An Advanced Probe Characterization Tool for Online Contact Basics Measurements

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An Advanced Probe Characterization Tool

Outline

- Motivation
- Existing Tools
- Schematic
- Realisation
- Components
- Calibration
- Exemplary Measurements
- Summary
- Outlook

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Motivation

- Modelling contact basics
- Optimizing contact resistance
- Avoiding oxide / low-k crack generation
- Influence of vertical and lateral forces wrt Cres
- Investigation of pad materials (thickness, hardness, etc.)
- Analysis of oxide films
- Evaluating new probe types
- Investigating prober dynamics

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Existing Tools for Contact Force Measurement

- Single Probe Plunger in Probe Card Analyser
- Weighing Platform (only z-force)
- Piezoresistive force sensor in Probe Holder
- Micromechanical sensors
- Pad-integrated sensors
- Automatic Prober

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Requirement Specification

1. Realtime contact resistance measurements
2. Automatic contact point definition
3. Positioning Accuracy in …
   xy-direction: ± 0.5 µm
   z-direction: ± 0.05 µm
3. Capable for mounting different probe card types
4. Simultaneous sensing of lateral and vertical forces in the range of 0.5mN …. 10 N
5. Retainer for various samples (Al, Cu, SiO_2, chips, …)
6. Static and dynamic measurements
7. Microscope w/ video camera
8. Optional test under variable environment gas (O_2, N_2, …)
9. Optional test with variable probing temperature (-40 - 125°C)

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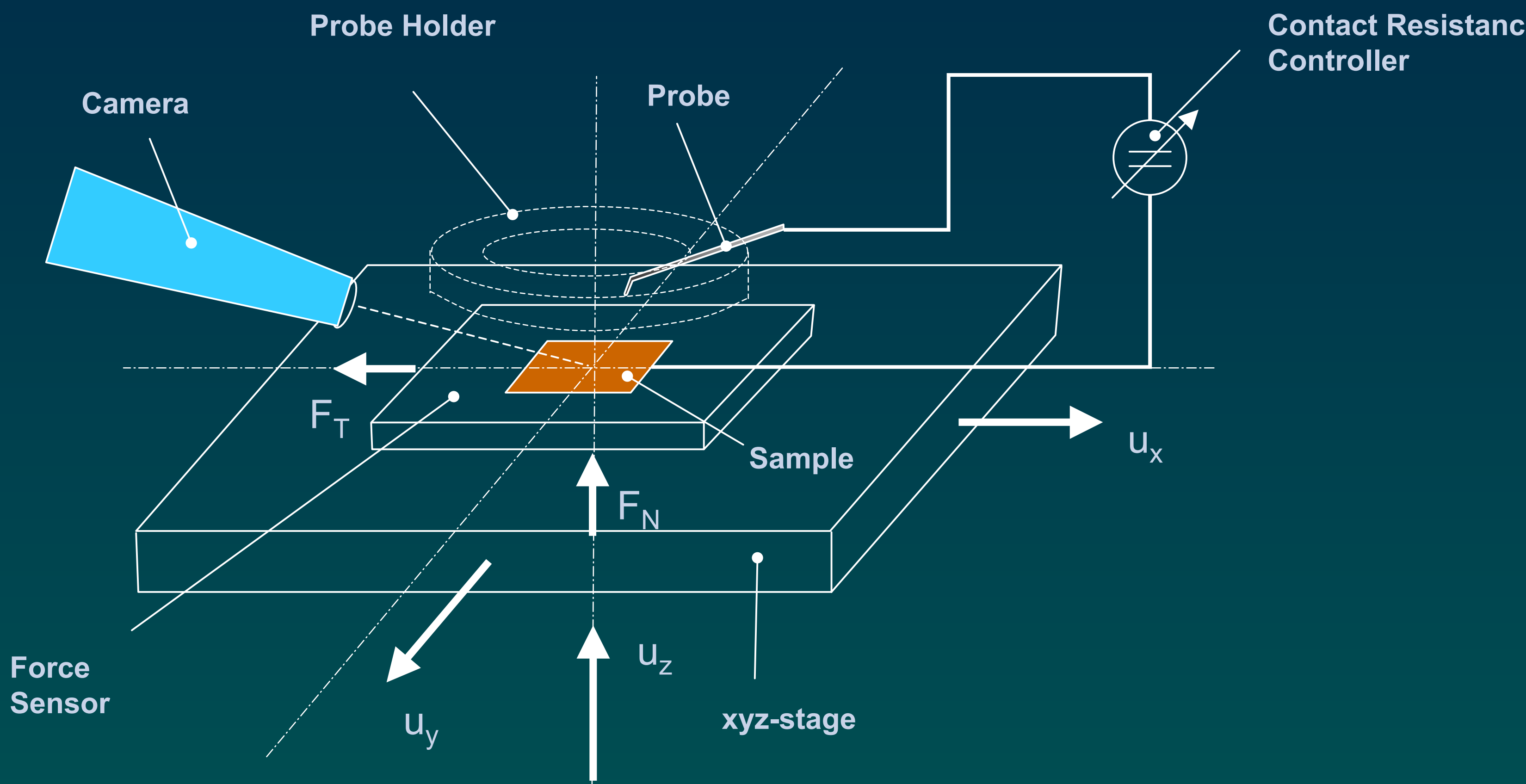
Tool Schematic



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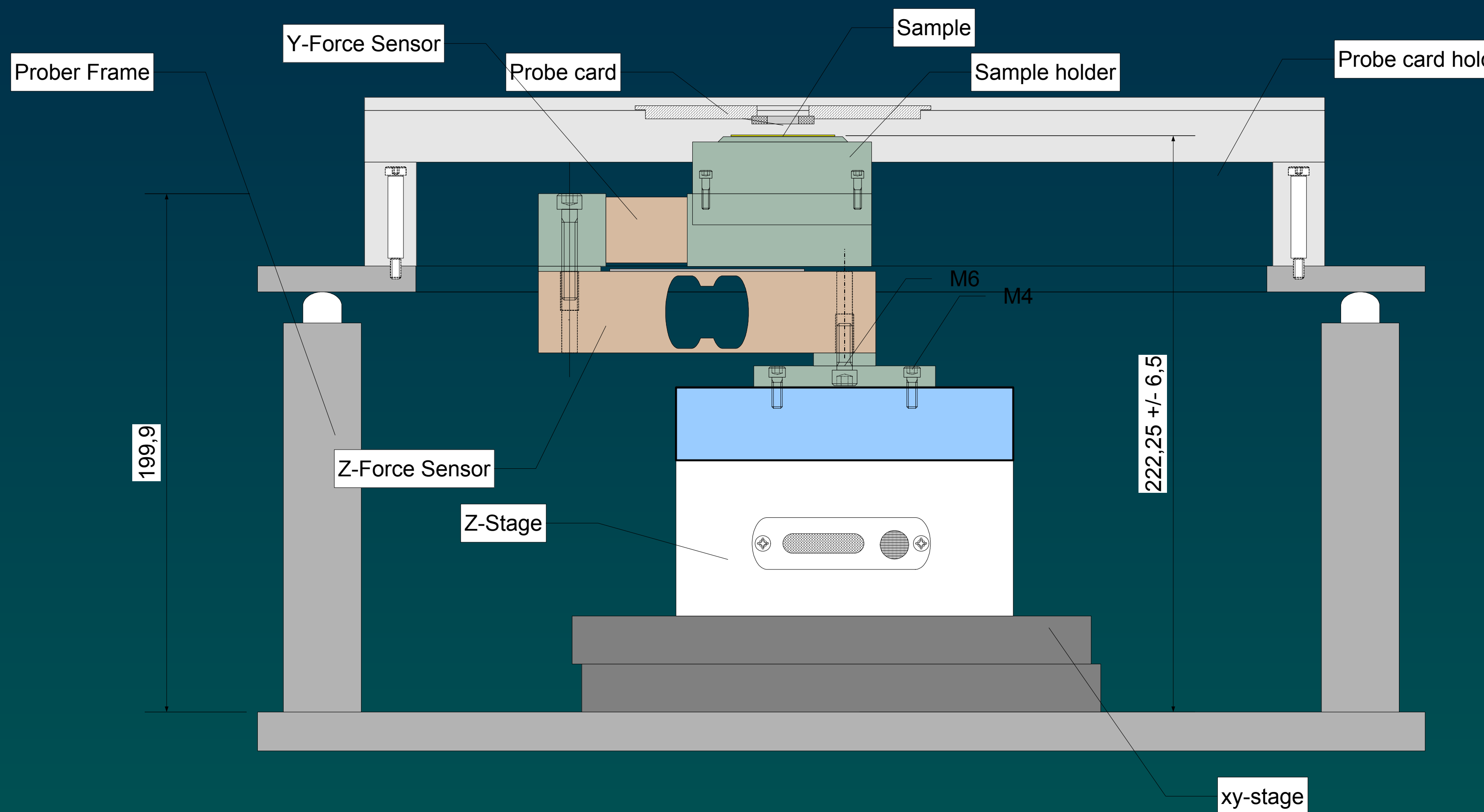
Manufacturing Drawing



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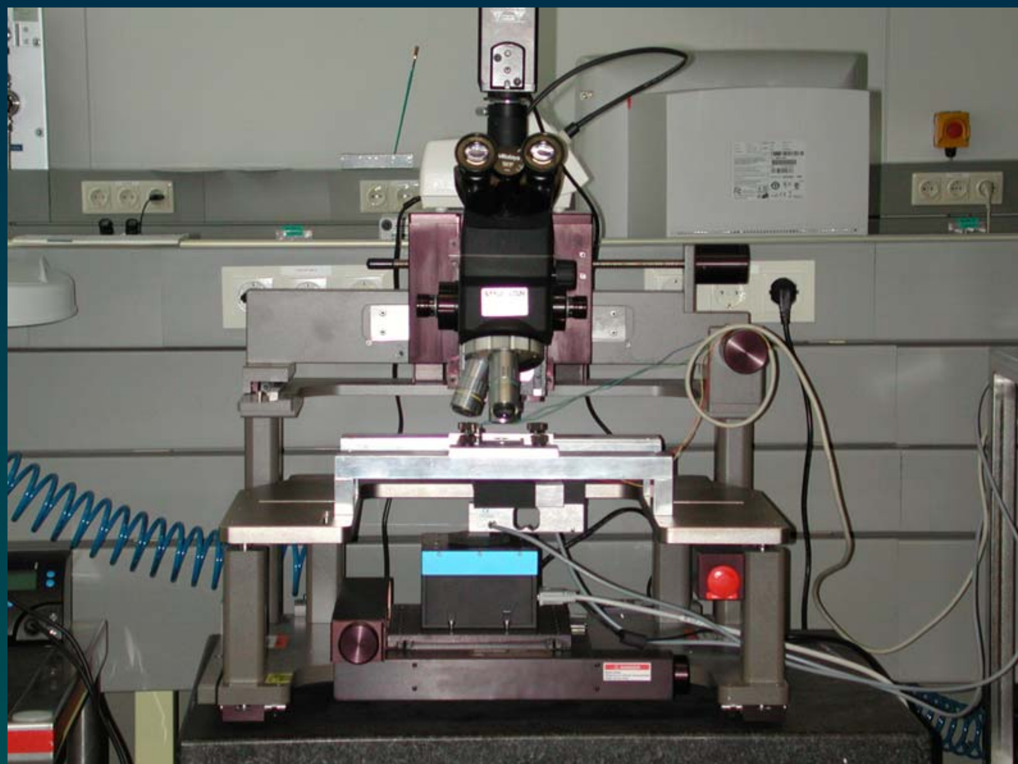
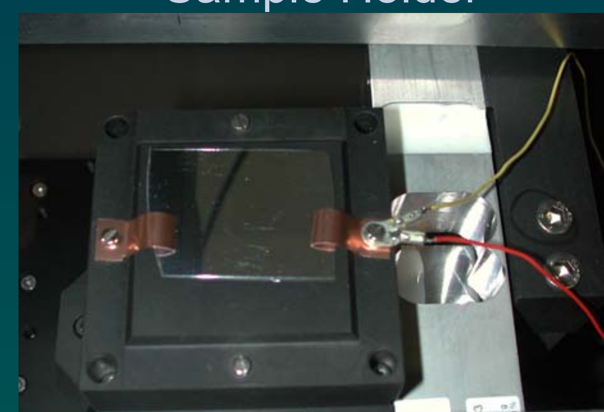
General View



Single-Probe Card

Sample Holder



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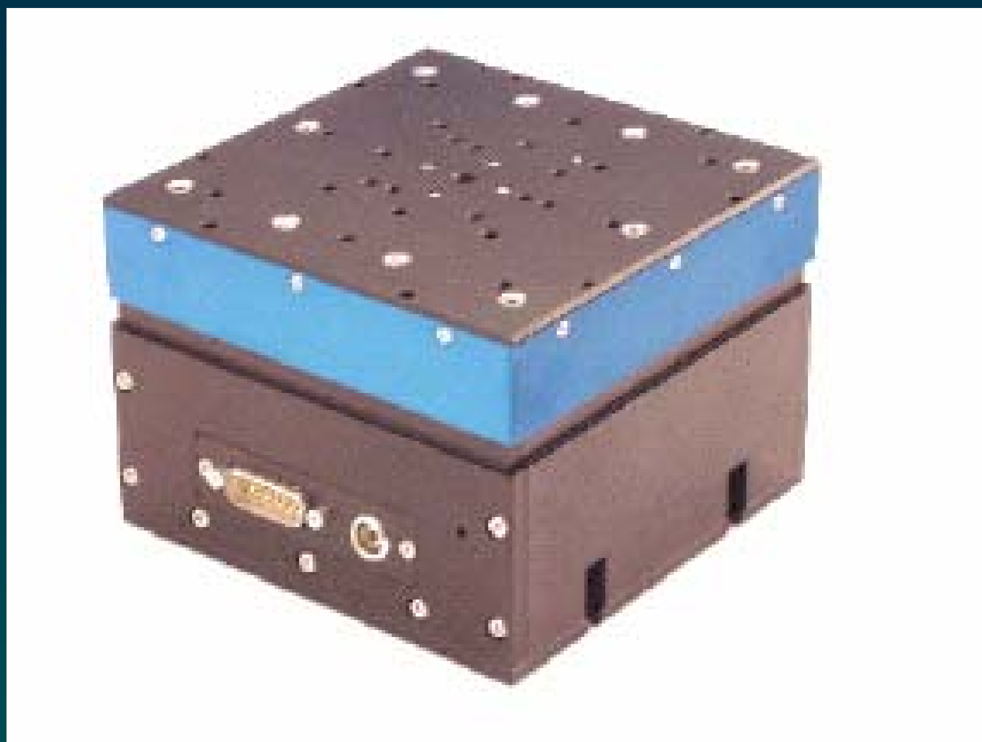
Vertical Positioning Stage



Travel range	12.5	mm
Design resolution	0.024	µm
Min. incremental motion	<0.1	µm
Unidirectional repeatability	0.1	µm
Max. velocity	12	mm/se
Max. normal load capacity	5	kg
Max. holding force (motor off)	20	N
Encoder resolution	40,960*	cts/re
Ballscrew pitch	1	mm/re
Gear ratio	80/26 (belt drive)	
Nominal motor power	17**	W
Motor voltage range	0 to ±24	V
Weight		
Body material	Al	

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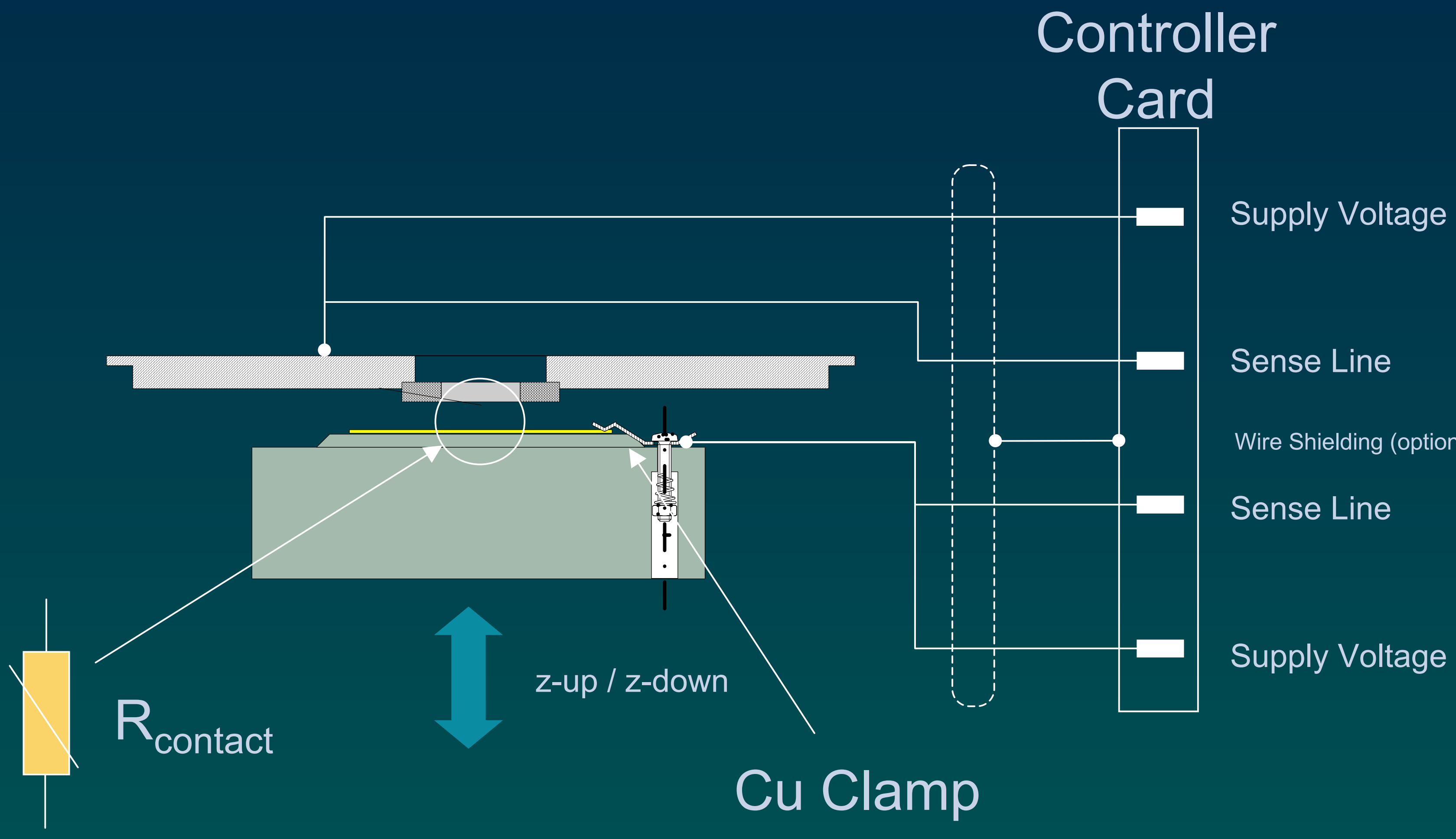
4-pole Cres Measurement



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Single Point x- and z-Load Cell

Special Feature: Off center load compensated

Type		**PW2GC3**				
Accuracy class		**C3** 1)				
Maximum number of load cell intervals (n_{LC})		3000				
Maximum capacity (E_{max})	kg	7.2	12	18	36	72
Minimum LC verification interval (v_{min})	g	2	2	5	10	20
Maximum platform size	mm	380 x 380				
Sensitivity (C_n)	mV/V	2.4 ± 0.24				
Zero balance(without dead load)	mV/V	0 ± 0.1				

Absolute Accuracy:

x-direction: 21,6 mN

z-direction: 36 mN

Resolution:

x-direction : 0,36 mN

z-direction : 0,6 mN

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Data Acquisition and Visualisation

- Software Options:
  - Automatic amplifier recognition
  - Sensor database available and expandable
  - Graphical display
  - Real-time
  - Different interfaces supported (USB, Ethernet, GPIB, etc.)
  - MS Windows XP
  - Measurement data exported in commonly used formates (e.g. ASCII, EXCEL, ….)

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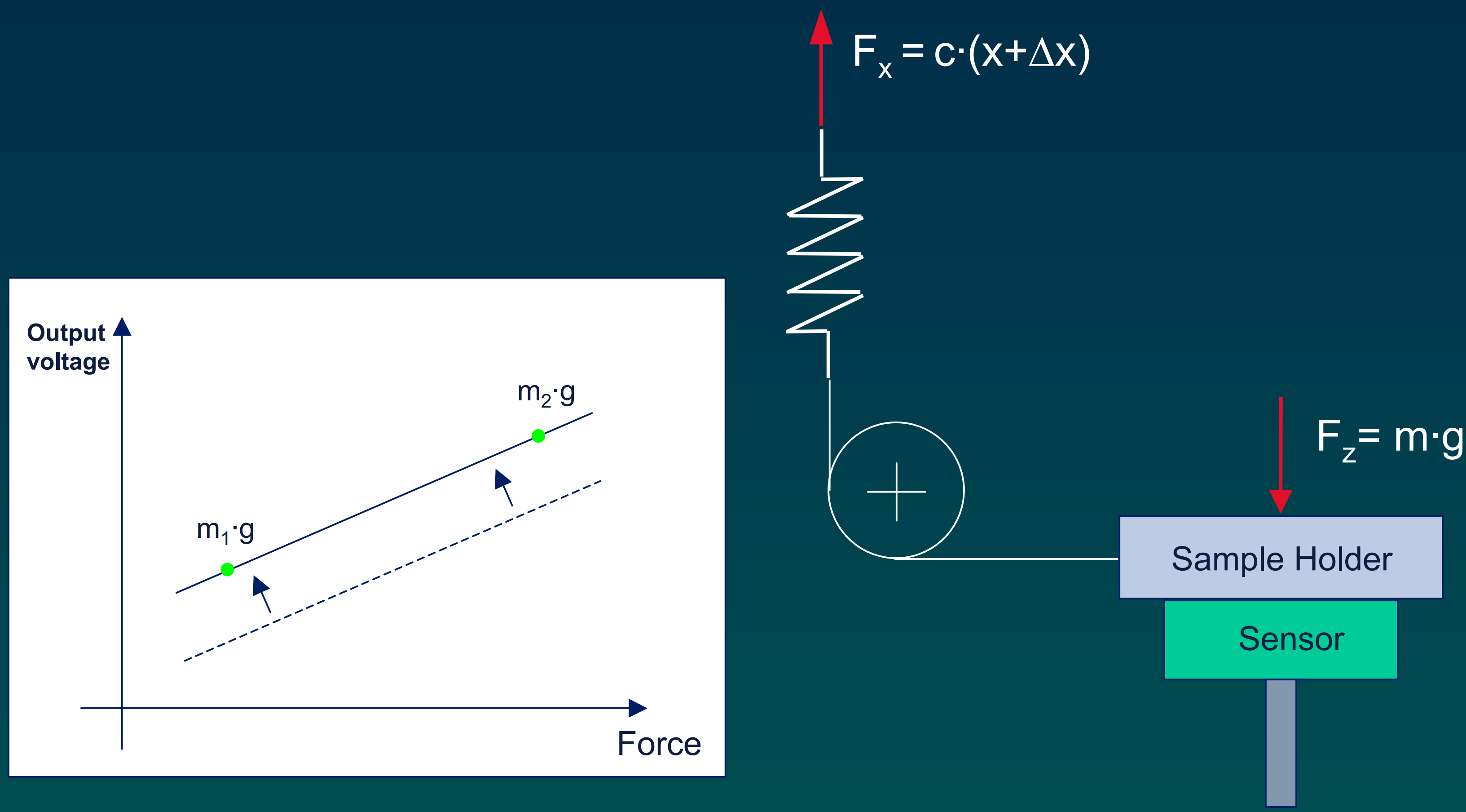
Calibration Method



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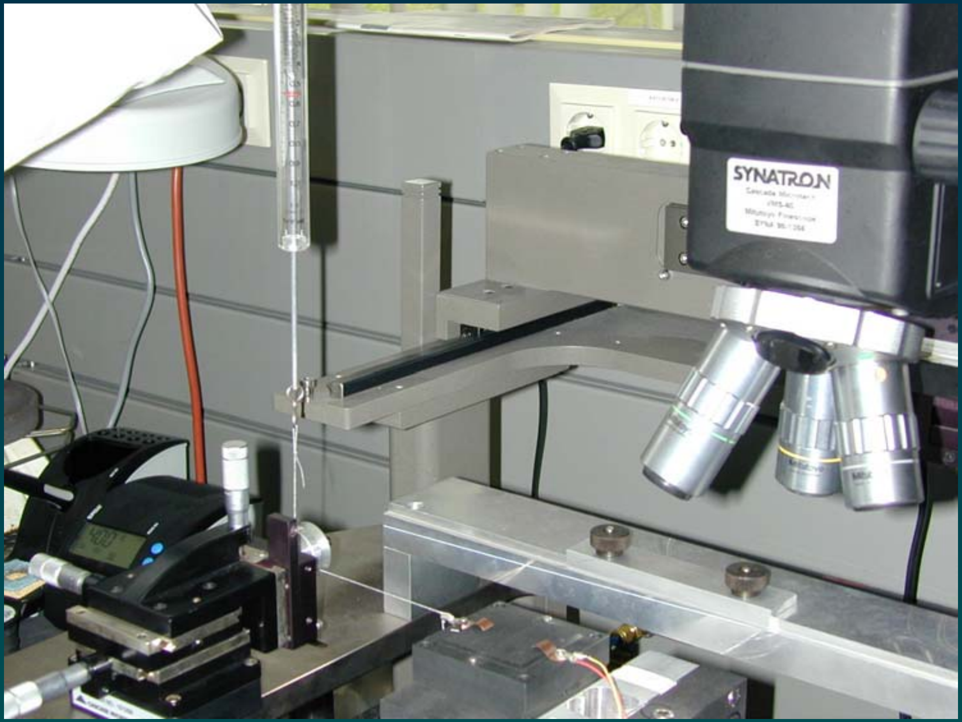
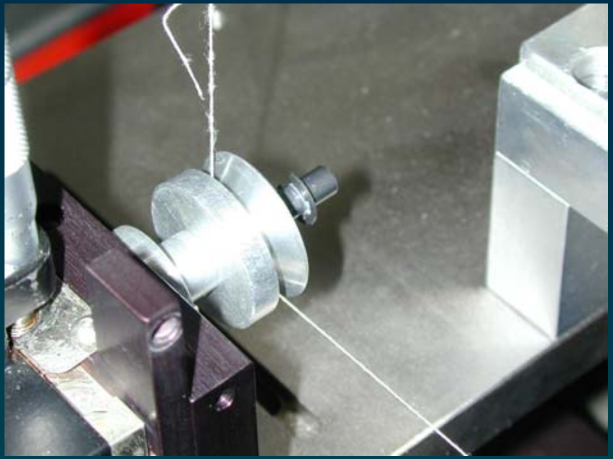
Calibration Realisation





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Exemplary Measurements with a Cantilever Probe

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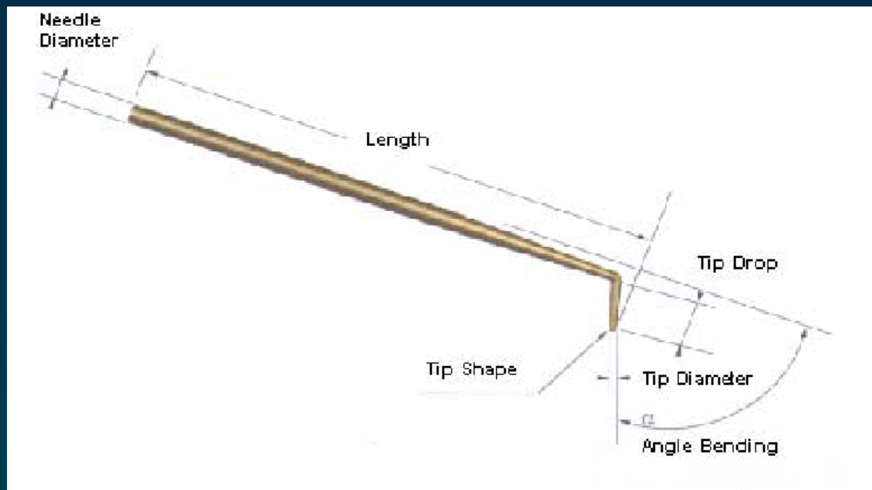
Cantilever Probe used for Demonstration

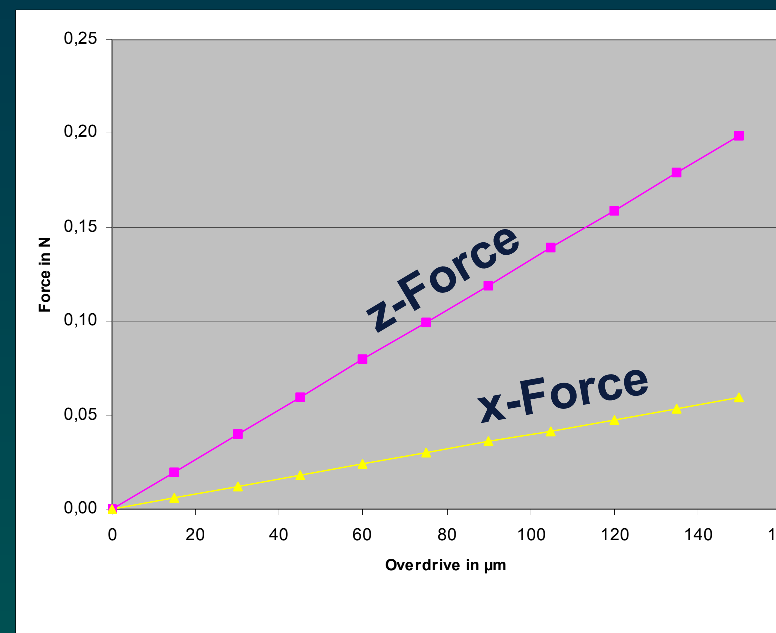


Approximation of Probe Pressure

$$W = \frac{3\pi \beta D^4 E \delta}{64L^3} \text{ (N)}$$

Definitions:
W: Probe pressure (g), L: Beam length (mm),
D: Probe diameter, δ: Overdrive amount (mm),
E: Young's modulus (N/mm²),
β : Attenuation constant depending on tapers and shapes.

Source: MJC



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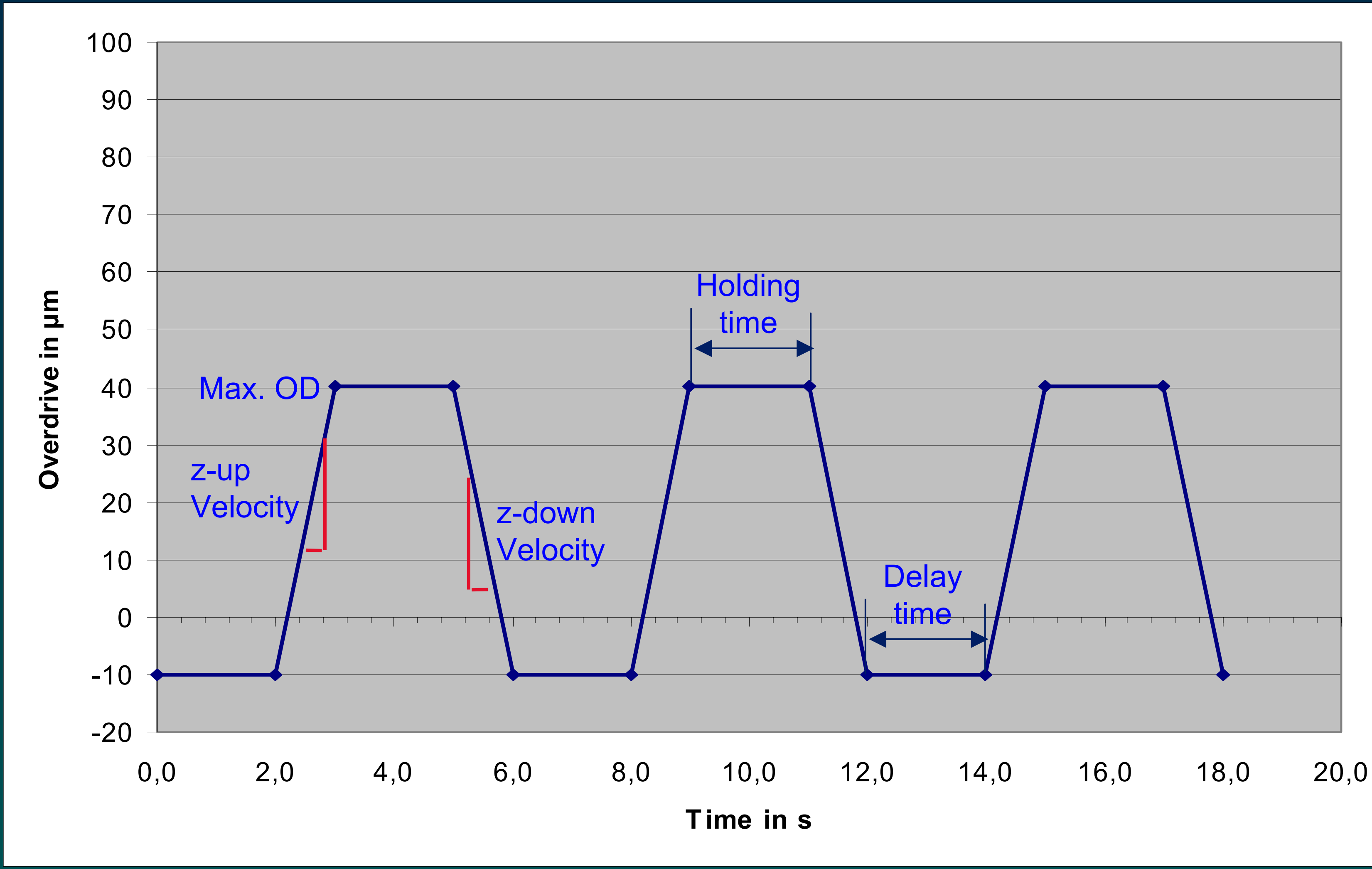
z-Stage Profile



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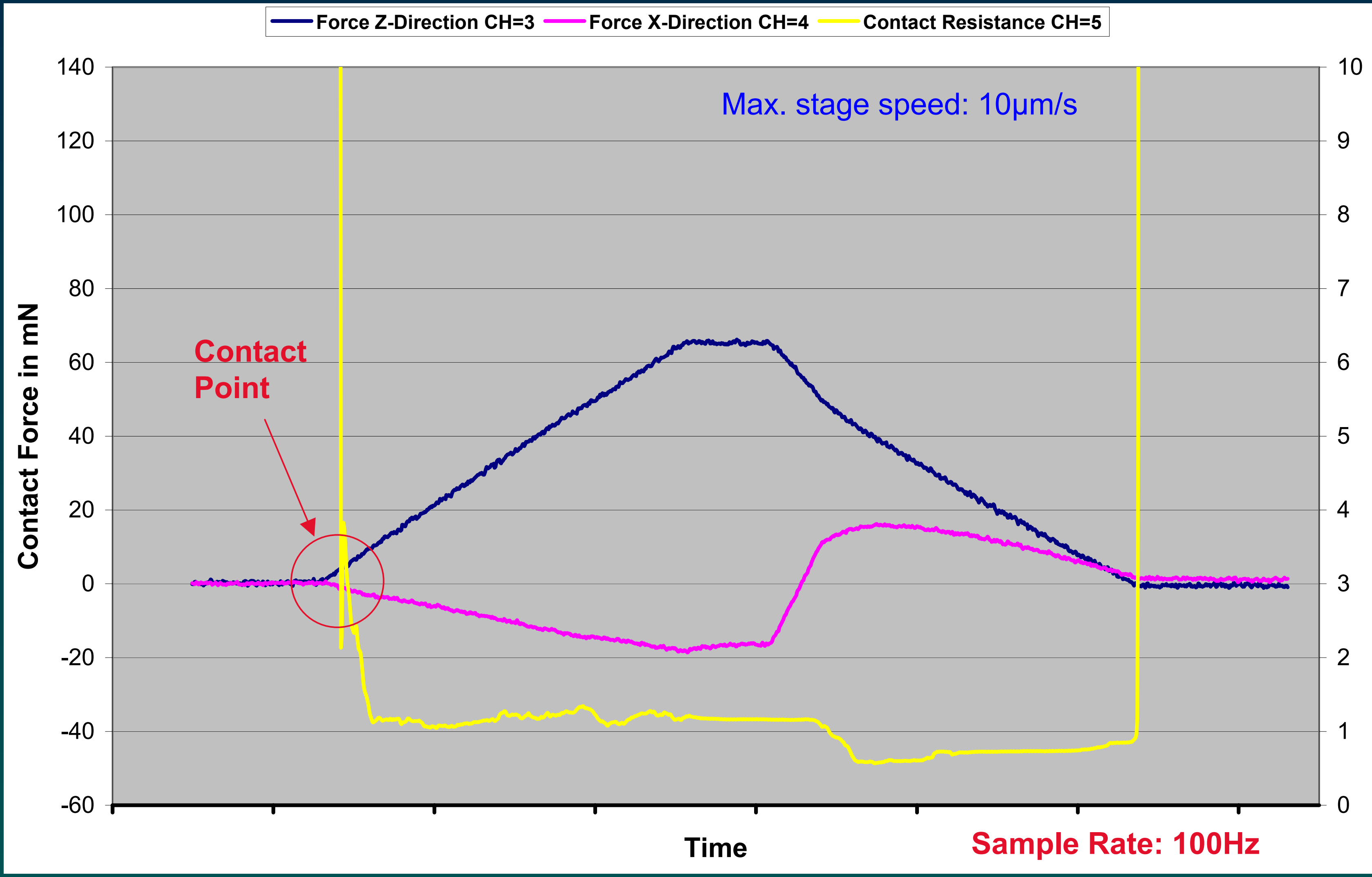
Measurement on Gold Wafer (max. OD = 50µm)



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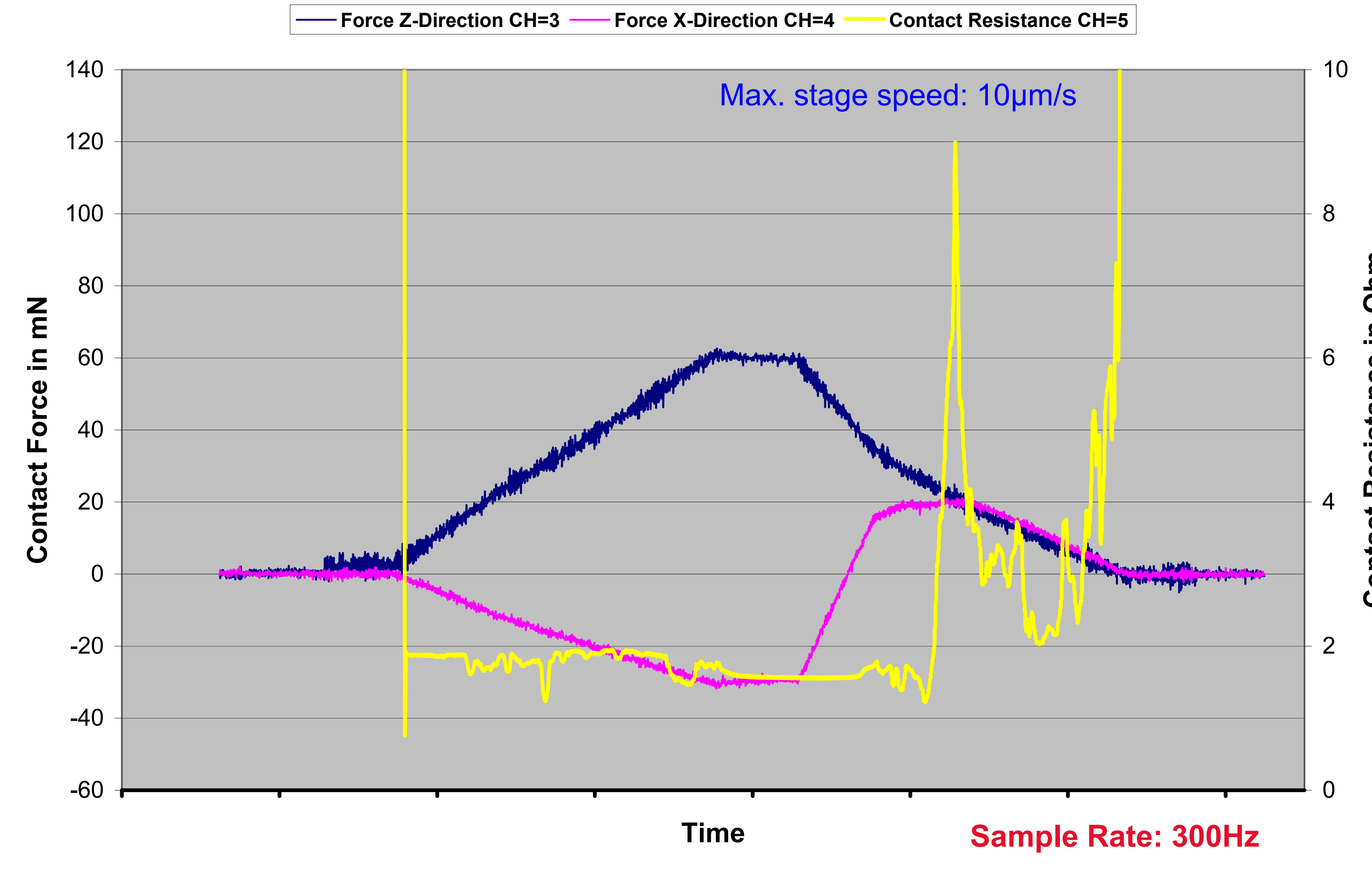
Measurement on Aluminum Wafer (max. OD = 50µm)



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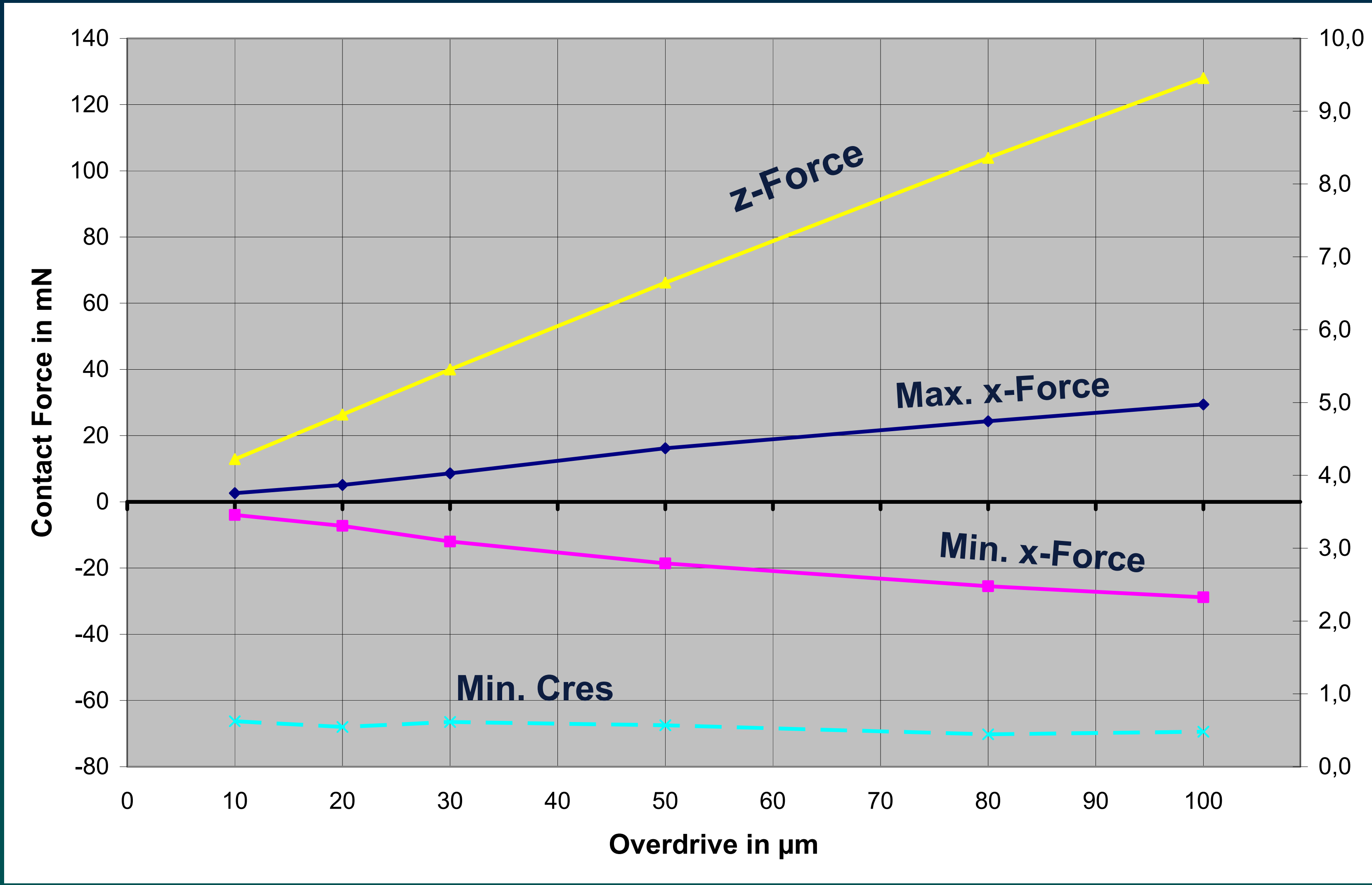
Probe Parameters vs. OD on Gold



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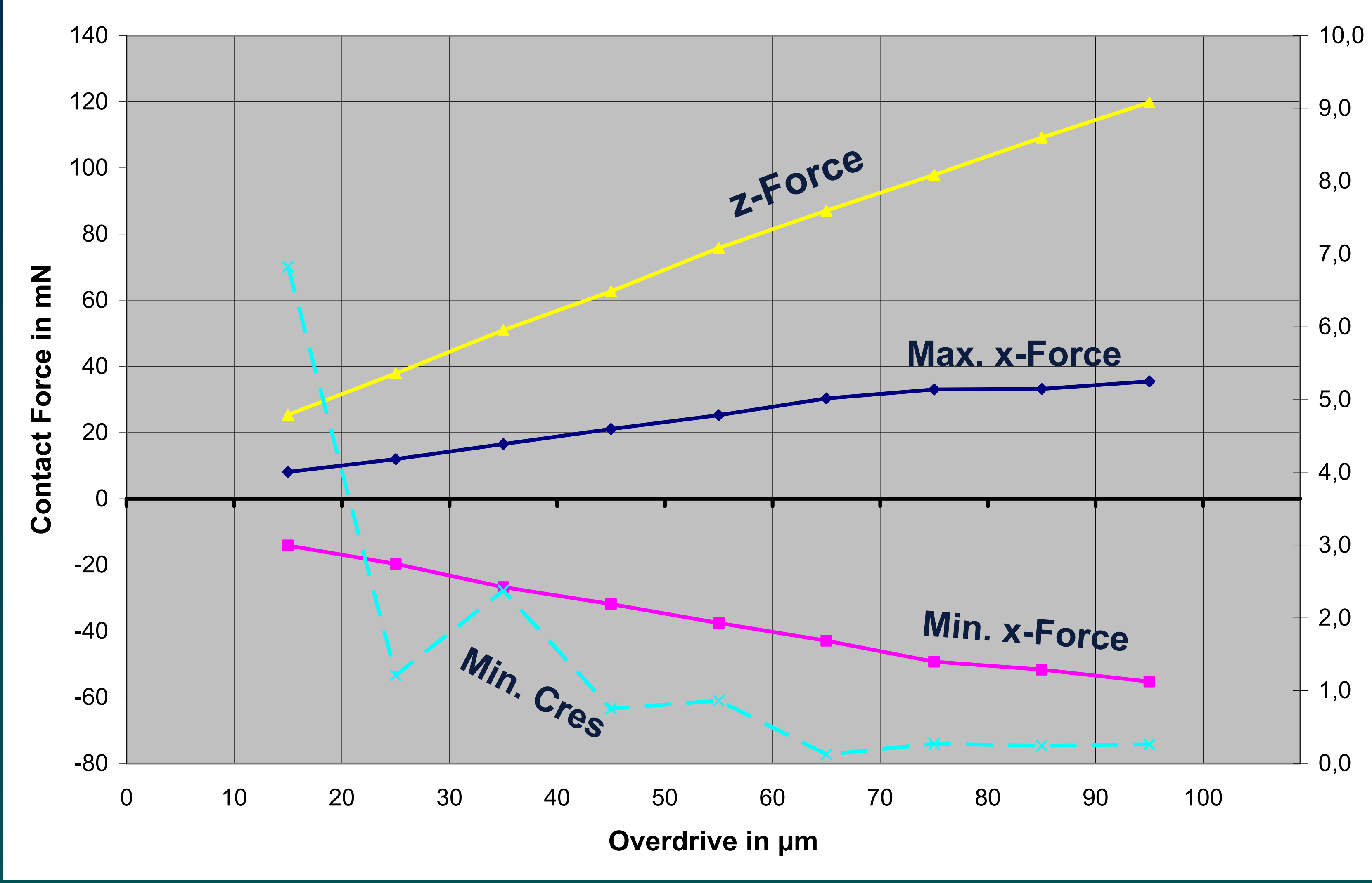
Probe Parameters vs. OD on Aluminum



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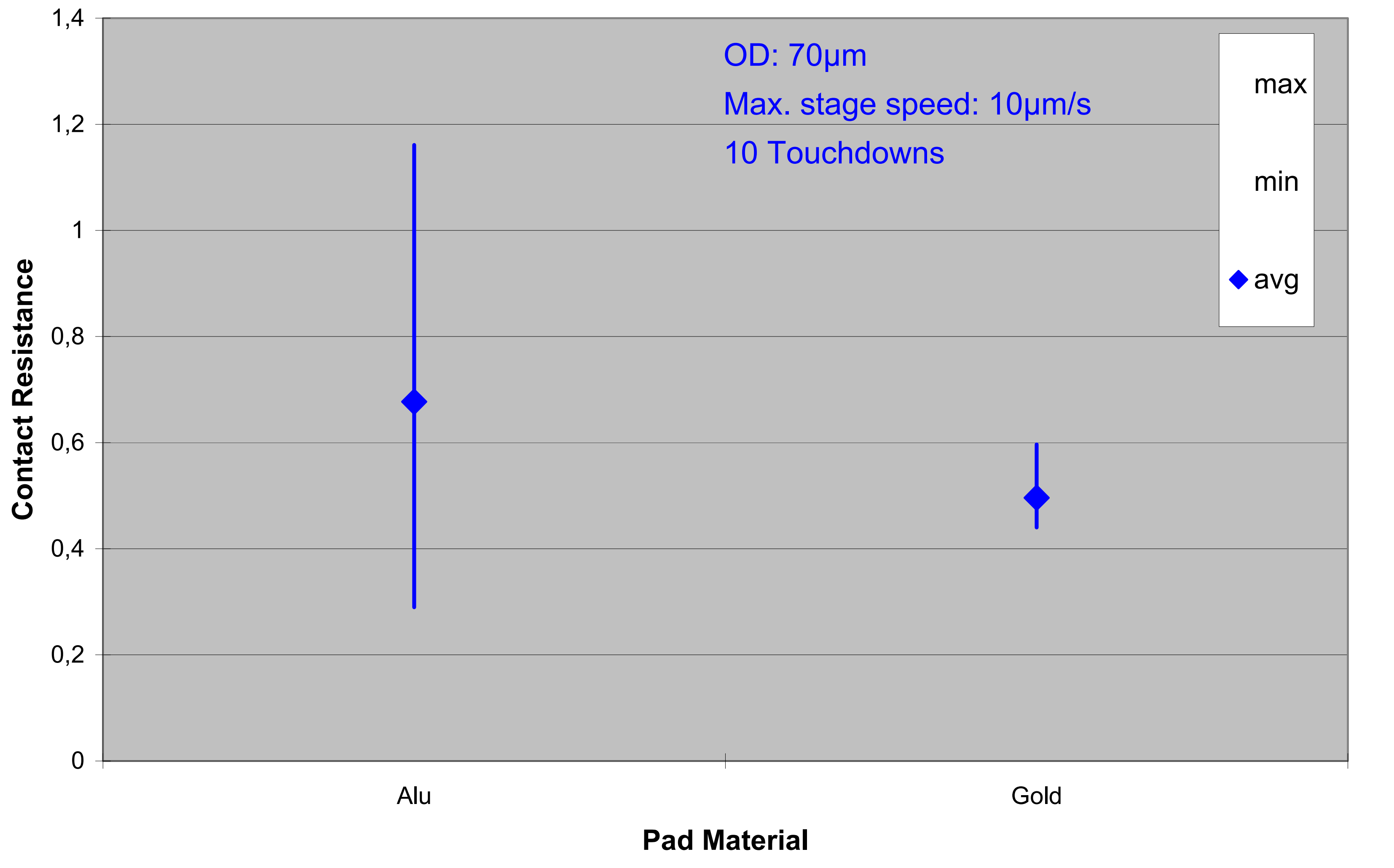
Cres Distribution



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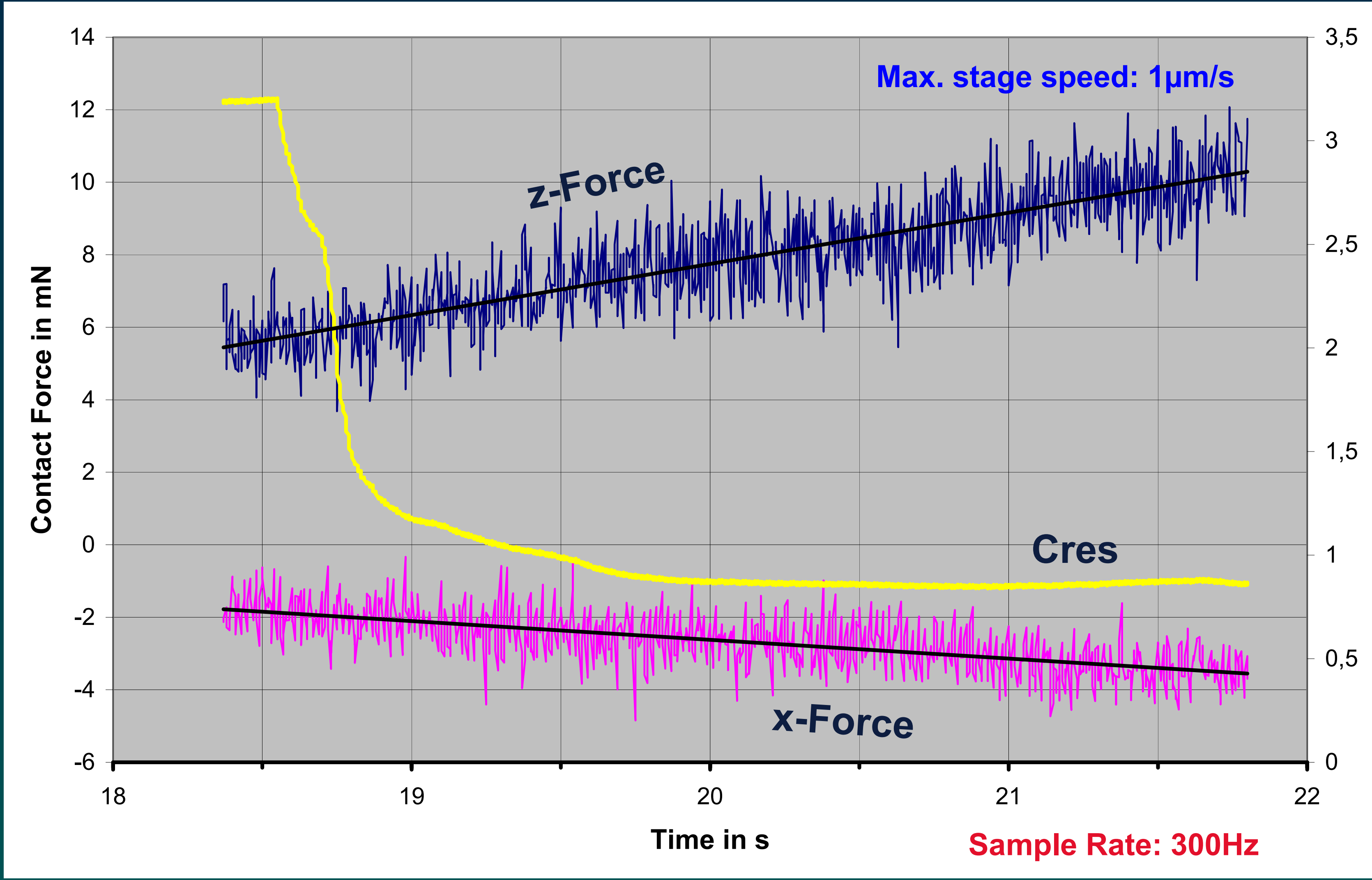
Quasi-Statical Measurement on Gold



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Summary

- A novel tool was demonstrated real-time measurements of lateral, vertical forces and contact resistance
- External noise must be minimized to improve accuracy
- Capable to all probing technologies
- Preliminary results show, that …
  - Contact resistance on Au more stable than on Al (Oxide Film?)
  - Change of sign of lateral force during z-up/-down for cantilever probe
  - Coefficient of friction between 0.2 and 0.5 (material dependent)
  - Average Cres and distribution on Au smalller than on Al
  - Holm Theory to be verified

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Next Steps

- Elimination of disturbing factors (cabling, acoustic noise, ESD, vibrations)
- Labview Programming of z-stage
- Image processing software for microscope
- Verification of contact resistance model („Holm Theory“)
- Investigation of different probe types (vertical, MEMS, etc…)
- Influence of dynamics
- Analysis of new pad materials
- Oxide / low-k crack generation and avoidance
- Automated x- and y-stage control

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