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Mechanical testing of elements of microsystems technology

Downscaling

- Specimen tension, load application into smallest specimen

→ Positioning aspect of specimen into force flow is more coarse
→ Increased variation of results
→ typical metall specimen ∅10 mm positioning accuracy in load axis/diagonal pull > 0,5mm
→ e.g. bond- wire ∅30 µm positioning accuracy in load axis/diagonal pull > 1,5µm ? ⇒ manually not possible

- New strategies to ease handling for load conformity
- More tests for statistics → efforts, costs
- Handling for specimen arrangement in load axis free of backlash
- Load noise due to vibrations

→ ratio of load range and dead weight of sensors is less
→ weight 100 kN load cell = 10 kg (0,1% FS, resonance frequency 6,5kHz)
→ weight 10 N load cell = 18g (1,8% FS, resonance frequency 1,5kHz)
→ eigen frequency of test setup close to eigenfrequency of sensor chain → interactions/interference

Downscaling

→ Effective use of measurement range at least 1/10 power less, 10.000
- digits useable

→ Resolution of position measurement system
  → sufficient increments, digital signals – high costs for precise systems
    - (accuracy < 1 µm, resolution < 0.005 µm, range > 10 mm)
  →Possibilities of indirect position measurement limited–hystereses effects at high speed

→ System stiffness and hystereses to correct positioning system
  →Enhanced stiffness for dynamic tests and for fracture toughness
  →low stifness = high energy storage
  →stiffness has to be reproducible for correction calculations
    - (ideal linear , max. polynom 2nd order)

Application and technics

Classical load range 500N > < 2MN	*Separation with respect to MTS <500N*
•**Endurance testing** Dead weights + lever transmission or motorical	•**Endurance testing** Dead weights
•**Universal testing machines** Spindle machines or hydraulic drive systems, Low cycling testing possible, various clamping tools	•**Static testing** Spindle mechanic drive
	•**Static-Dynamic testing** Coil drive
•**High frequency pulser up to 100Hz** Hydraulic drive	•**High frequency pulser up to 10 kHz** Piezo- or coil drive
•**Multi axis testing** hydraulic drive	•**Multi axis testing** Piezo- or coil drive

Needs and possibilities

System parameter	Static testing	Static dynamic testing	Static-dynamic precision testing
Loads	+++	++	+
Static load	++	+++	+
dynamic testing (LC-range)	-	+++	+
Speeds	+	+++	++
Resolution positioning	+++	++	+++
Accuracy of integrated positioning	+	++	+++
Stiffness / linearity	+	++	+++
Positioning range / crosshead travel	+++	++	+
Costs	1	2	3

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H&P micro testing systems

- Static-dynamic testing systems with voice coil drive
  - » Nominal load ±100N
  - » Stroke 10mm
  - » Resolution positioning measurement 0,020µm
  - » speed max. 100mm/s and 50Hz Sinus
- Static testing system with spindle drive
  - » Nominal load ±500N
  - » stroke 50 mm
  - » Resolution positioning measurement 0,005µm
  - » speed max. 2mm/s
- Static-dynamic precision testing system
  - » Nominal load ±20N
  - » Test path 50µm +pre-positioning
  - » Resolution positioning measurement 0,002µm
  - » Speed max. 4mm/s and 10Hz Sinus

Inspekt micro LC 100N

Static-dynamic testing machine

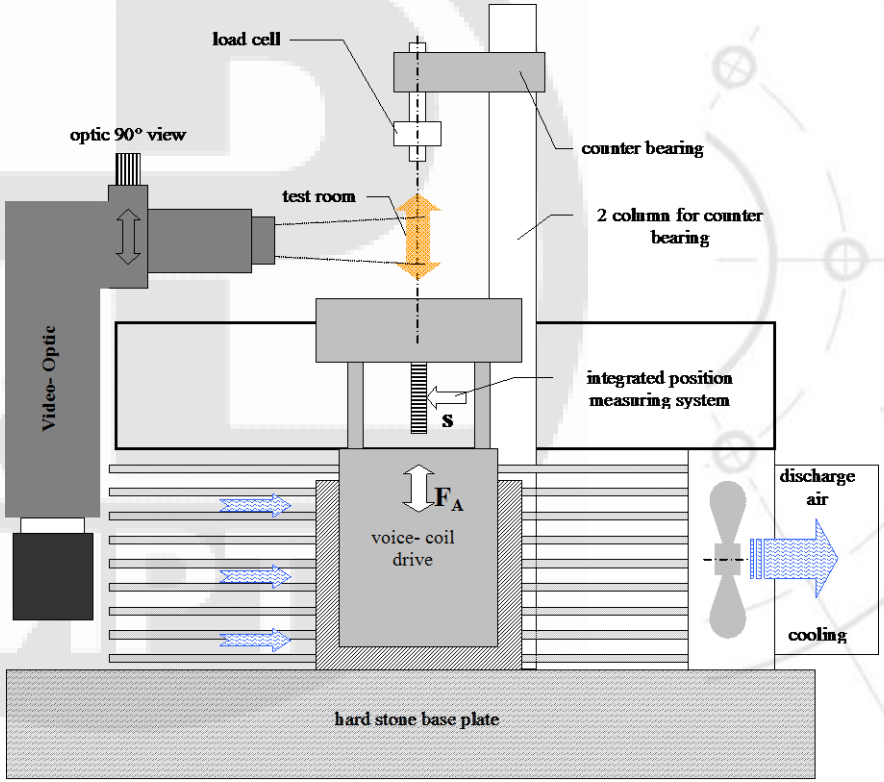
Inspekt micro LC 100N
Technical data

- Endurance test force up to 100N, up to maximum 50Hz sine wave, stroke 10mm
- Voice coil drive with direct measuring system
- Resolution measuring system up to 0.020µm, Gen.3µm
- System stiffness with 100N force sensor 4N/µm

- Maximum test speed vmax =100mm/sforce resolution up to 100.000.digit possible
  - Sensors exchangeable, gradation 10N / 50N / 100N
- Data acquisition rate up to 1000Hz in the software
- Range of view Camera zoom from 1.2x0.9mm to 6.5x5.0mm
  - As video microscope integrated in the test software or optionally as video extensometer
- Basic structure on hard stone slab
  - with additional mounting options
- Device suitable for clean rooms ISO 14644-1 class 8
  - Exhaust air duct to the rear

Inspekt micro LC 100N

- System design Load unit/ basic unit (sectional view)



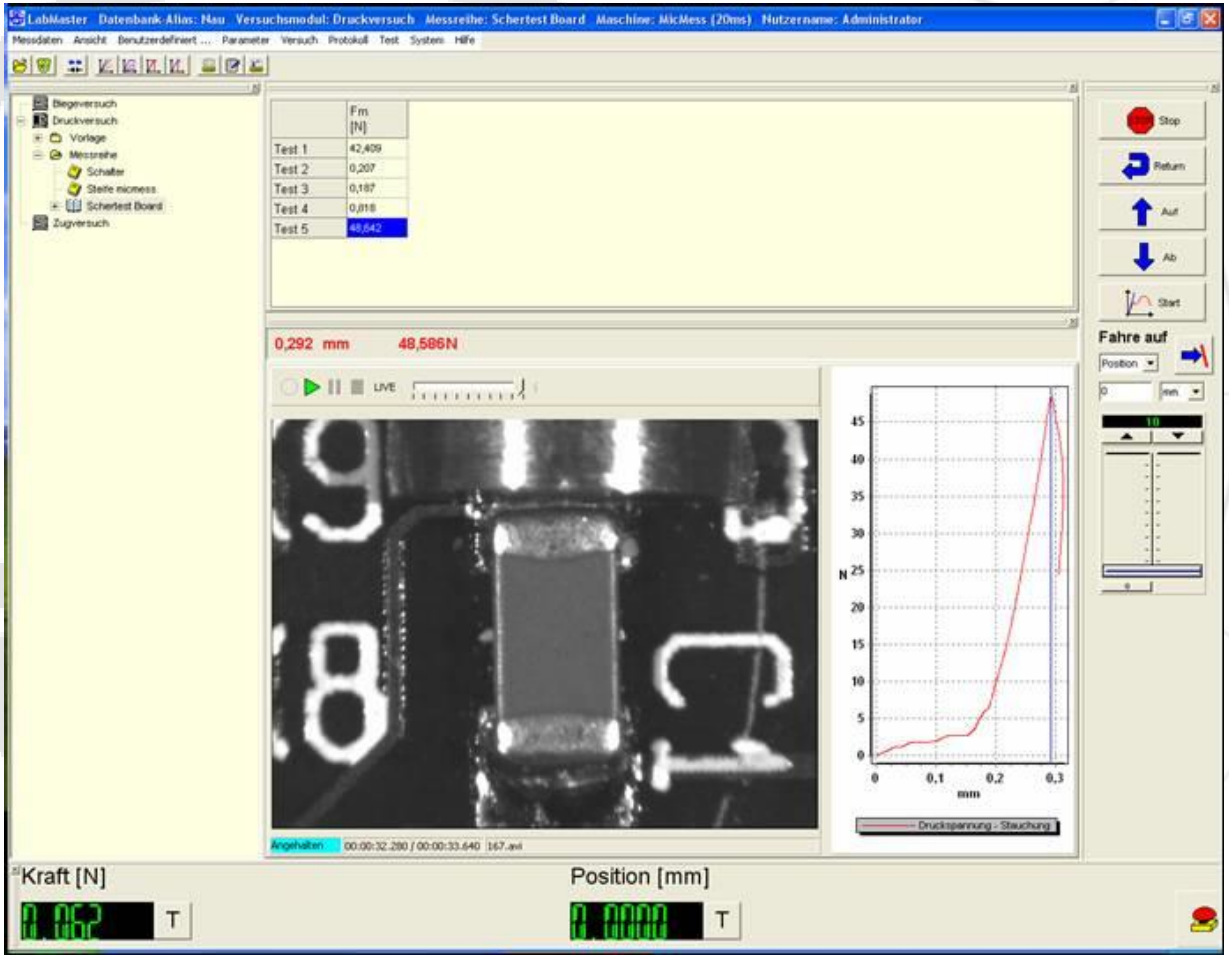
H&P Testing machine software Labmaster

- Management of test templates with test and machine parameters
- Free programming of the travel commands via block program
- Management of the measurement series and storage of the raw data
- Force-position control, derived therefrom tension and elongation control
- Control according to external signals possible
- Switching of the control channels possible during running tests
- Processing of input and output signals in the program sequence
- Online display of the measured values in the diagram
- Statistical evaluationprotocol printing
- Integrated video image and synchronous recording for testing (static tests)

LabMaster

H&P Testing machine software Labmaster

Screenshot of the testing machine software

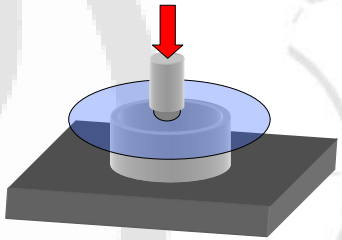


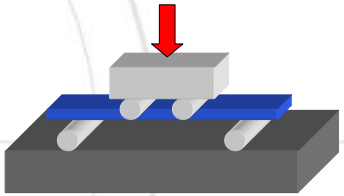
Sample shapes and testing technology

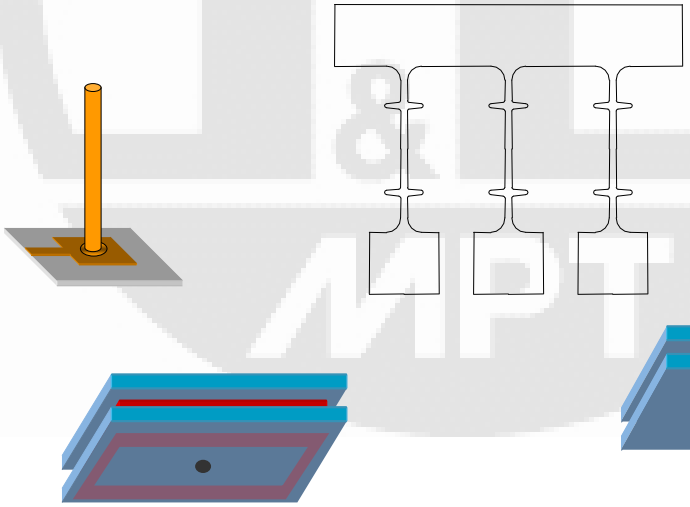
Generally possible sample types

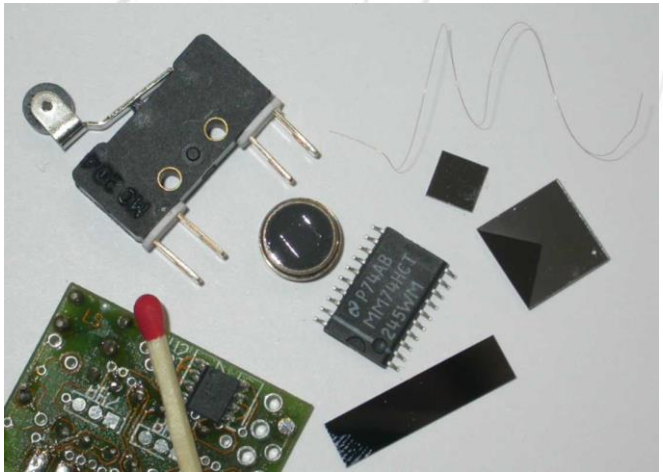
- Mini tensile specimens LIGA method
- Wire bonding and bonding wires
- Chevron samples
- Bond frame structures

- Miniature bending specimens
- Membrane bending tests
- Microassembly structures



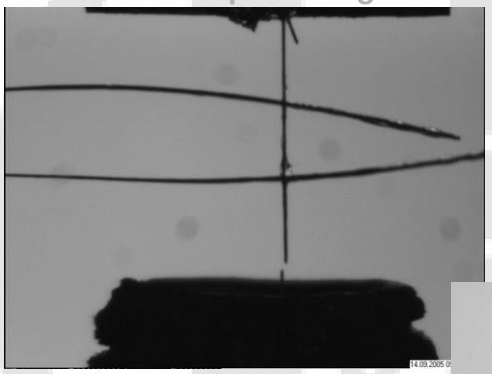


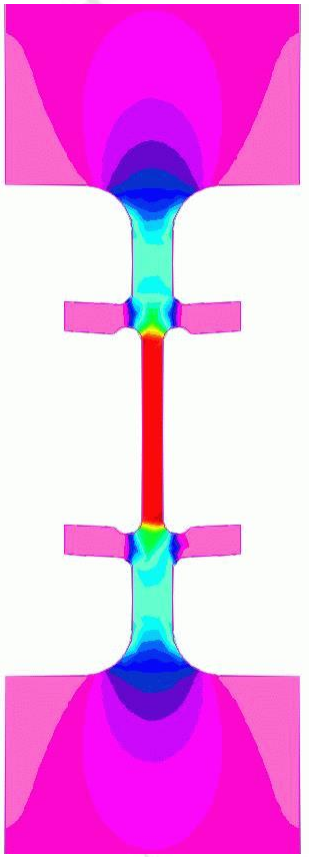




Sample shapes and testing technology
Design of a sample form for video strain measurement

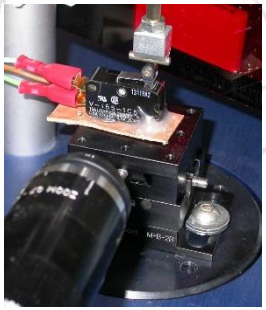
- Tensile specimens with marks for video measurement
  - Wire 50µm with glued marks

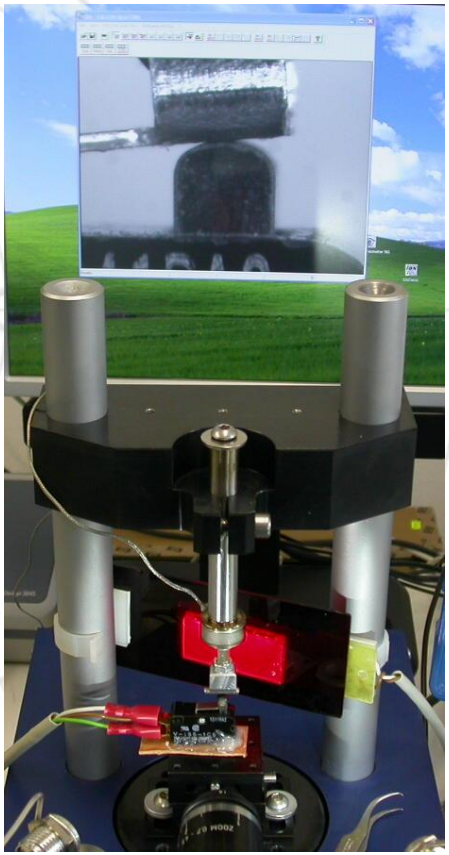




Sample shapes and testing technology
Test of a microswitch for service life

- Use of the Block Program module for conducting experiments
- one test run is automatically stored every 10000 cycles
- The switch is connected to the I/O inputs of the controller and the switching points are stored synchronously with the position values.
- The 10000 load cycles each were run with 10Hz sine wave with 2mm stroke.
- Load cycles are not recorded, only limit monitored





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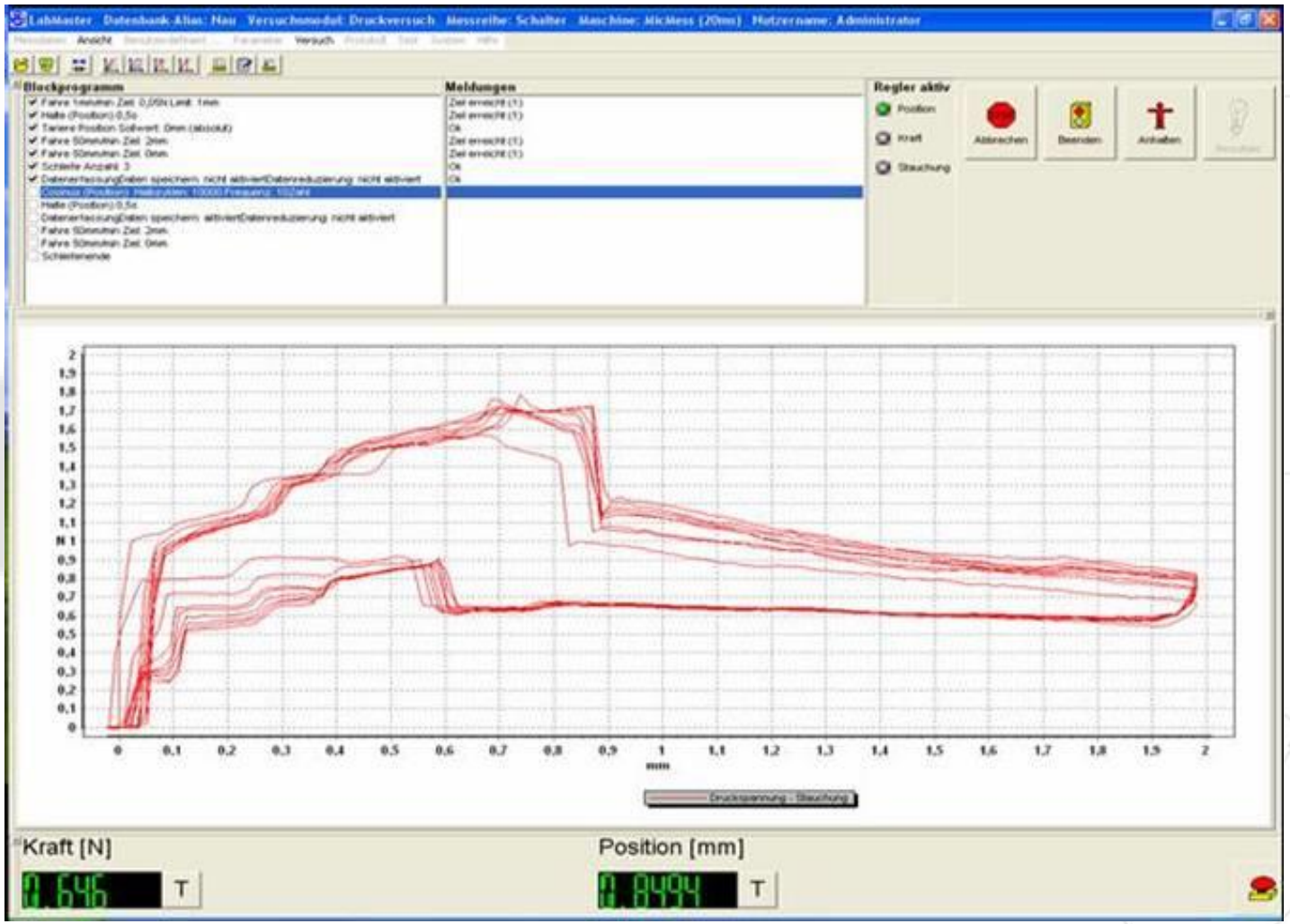
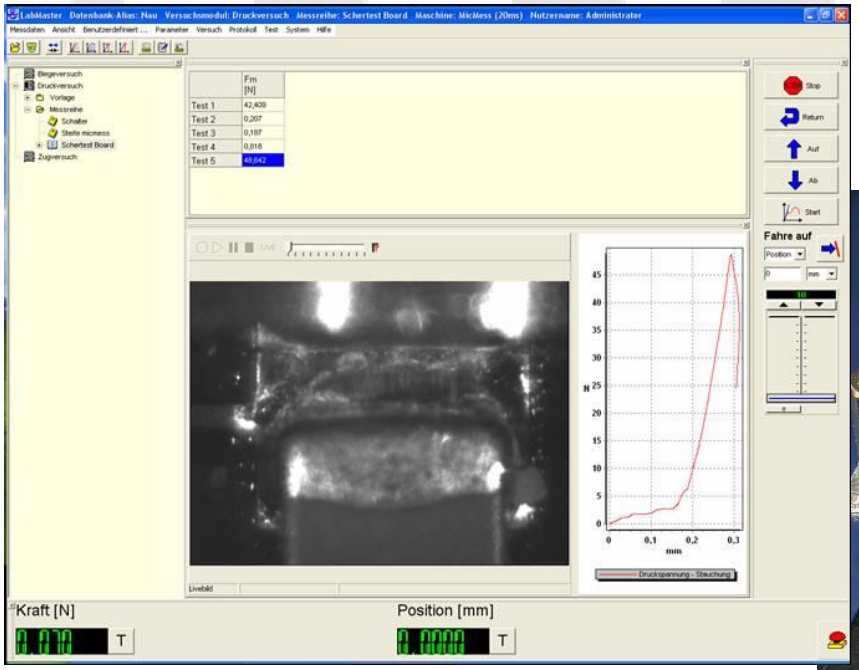
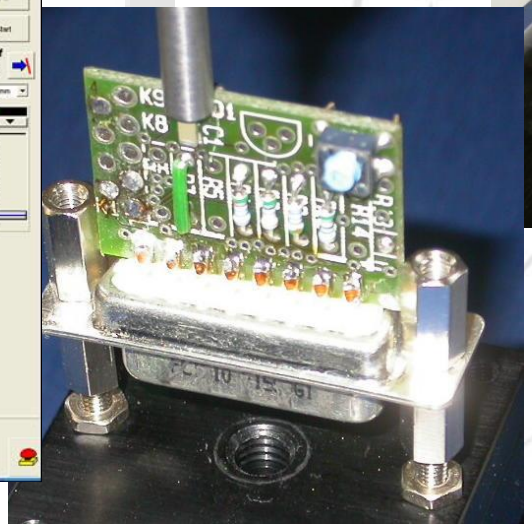
Cyclic Tests utilizing bockprogramming – Testing Software LabMaster



Sample shapes and testing technology
Shear test on SMD assembly(1)

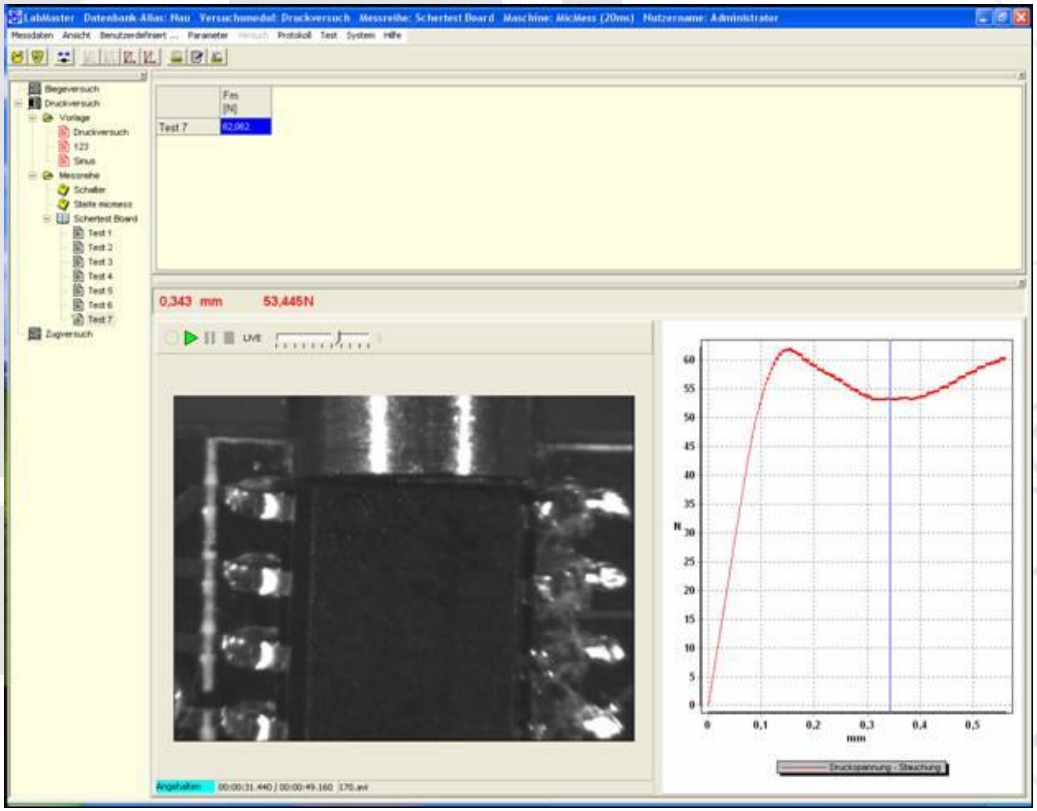
- Board on the X-Y positioning table of the testing machine
- Force measuring sensor with shearing tool
- Evaluation software with video documentation of component behaviour





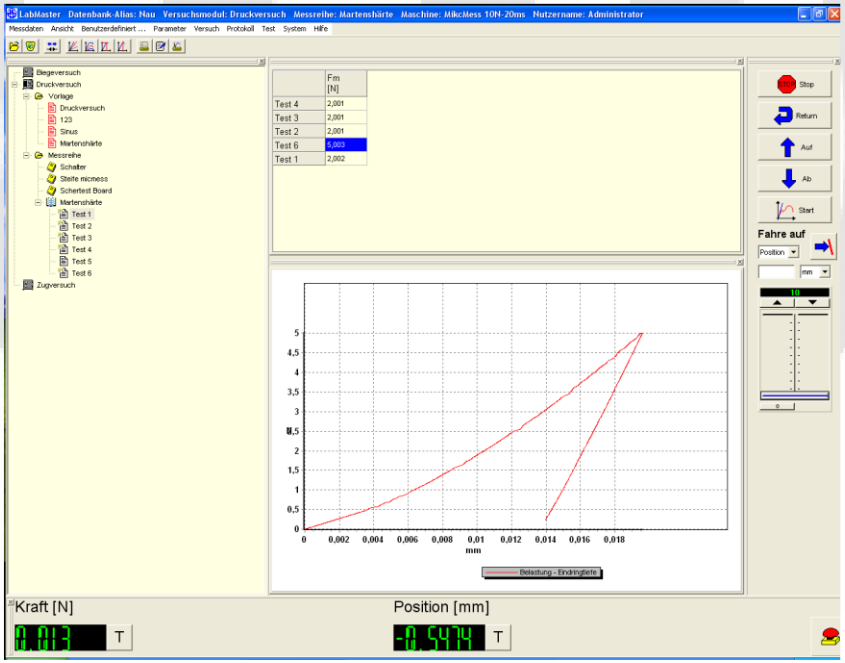
Sample shapes and testing technology
Shear test on SMD assembly(2)

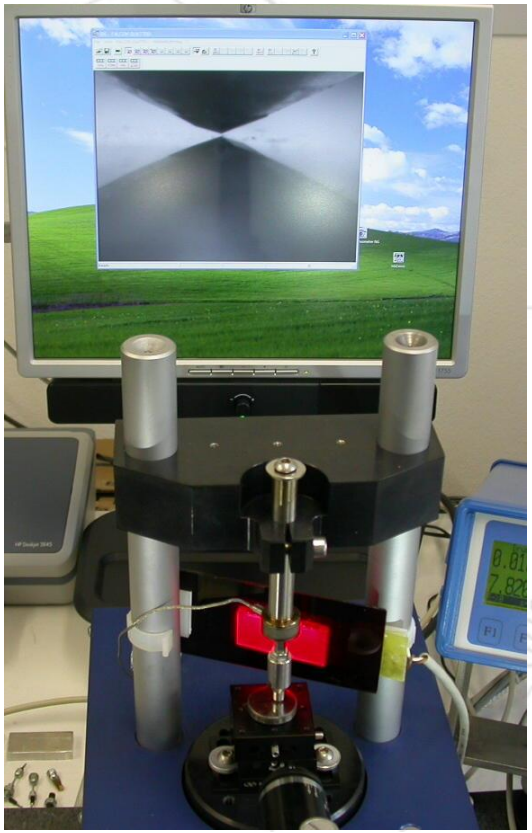
Example for documentation and evaluation of a component failure



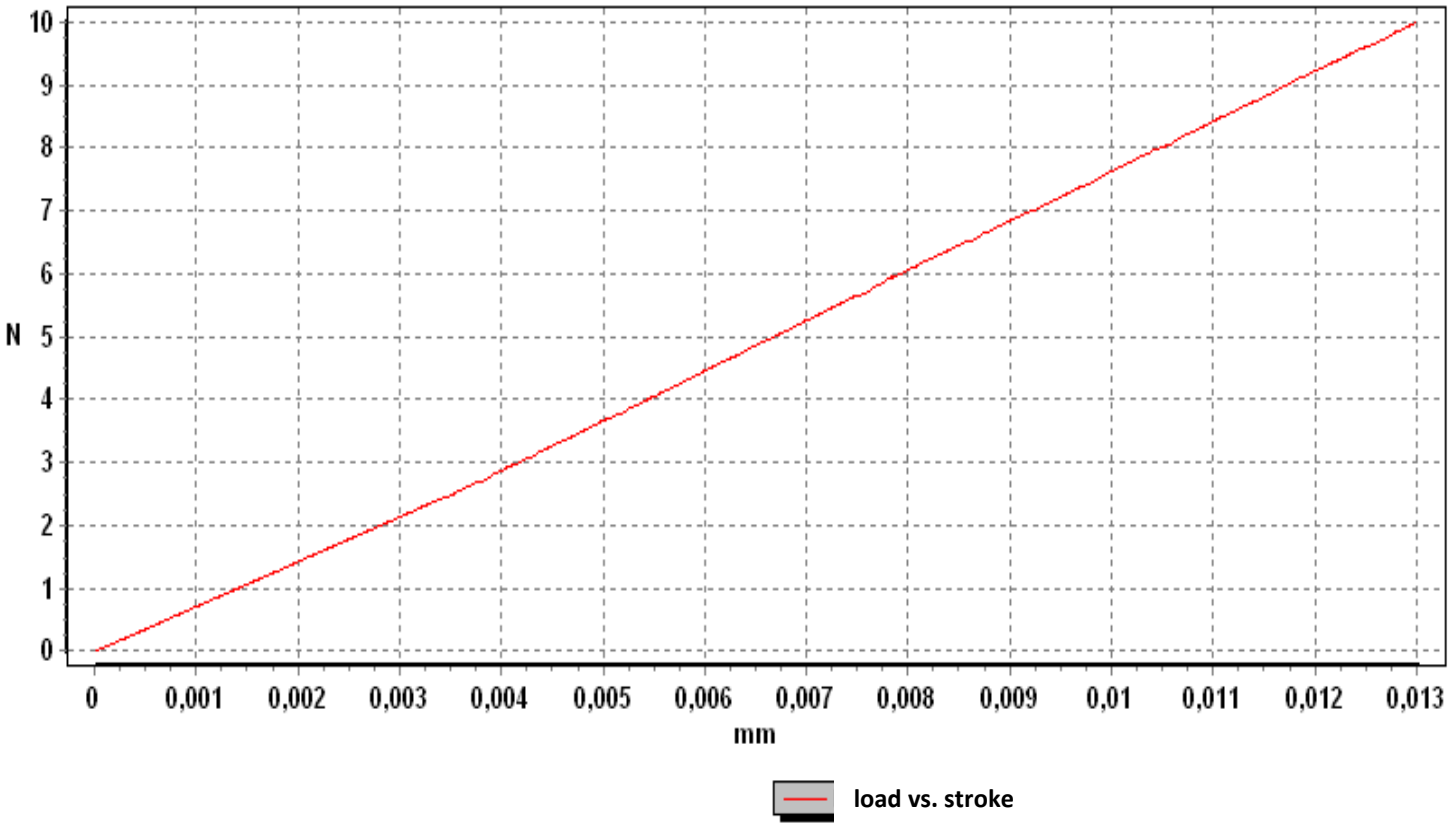
Sample shapes and testing technology
Recording hardness testing

- Use of the testing machine for recording hardness testing
- Correction of the penetration path with the machine stiffness





inspekt micro LC 100N
stiffness 0,75 N/µm with 10N load cell



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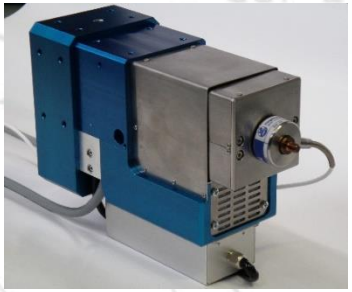
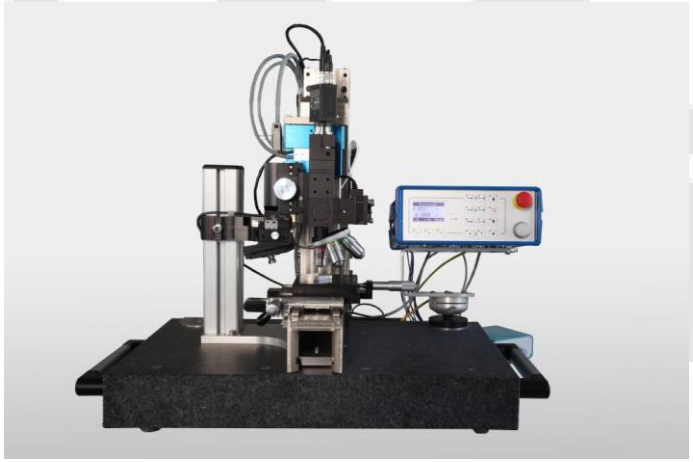
S 500 Static Micro Testing System

Static Testing System with Spindle Drive

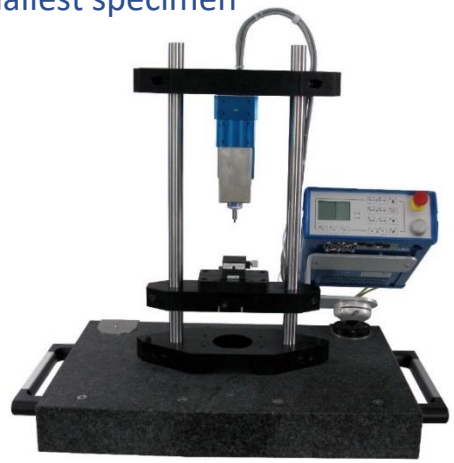
Nominal load ±500N
stroke 50 mm
Resolution positioning measurement 0,005µm
speed max. 2mm/s
stiffness 25N/µm (incl. load cell)



C-framed Test System for hardness testing incl. Indentation depth evaluation as well as optical evaluation of indent



Two-Column Static Test System for tensile/compression/bending and peel testing of smallest specimen



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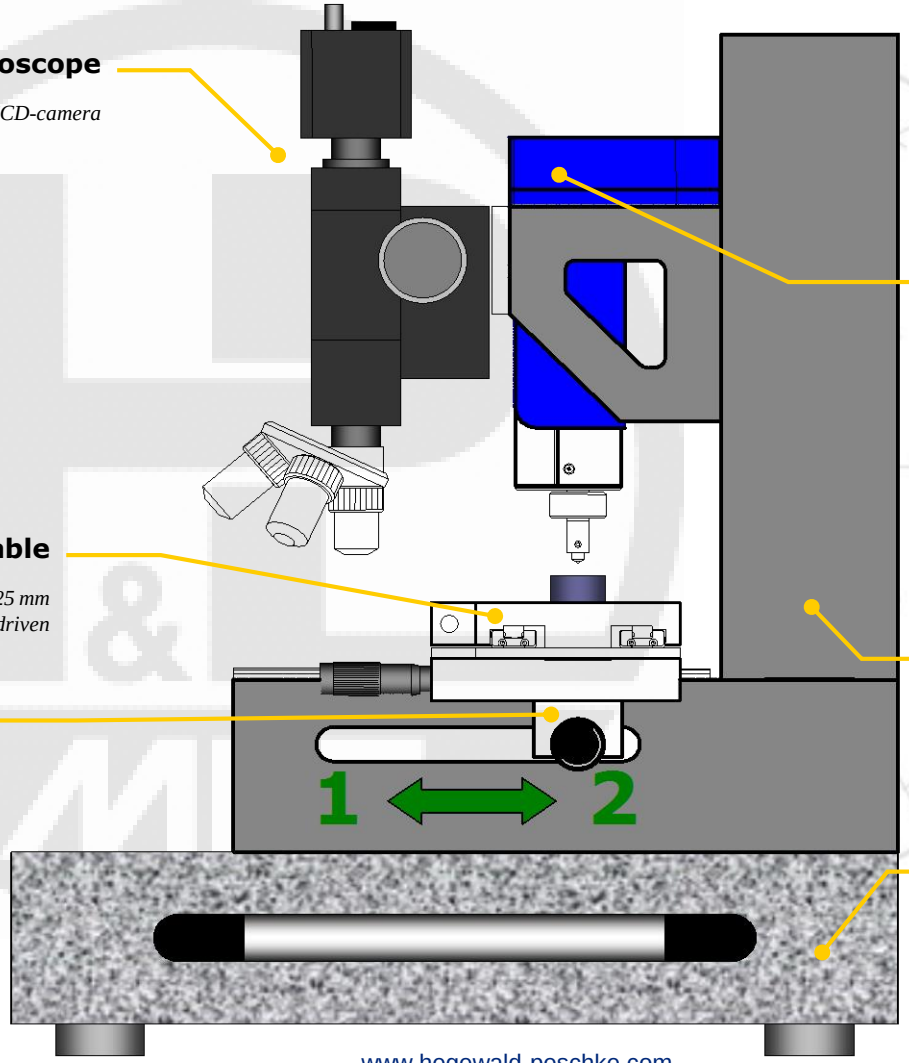
S 500 Static Micro Testing System

C-framed Test System

S 500 Static Micro Testing System

C-framed Test System – spezialized for hardness testing



Microscope

with CCD-camera

Loading head

with high precise integrated incremental displaceent measurement system

X-Y table

25x25 mm
manual or motorical driven

C-frame

strong U profile with additional displacement sensor integrated to determine deformation of x-y table

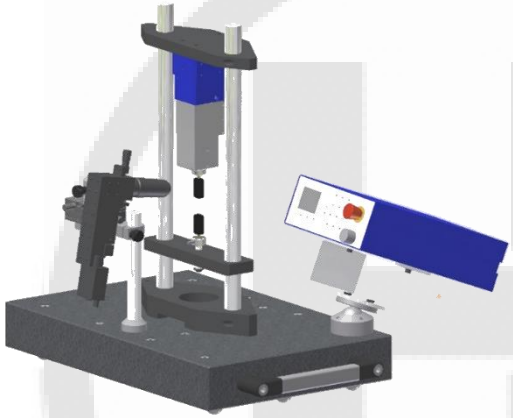
Sliding carrier

for positioning of x-y table
1) Measurement position
2) Testing position

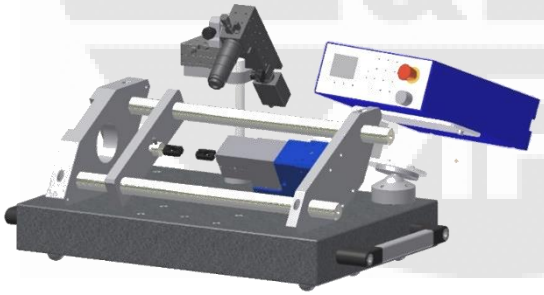
Solid base plate with dumping feet

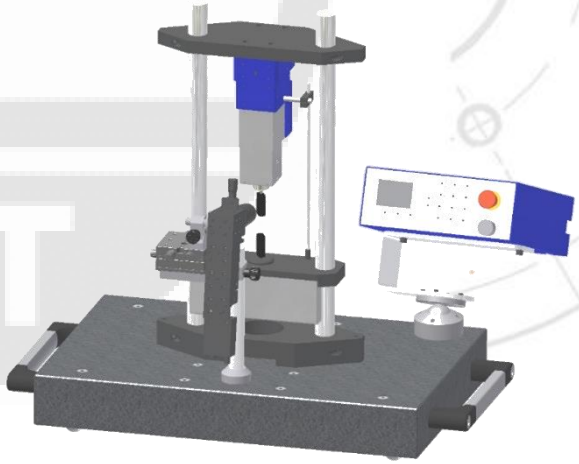
Solid massiv stone plate with carrier handles and dumping feet

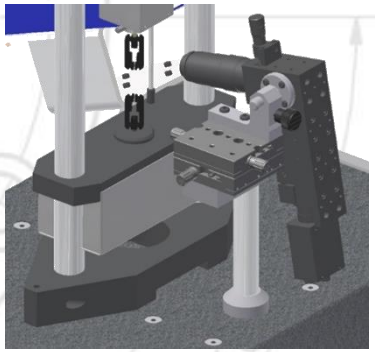
Testing Probe for Tensile / Compression / Bending/ Peel Testing



- Modular design vertical or horizontal
- Loads up to 500N
- Possible Adaption of video system (video module) or microscope possible
- Auxiliary deformation compensation in counter bearing integrated



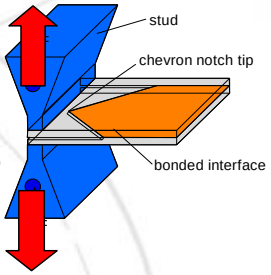


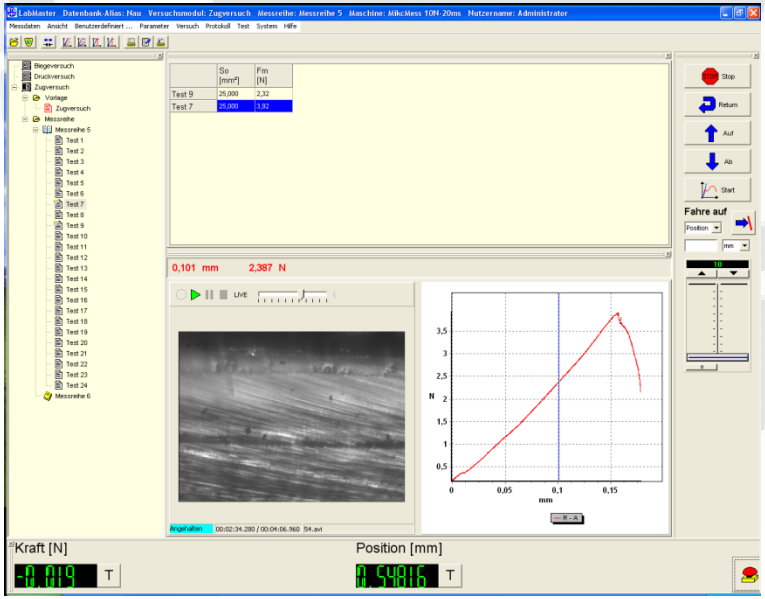


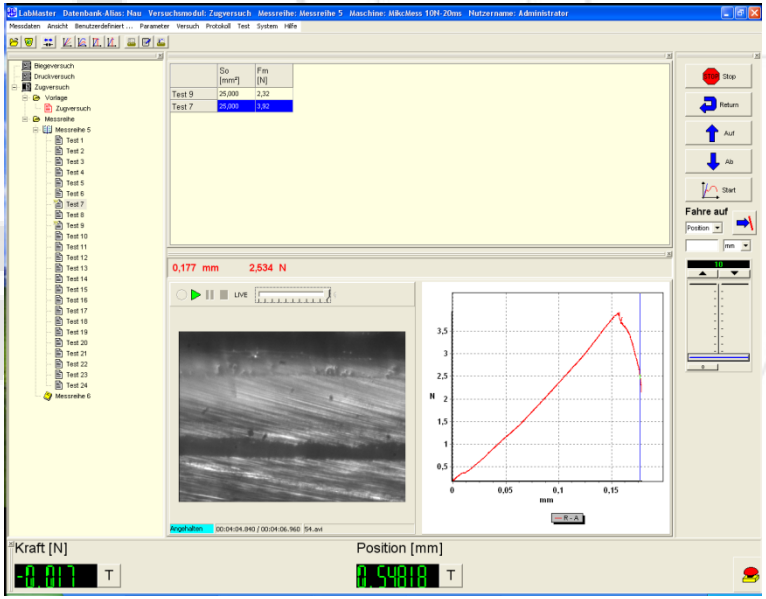
Sample shapes and testing technology

Chevron-Test

- Specified sample dimensions 2.5 - 5 - 10mm
- Example shows the crack opening of a 10mm sample
- The previous sample and test technology still needs to be optimized, with a focus on force introduction to the sample and its handling.

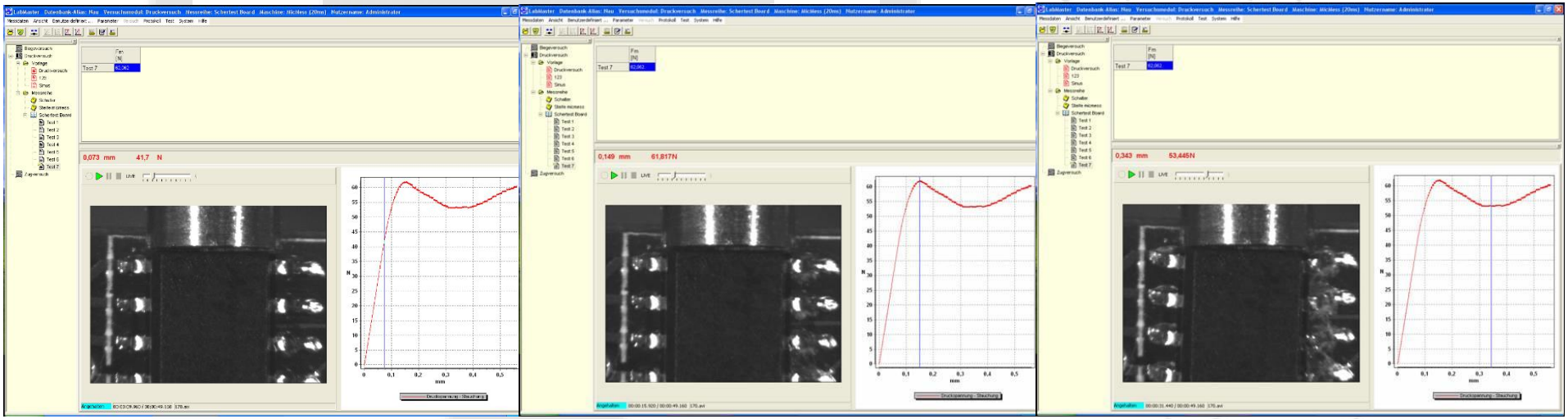






Auxiliary Accessories

- *Various tensile/compression/bending/peel grips and fixtures*
- *Strain evaluation systems (extensometers)*
- *Videomodule for optical visualization of the test run also in reference to the physical parameter/results (stress-strain curve)*
- *Etc.*



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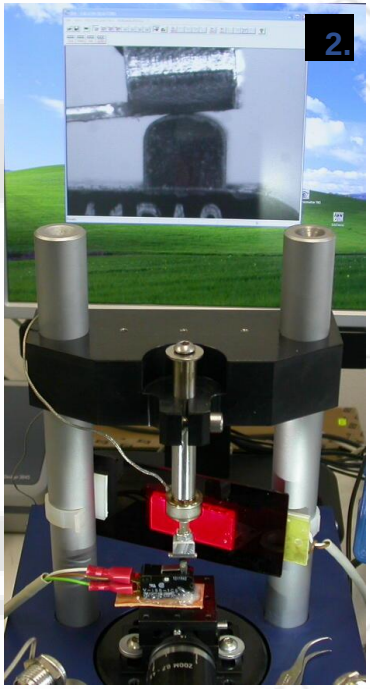
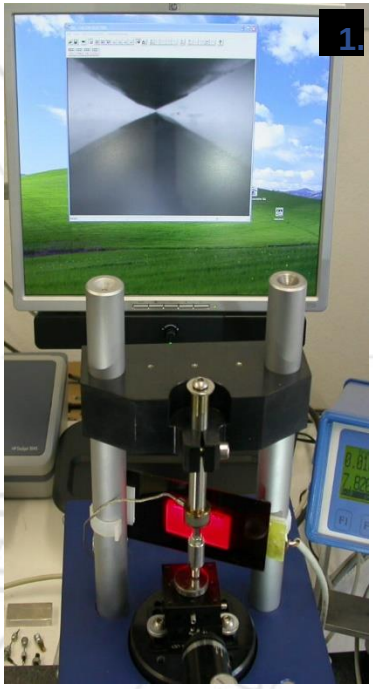
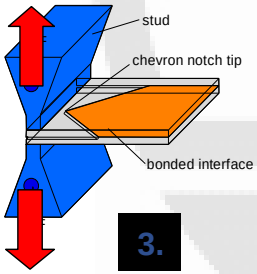
Static-Dynamic Micro Testing Systems

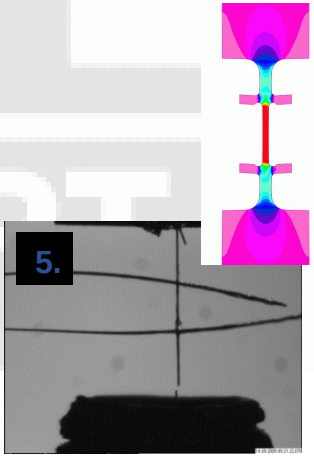
Applications:

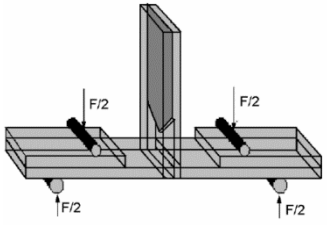
1. matrins hardness (registrated hardness)
2. fatigue testing on micro-switch
3. Chevron test (specimen 2.5-10 mm)
4. shear test on SMD device
5. mini tensile testing (LIGA method)
6. micro component testing/bond testing
7. micro bending testing, e.g. on membranes

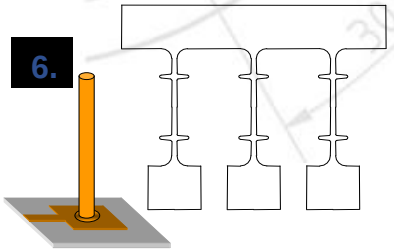


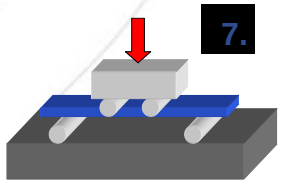






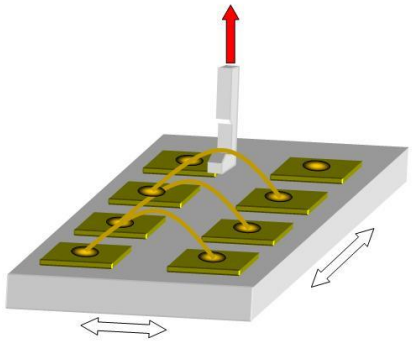




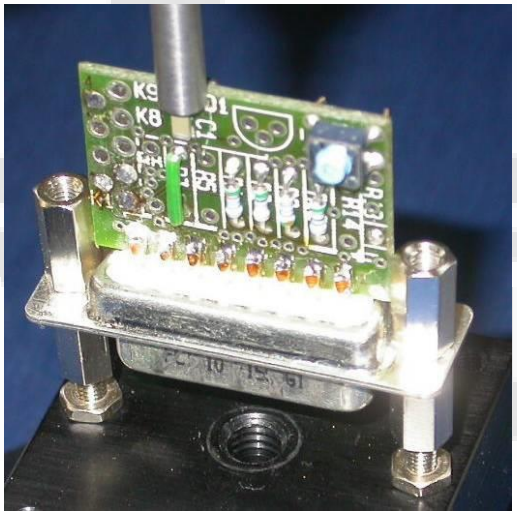


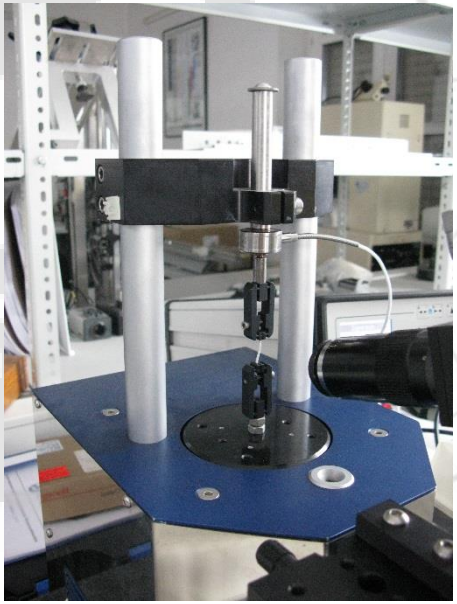
Applications

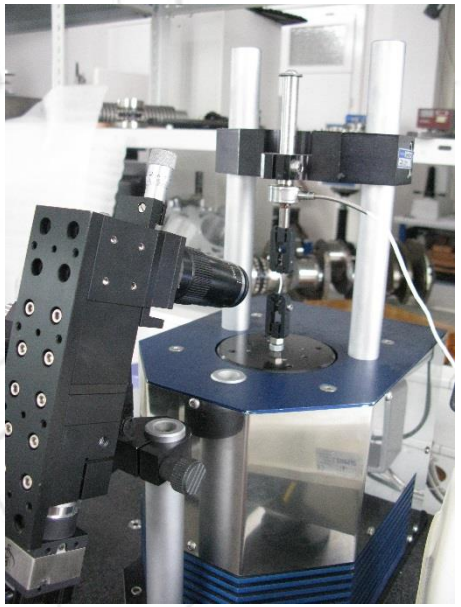
Tensile Test of smallest and finest materials



- finest plastic stripes and foils
- natural fibre
- tissue generated by tissue engineering
- Electronic contacts/bonds (SMD)
- Glued and welded parts



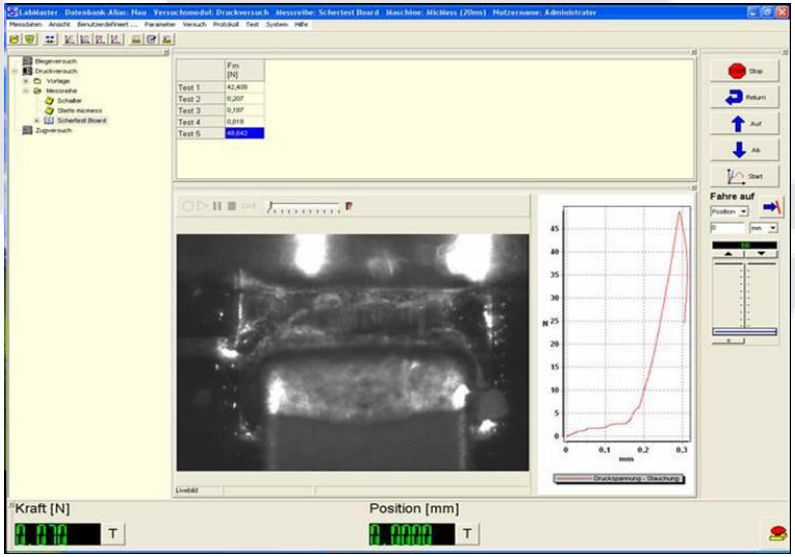


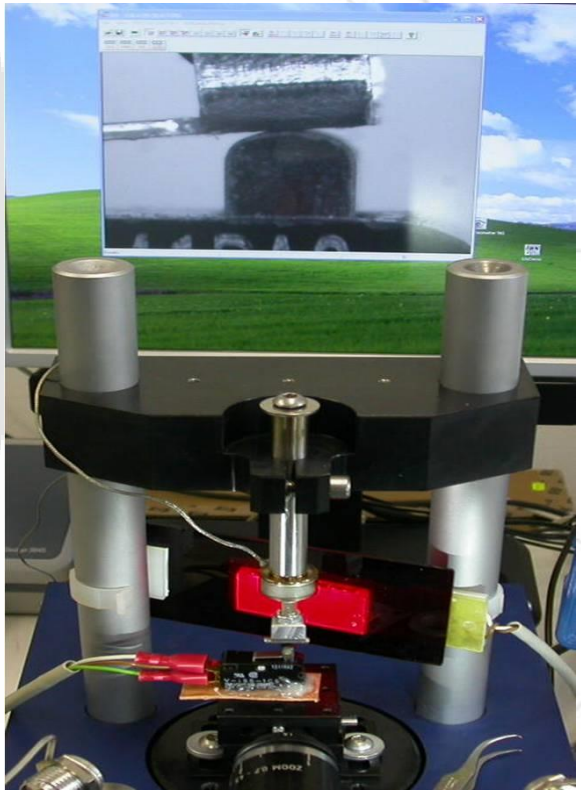


Applications

Dynamic Testing of

- Heart stands
- Muscle fibres
- Electronic switches
- Watch components and parts of chronometric instruments
- Joints and glued components





Applications

Hardness Testing by the option of measuring the indentation depth and also the optical evaluation of the indent:

- Coins
- Extruded, injection molded, hot embossing, thermal forming processed plastic components, i.e. for evaluation of processing features
- Metal alloys