Pt can be used when the section between the last edge of the start mark S and the first edge of the end mark E is evaluated: $F = k_E * P_t$
In the common case of the existence of a zero load bending z_o because of internal stress and the weight of the cantilever the measured profile depth must be corrected by z_o (zero load bending upward: $z_o < 0$): $F = k_E * (P_t - z_o)$.
Performing the measurement of the probing force following must be observed:
• The way of the scan must be adjusted quite exactly to the direction of the cantilever. The guiding marks in the plateau region support this operation. In the case that the stylus tip leaves the cantilever during the scan the measurement must be aborted. The end mark should be traced across its middle region.
• The scan must be finished before the end of the cantilever is arrived. The distance of the end mark to the end of the cantilever amounts about 500 µm.
• The use of a too weak cantilever (too small stiffness) can cause vibrations at the end of the cantilever. This makes it difficult to determine the exact static deflection z_E. A more stiff cantilever must be used. Because of the activation by friction forces the vibrations occur more likely in the case of smaller radii of the stylus tip.
• The reduction of the probing force to the order of magnitude of the friction forces acting in the mechanical probing system leads to an instable state. Then the measurement of the probing force is impossible.

The standard is available either with a PTB calibration certificate (PTB: Physikalisch-Technische Bundesanstalt, the national metrology institute of Germany) or a calibration certificate (traceable to the PTB) by SiMETRICS. It contains the stiffness together with the zero load bending (and dimensions of the beam).



3. Packaging, Handling and Cleaning

For a better handling the silicon standards are mounted on borosilicate glass with a size of 5 cm x 5 cm as substrate. Further sizes and different support materials are possible on request. The chips are mounted by an epoxy resin adhesive.
The standards are stored in a membrane box. The cantilever does not come into contact with the membrane.
In all cases the suitability of clean room use is guaranteed.
Do not touch the silicon chip especially the regions destinated for measuring and calibration. Use suitable (plastic) tweezers for handling.
For cleaning the force standards the following procedures are recommended:

- Removing of particles of dust: blowing off by softly flowing pure nitrogen or air
- Removing of tightly sticking particles: rinsing with deionised water, blowing dryly by softly flowing nitrogen or air
- Removing of organic deposits: rinsing with ethanol (analytic-grade), rinsing with deionised water, blowing dryly by softly flowing pure nitrogen or air.

If none of these methods is successful please contact SiMETRICS for a cleaning process.

4. Assortment and Specification

Type	Nominal stiffness (mN/µm)	Nominal thickness of spring (µm)	Maximum bending (µm)	Maximum force (mN)
FS-C 15	0.015	50	100	1.5
FS-C 50	0.05	70	100	5
FS-C 130	0.13	100	100	12
FS-C 1000	1.0	200	100	100