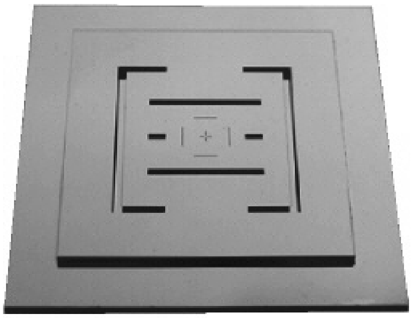
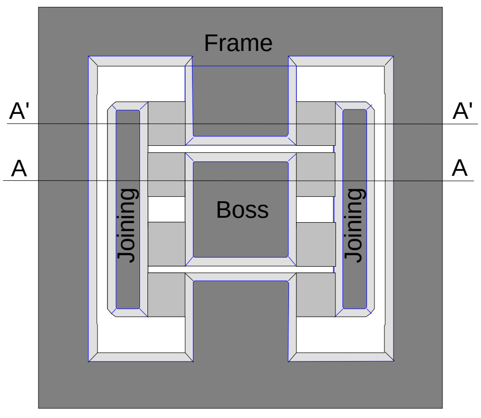
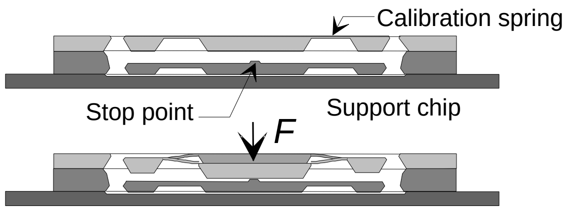


Force Standard Type FS-FD

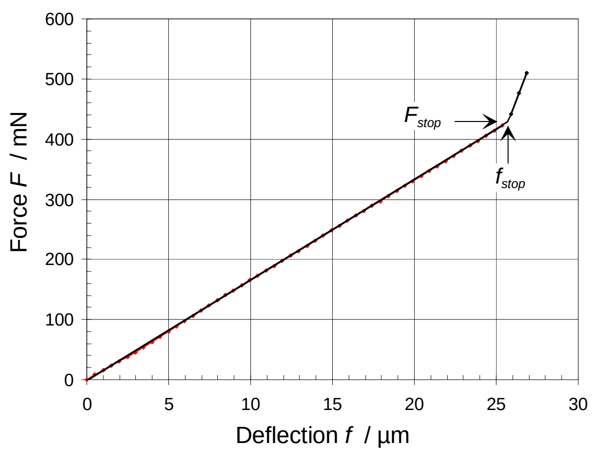
1. Structure and Operating Principle

The force standard of type FS-FD uses a stack of two systems of parallel bending springs. The load-deflection behaviour of the parallel springs is exactly linear.





Scheme of force standard FS-FD.
Left: backside of the chip with the test spring.
Right: cross sections A-A and A'-A' of the system without and with loading respectively



The stiffness k of the upper parallel spring is conformed to the forces and deflections used in microhardness testing. After a certain deflection f_{stop} the central plate contacts a central point of the lower spring system producing an abrupt higher stiffness.
The resulting kink in the load-deflection characteristic defines f_{stop} and together with the stiffness k the load F_{stop}. The **stiffness k** (spring constant) by centric loading and the **stop deflection f_{stop}** are stable characteristics of the force standard which can be certified.

The chips are anisotropically wet etched out of monocrystalline silicon wafers. The crystallographic direction of the springs is <110>. The stack of the two spring systems is silicon fusion bonded and thereafter mounted onto the support chip by glueing.

J. Frühauf et al.: Calibration of Instruments for Hardness Testing by Use of a Standard, Proc. Int. Conf. HARDMEKO, Nov. 2007, Japan, p. 141
J. Frühauf, E. Gärtner, K. Herrmann, F. Menelao: Kalibriernormal für Geräte der registrierenden Härteprüfung. tm – Technisches Messen 74, 7-8, 2007, p. 385

2. Operation Procedure

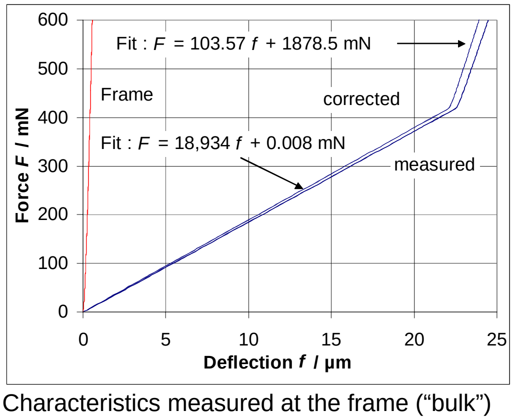
In practice, the standard should permit an assessment of a hardness testing instrument. That is the verification of the scales of **force** and **indentation depth**. Usual methods are the verification of the force by an electronic balance and of the depth by an interferometer. These procedures need a considerable expenditure of instrumentation and time. In view of a quick assessment, the standard can be advantageously used. Two different procedures are realizable presupposing the standard itself is calibrated:

a) The instrument is equipped with a spherical indenter with a large radius

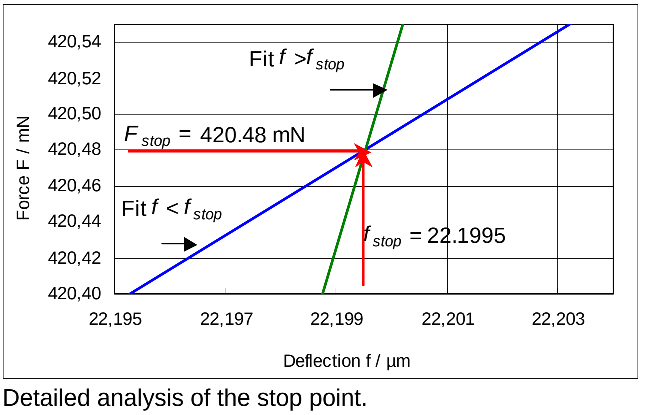
In this case the procedure is similar to the calibration of the standard itself resulting in certified values of stiffness k and deflection f_{stop}. At first, a characteristic of load-deflection must be measured with loading inside the centre of the cross bars at the boss. The branches of loading and unloading are identical but contain the elastic deformation of the instrument itself (instrument compliance) and of the silicon surface. For the elimination of these effects another characteristic of load-deflection must be measured with loading at a point on the stiff frame ("bulk" deformation). The measured points in both characteristics should be taken at the same values of force (or calculated by interpolation). Then, the elastic "bulk" deformations can be subtracted from the deformations of the spring system resulting in a corrected characteristic. The measured stiffness k_{meas} of the standard can be determined by linear fitting of the corrected characteristic below the stop point f_{stop}. The exact value of the measured f_{stop} itself results from the calculated intersection of the linear fits before and after the stop point. In the case the measured values differ from the certificated values of the standard the instrument must be adjusted up to the certified values of the standard or the measured forces and indentation depths must be corrected.

b) The instrument is equipped with a Vickers (or Berkovich) indenter

If the standard is used in an instrument with a Vickers (or Berkovich) indenter and if the characteristic is measured up to the stop point an indentation will be produced together with cracks and broken out particles. The loading branch of the characteristic reflects the plastic deformation and the creation of cracks resulting in nonlinearity and a depth difference to the branch of unloading. So the assessment of the instrument must be done at the base of the unloading or the measurement is repeated without changing the position. Then the branches of the characteristic are nearly identical. The procedure of assessment is the same as described under a). The restriction of the stiffness k by limitation of the characteristic to low forces allows a quick and non destructive assessment.



Characteristics measured at the frame ("bulk") and at the boss and the corrected one with its linear fit equations.

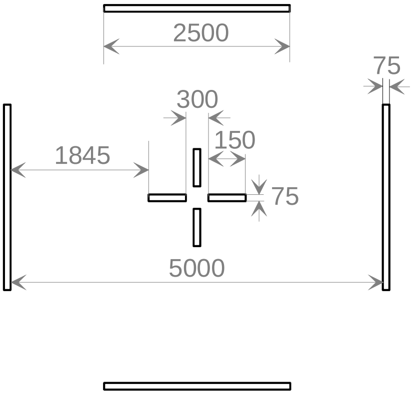


Detailed analysis of the stop point.

The standard is available with a PTB calibration certificate (PTB: Physikalisch-Technische Bundesanstalt, the national metrology institute of Germany). It includes the stiffness of the parallel spring and the value of the stop point.

3. Dimensions

Support chip: 40 mm x 40 mm
Chips with calibration spring and stop point: 30 mm x 30 mm
Marks for adjusting the indenter on the boss (µm):



4. Packaging, Handling and Cleaning

The standards are stored in a membrane box. The parallel spring does not come into contact with the membrane.
Do not touch the silicon chip especially the regions determined 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.

5. Assortment and Specification

Type	Nominal stiffness (mN/µm)	Nominal stop point (µm)	Nominal thickness of the spring (µm)
FS-FD	15	25	50