SW Test Workshop

Semiconductor Wafer Test Workshop

2017

# A Novel Superior Low Force Probe Geometry Enabling Probing on Micro Bumps with Very Small Pitches

FEINMETALL Contact Technologies

Texas Instruments


Matthias Schnaithmann (FM)

Achim Weiland (FM)

Gunther Böhm (FM)

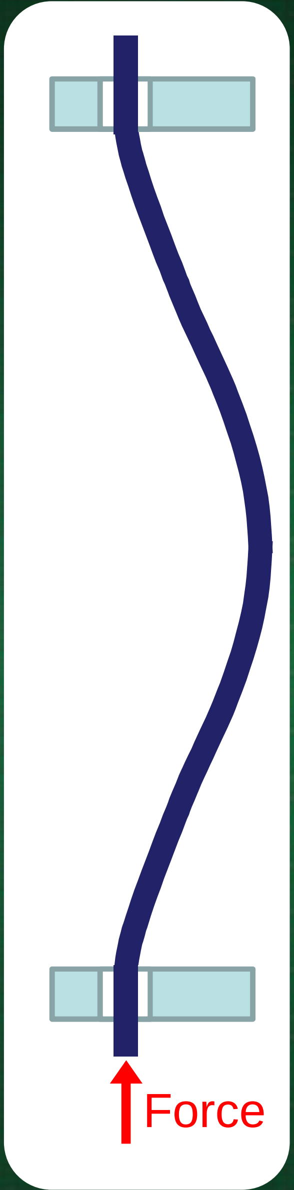
Franz Steger (TI)


June 4-7, 2017

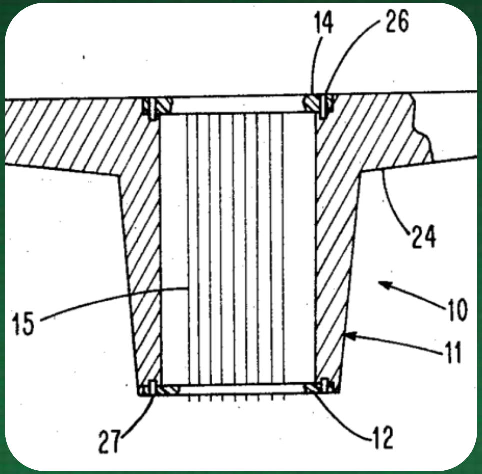
# Overview

- History of the Buckling Beam
- Striped Beam Principle
- Design Requirements
- Qualification Test Results
- Preliminary Production Test Results
- Summary & Follow-On Work

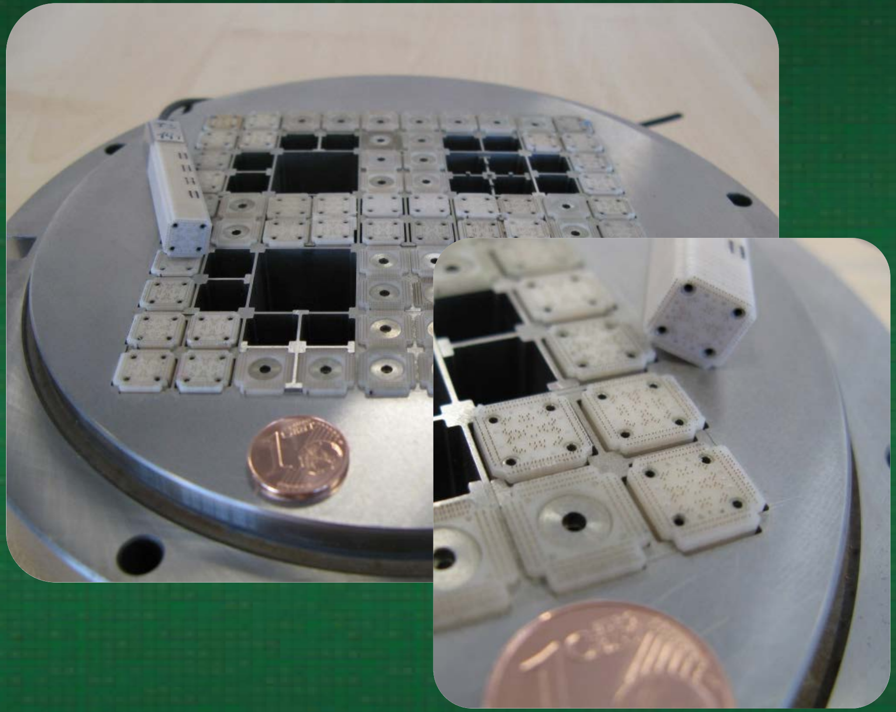
# History of the Buckling Beam



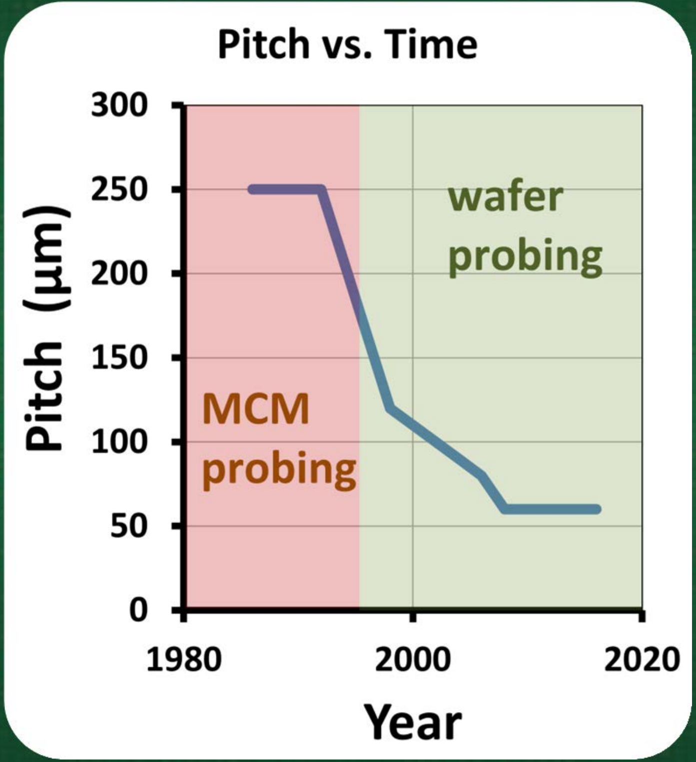

Buckling beam:
fundamental
principle




First patent:
US 3.806.801
Ronald Bove/IBM
1972



Modular testhead for multilayer ceramic
100mm (4‘‘) size, 40.000 probes,
250µm pitch, Feinmetall 1992




Changing pitch over time

# Development of Contact Probes

## Challenges of Future Contact Probes

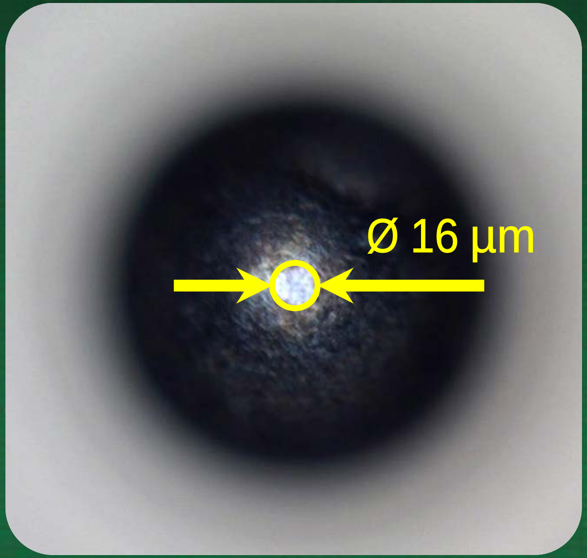
Low force:

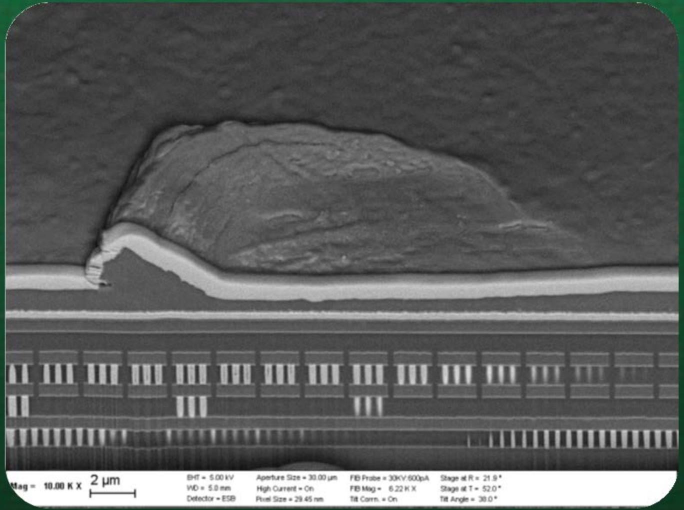
- è Small damages to pads and bumps
- è Pad over active area probing

Short length:

- è Lower el. resistance
- è Better heat dissipation
- è Lower inductance
- è Easier probe assembly

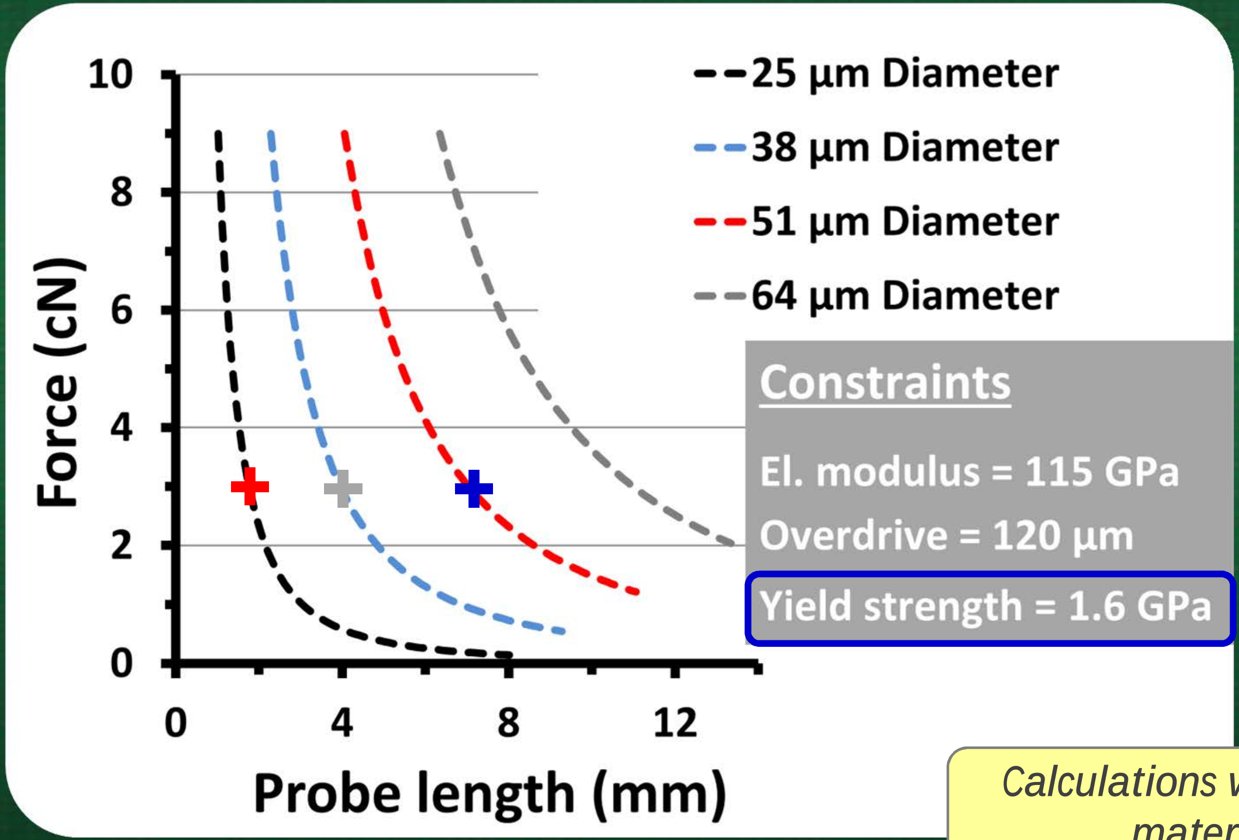
(Lower el. resistance, Better heat dissipation → Higher CCC)

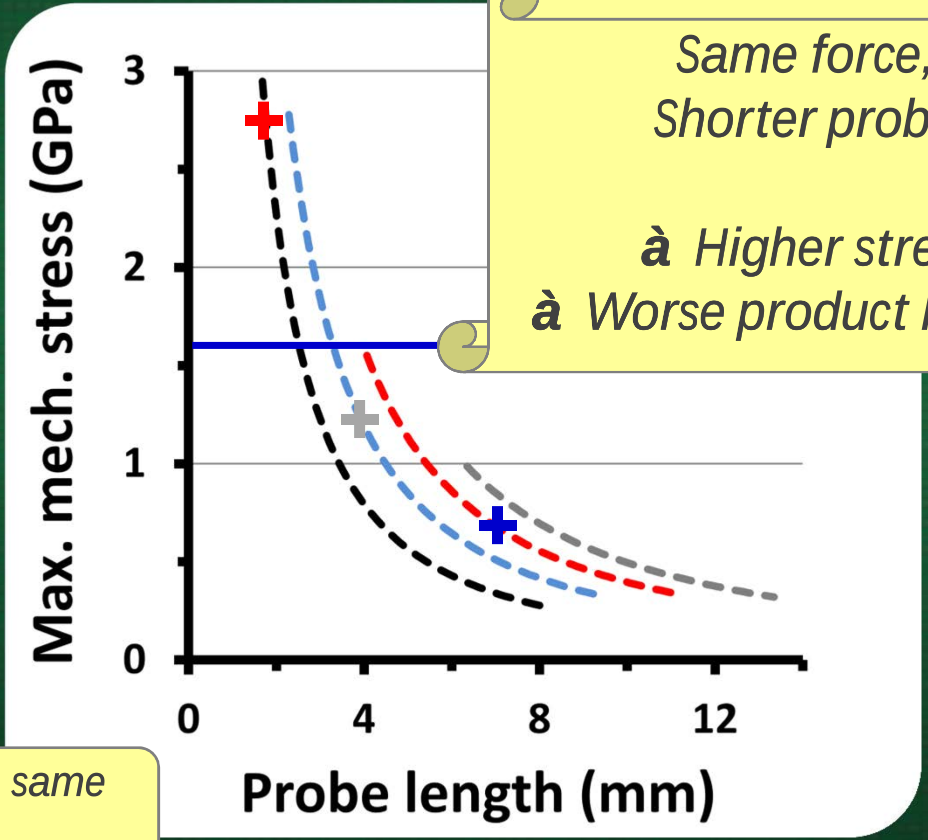


# Buckling Beam Principle

## Mechanical Limits of a Single Buckling Beam



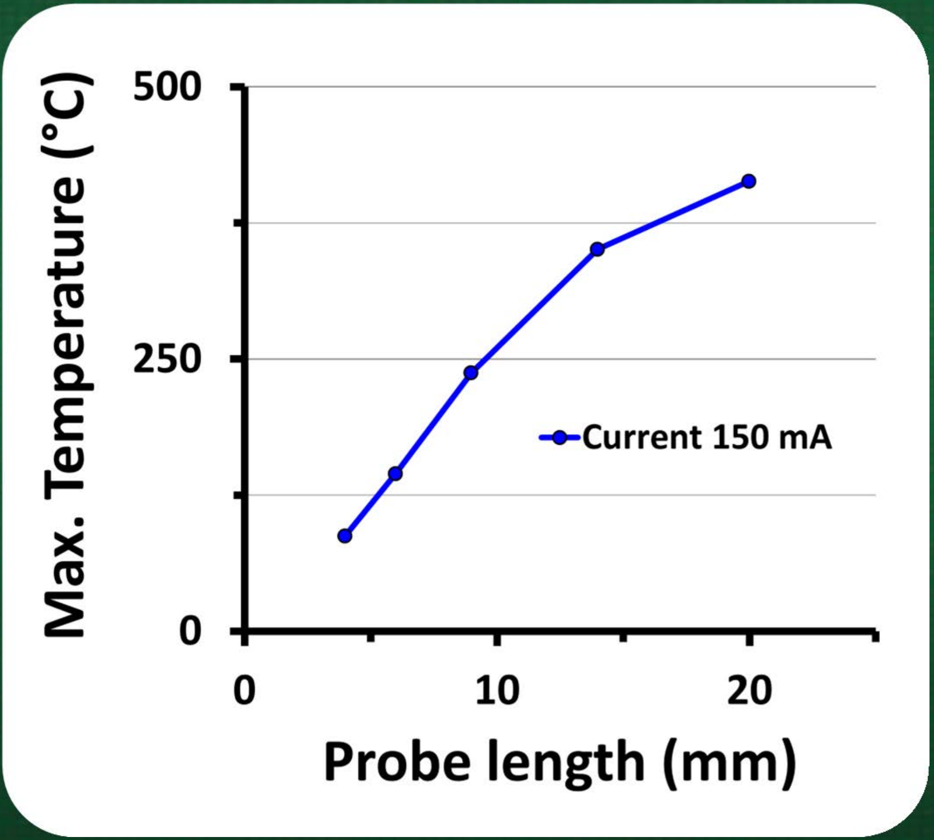

*Same force,*
*Shorter probe*

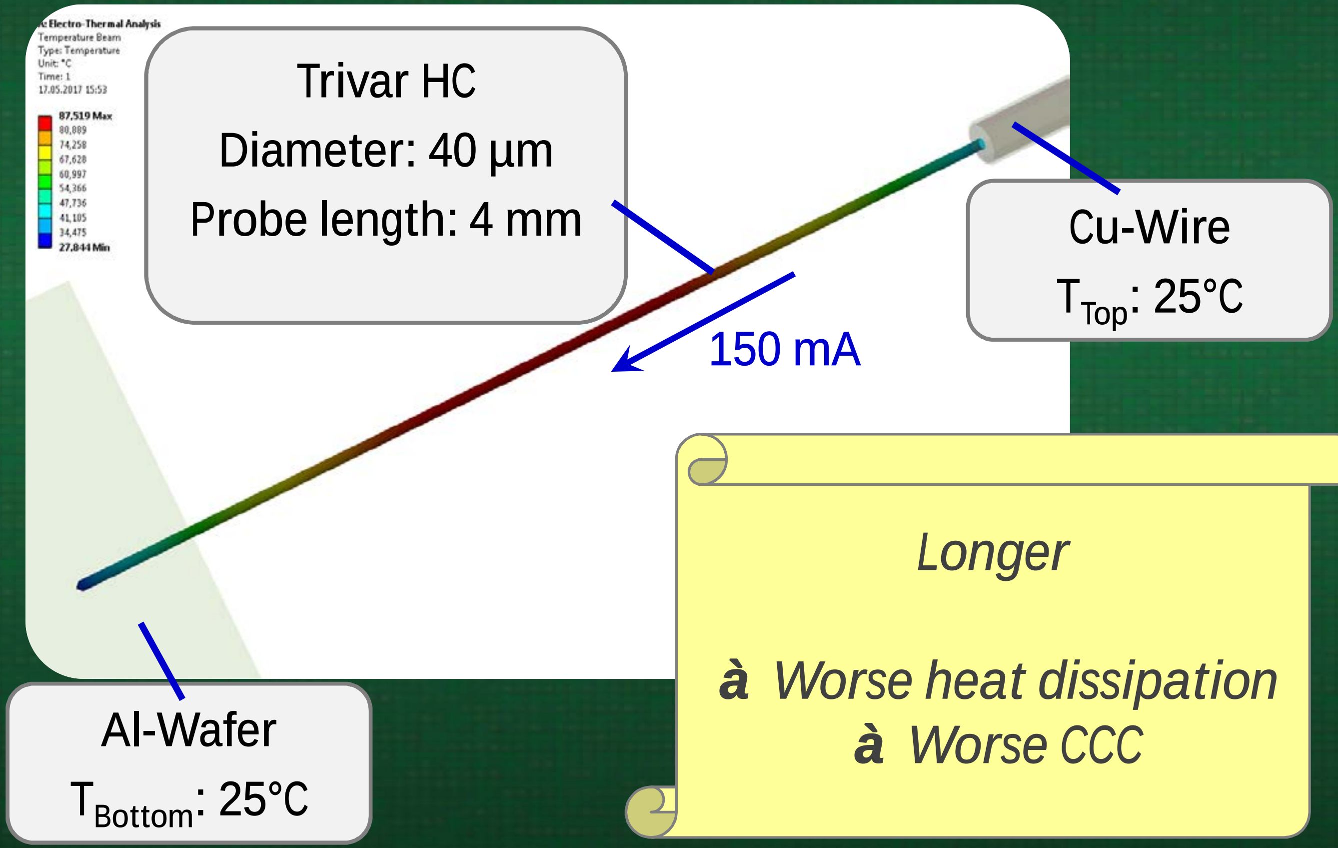
à *Higher stress*
à *Worse product lifetime*

*Calculations with same material*

# Buckling Beam Principle

## Electrical Limits of a Single Buckling Beam (FE-Simulation)



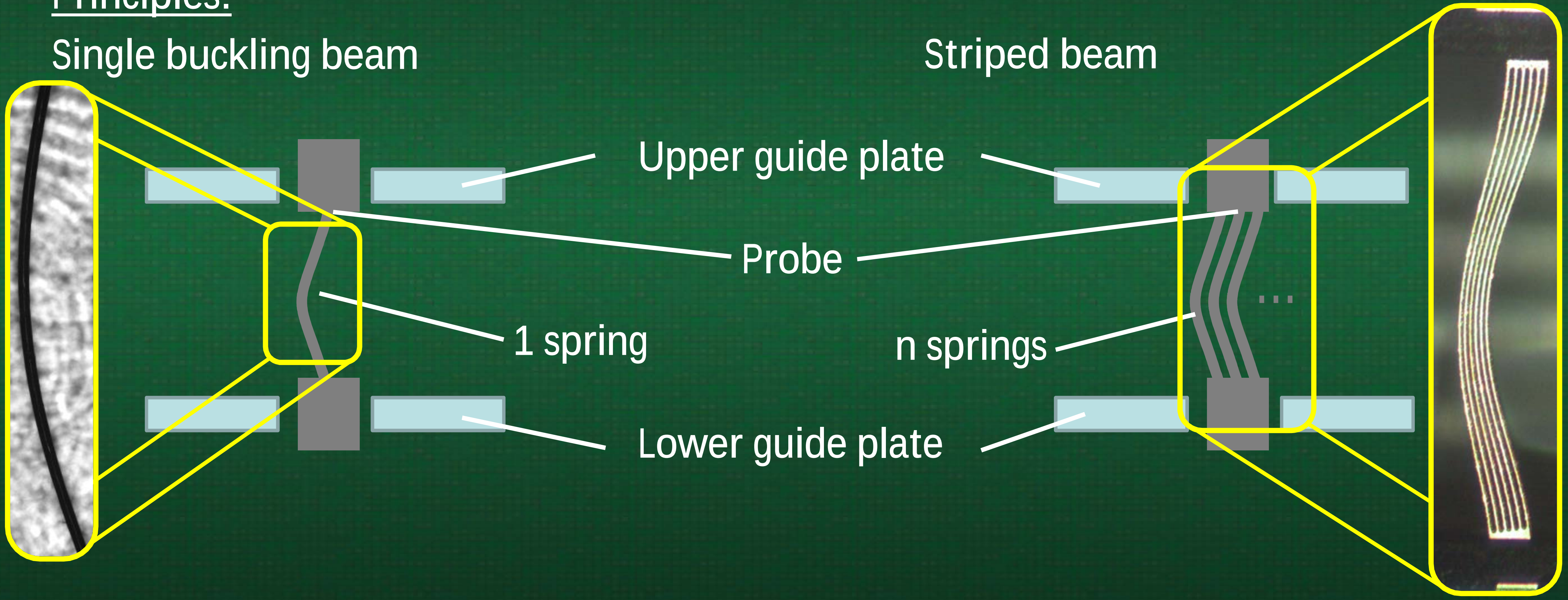

*Longer*

*à Worse heat dissipation*
*à Worse CCC*

# Striped Beam Principle

## What is a Striped Beam?

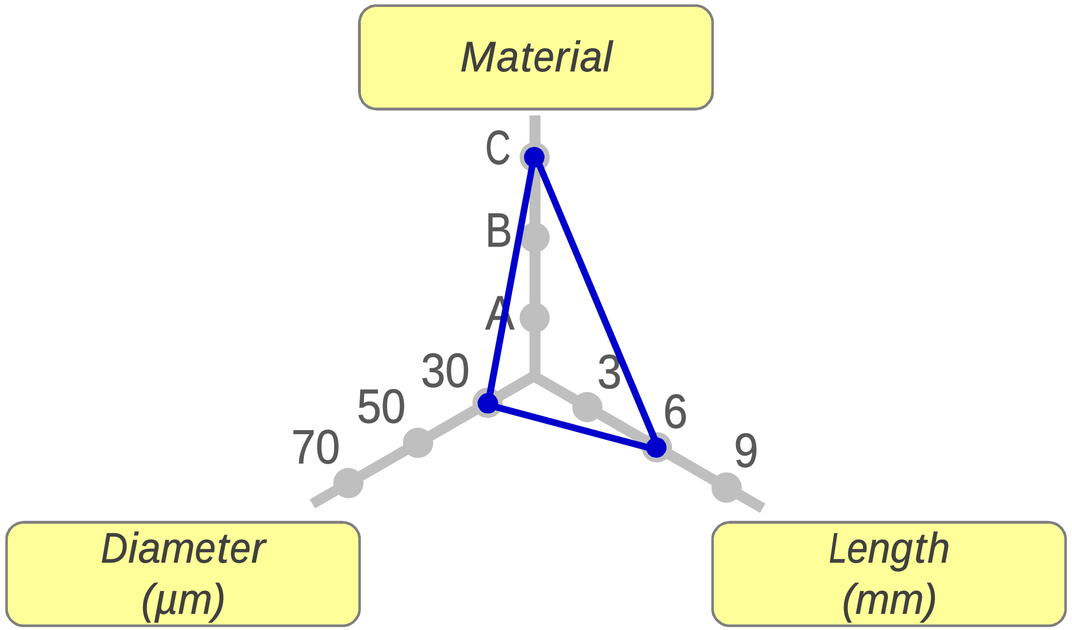
Principles:



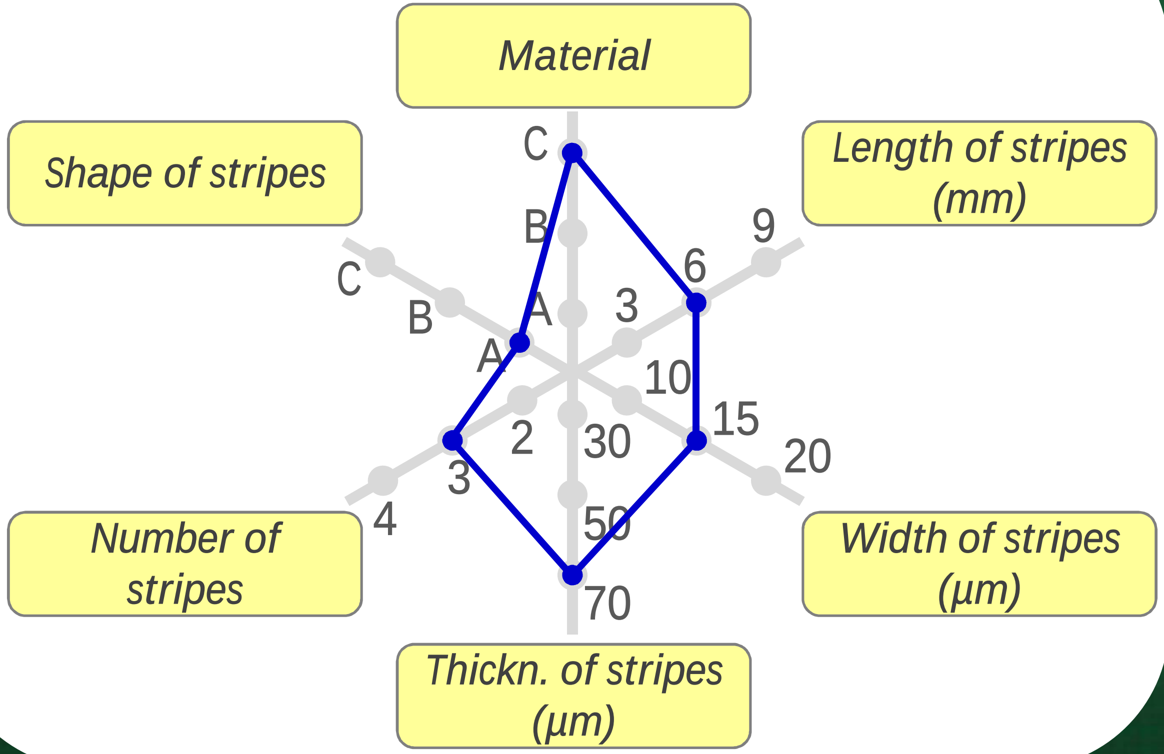
# Striped Beam Principle

## Comparison of Design Parameters

### Single buckling beam

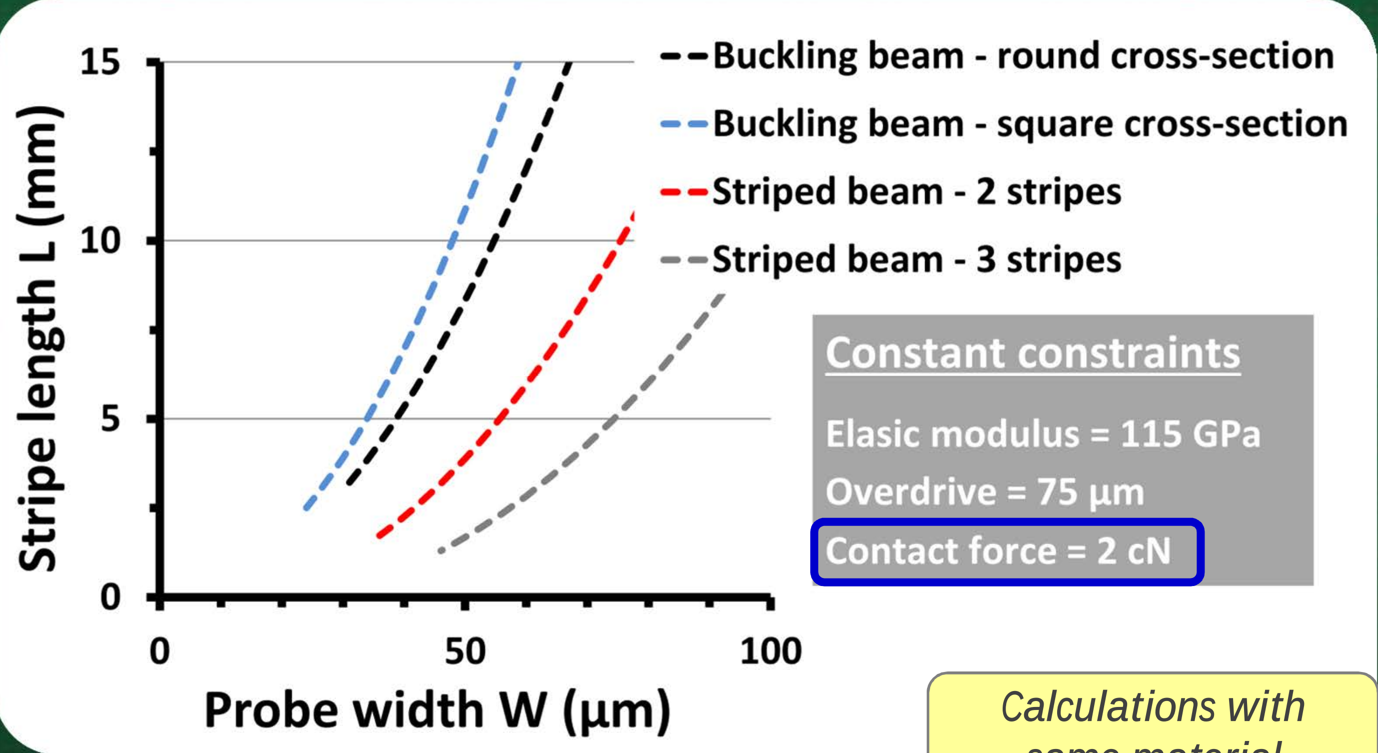



### Striped beam

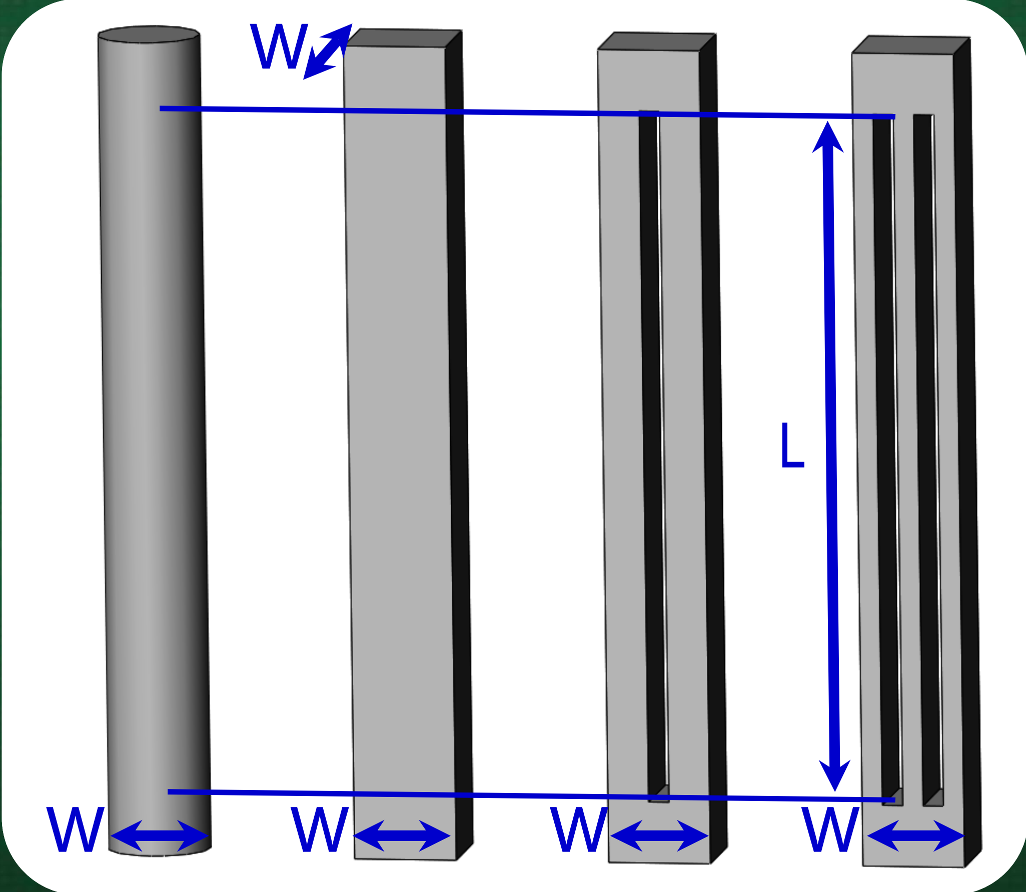


# Single Buckling vs. Striped Beam Principle

## Probes with same force

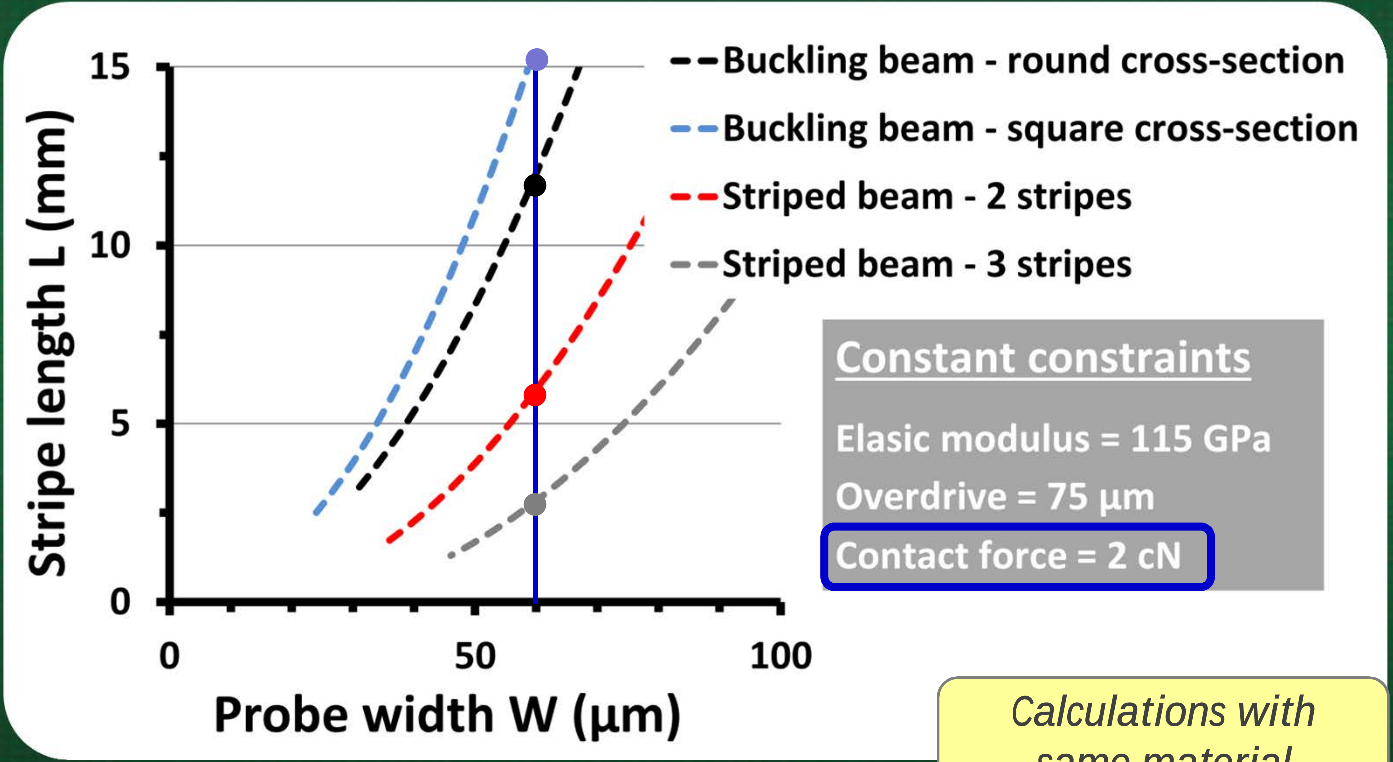



*Calculations with same material*

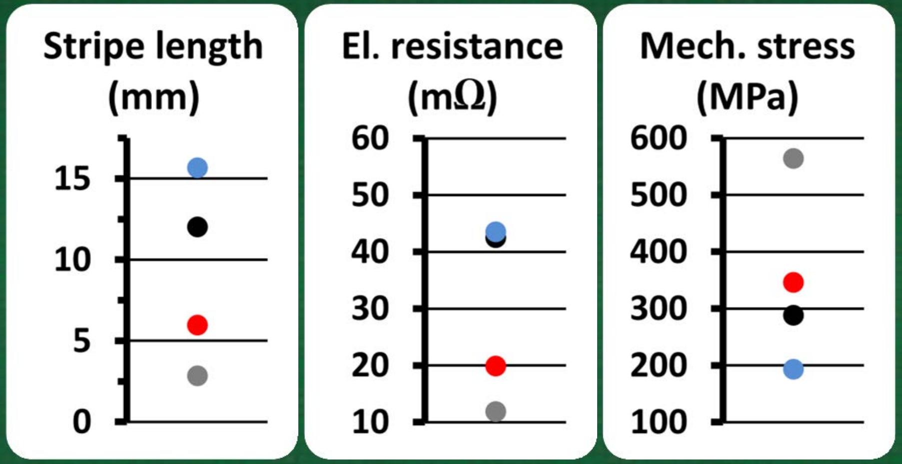


# Single Buckling vs. Striped Beam Principle

## Probes with same force




*Calculations with same material*



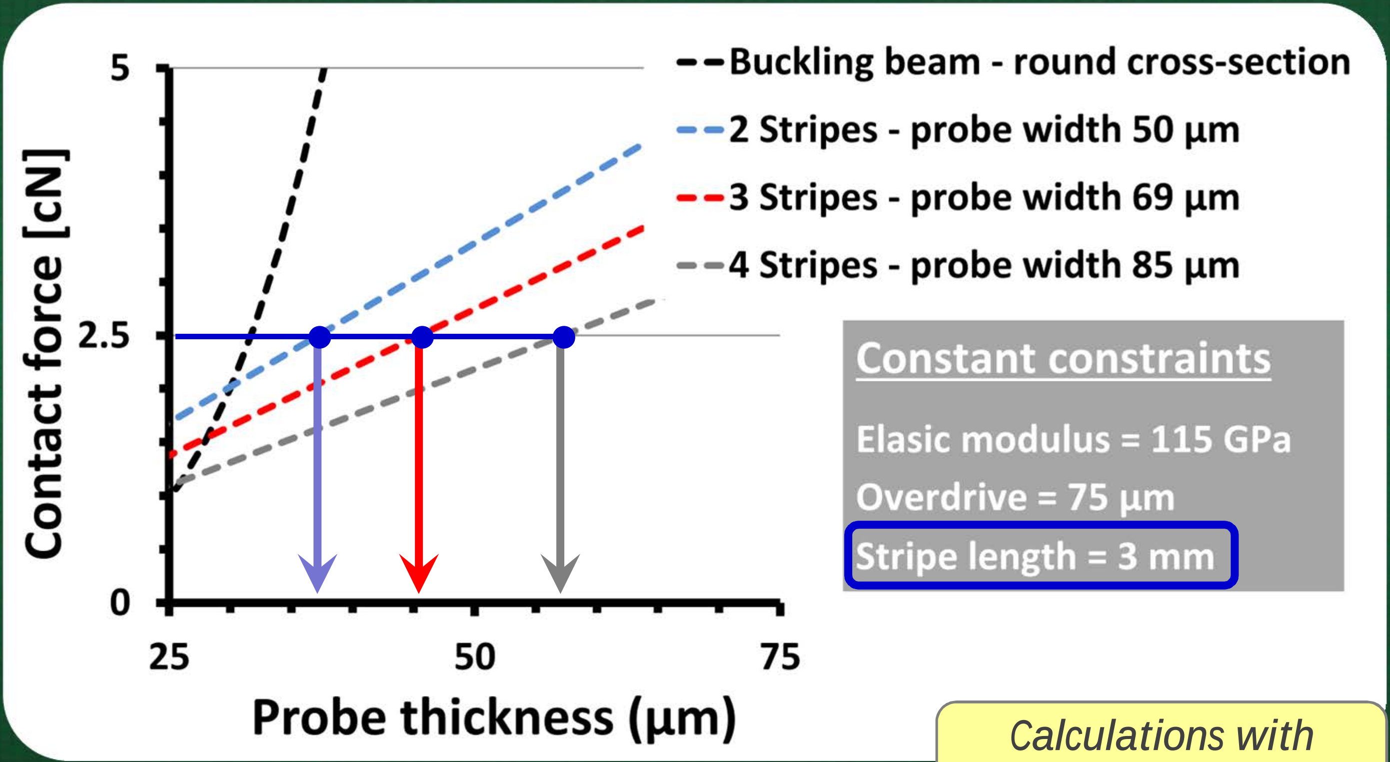

*Shorter length,*
*Lower el. resistance*

*Attention: Mech. stress*

Matthias Schnaithmann

# Striped Beam Principle

## Probe family with same length and force




| Parameter | 2 Stripes | 3 Stripes | 4 Stripes |
|---|---|---|---|
| Probe thickness x width | 38 µm x 50 µm | 46 µm x 69 µm | 57 µm x 85 µm |
| El. resistance | 20 mΩ | 13 mΩ | 9 mΩ |

*Calculations with same material*

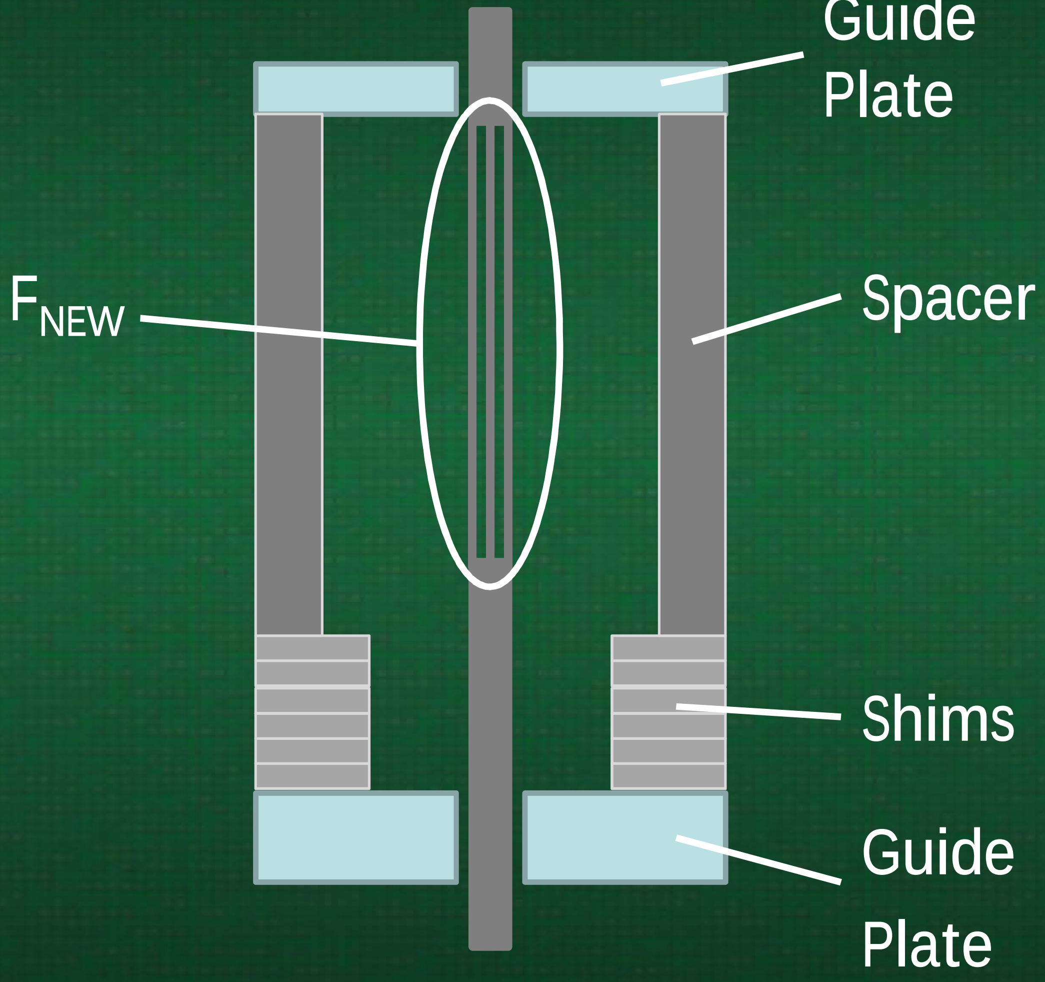
*Same length,*
*Same force*

*à Different pitches*
*à Different resistances*

# Striped Beam Principle

## Striped Beam Principle - Advantages

- High variety of designs possible
  - à Product family
    of *same force* and *length* possible
- Short length
- High current
- Low force
- Force doesn't change with lifetime



# Striped Beam Principle

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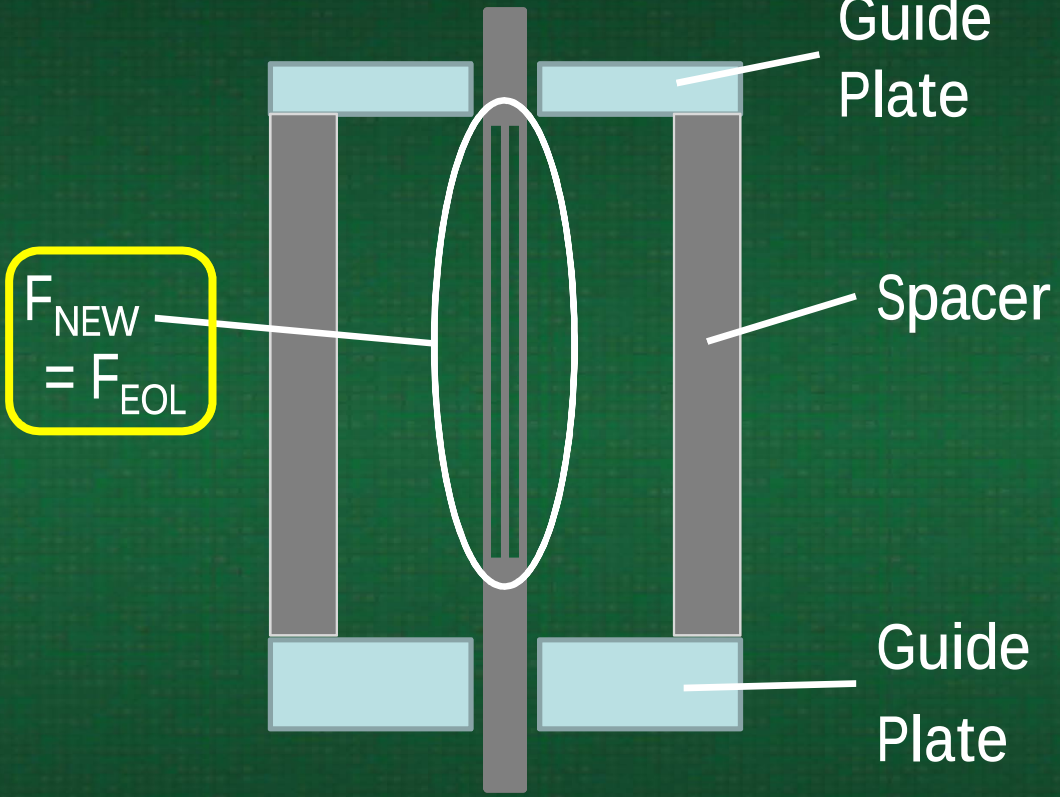
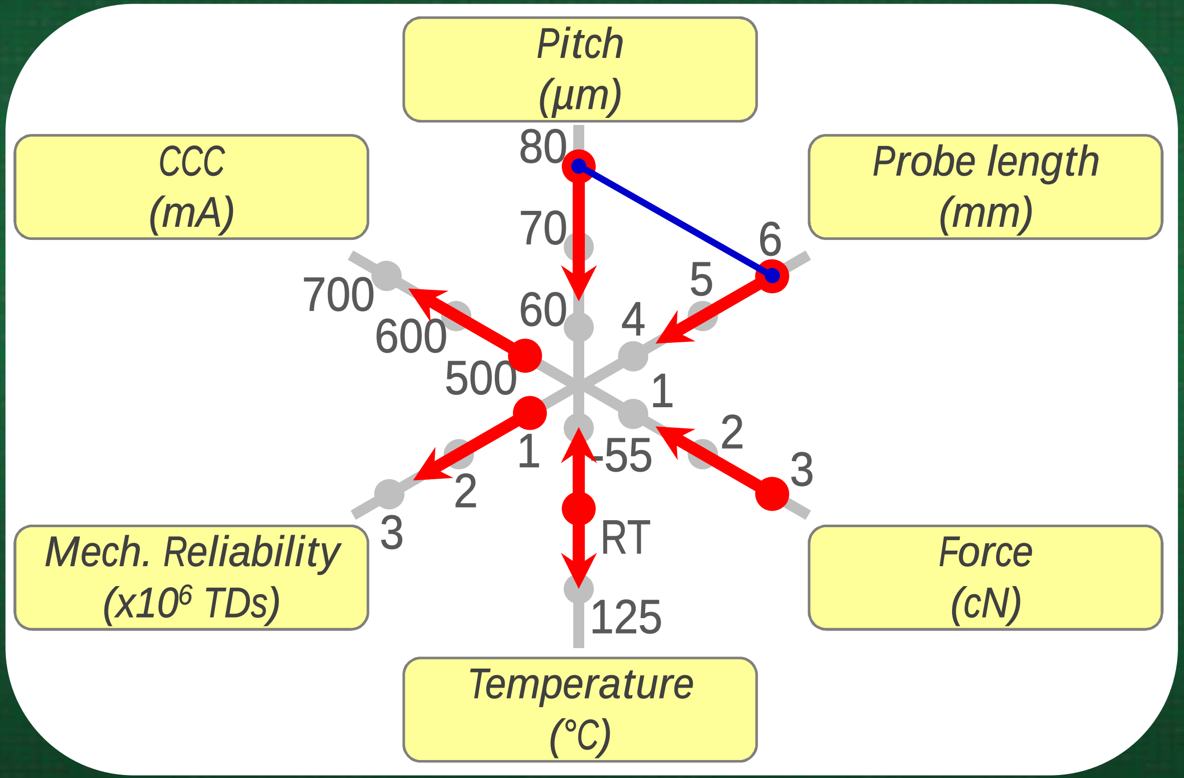
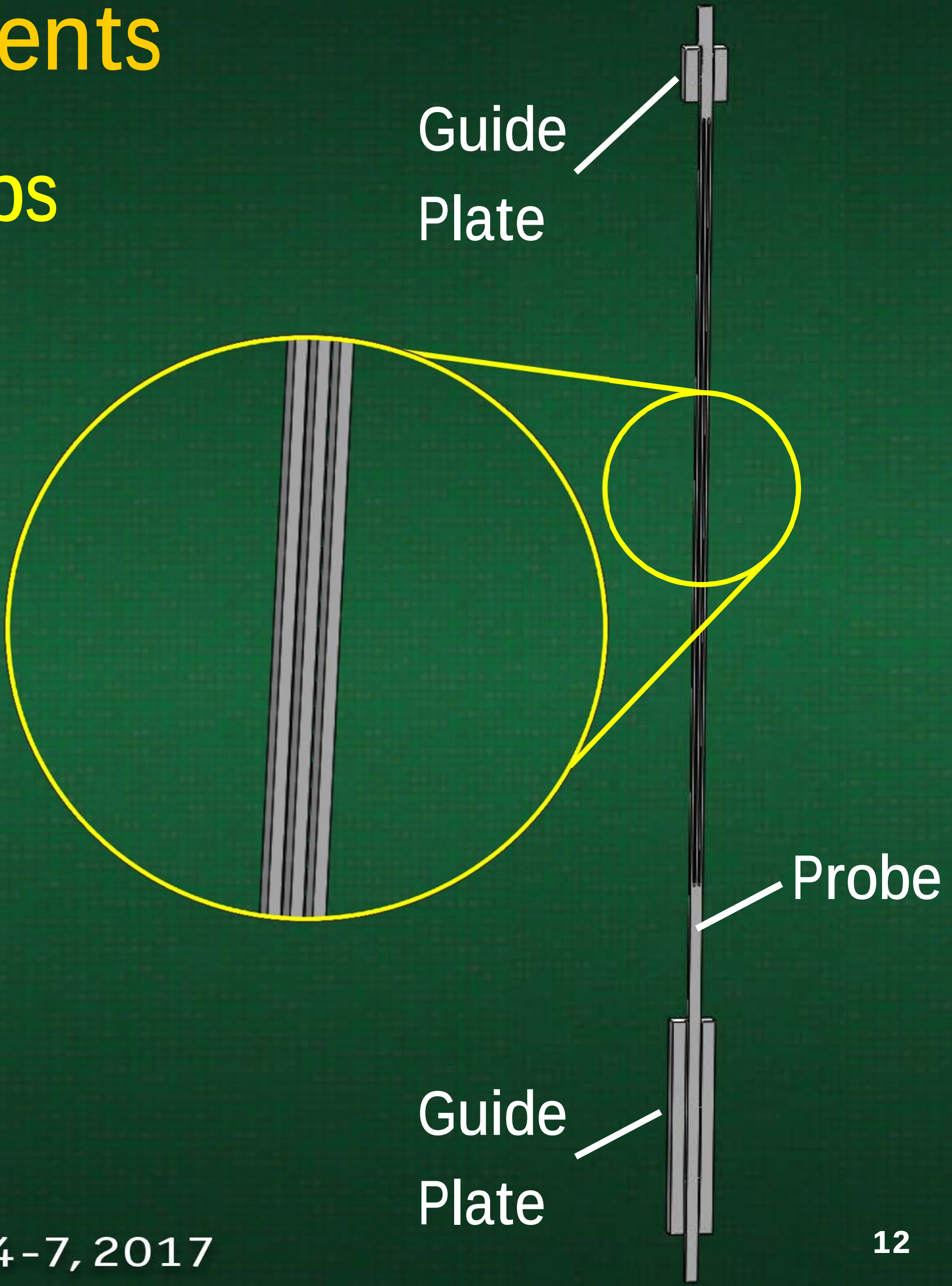


# Design Requirements

## Requirements for Probing on Micro Bumps

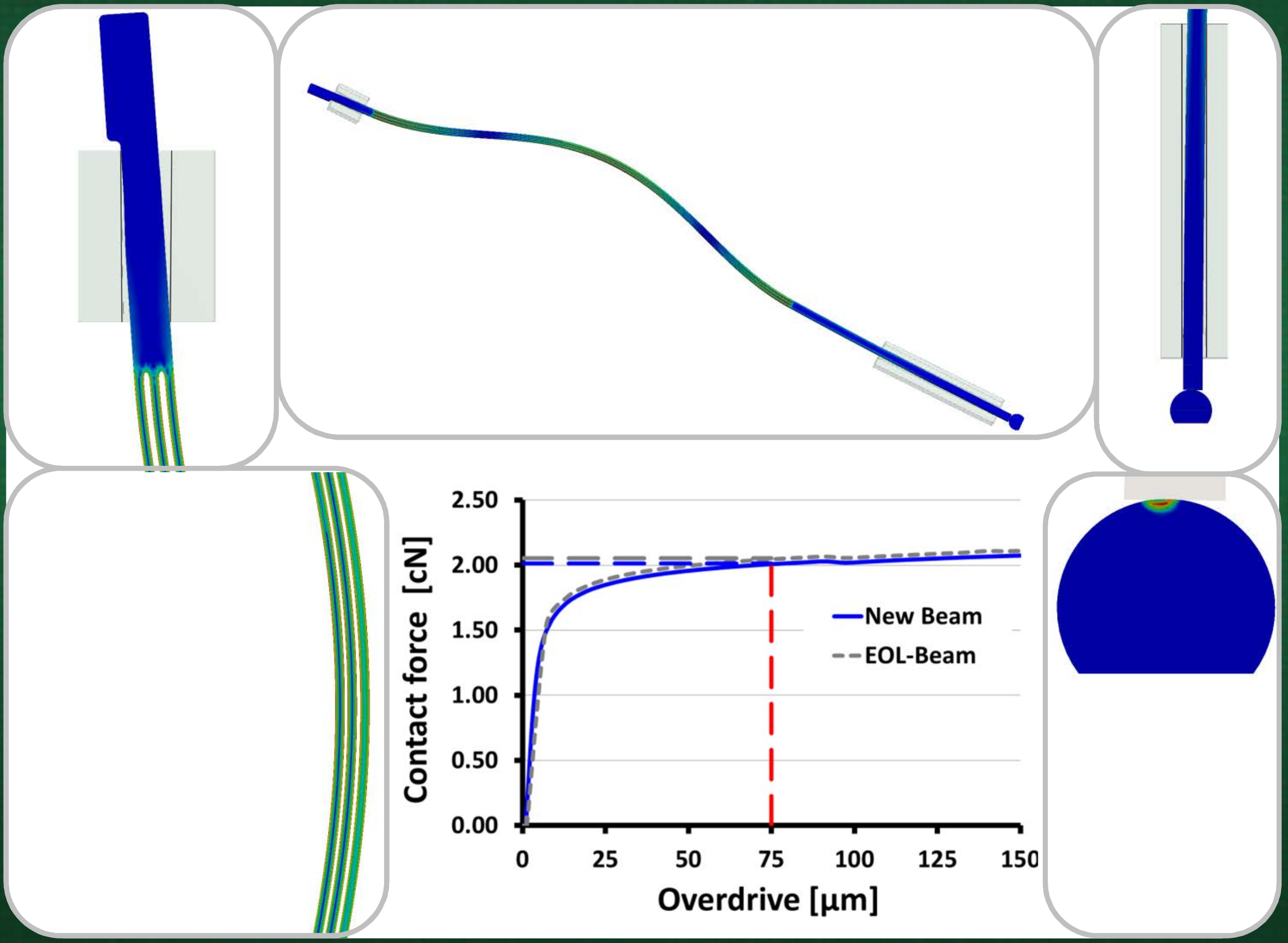


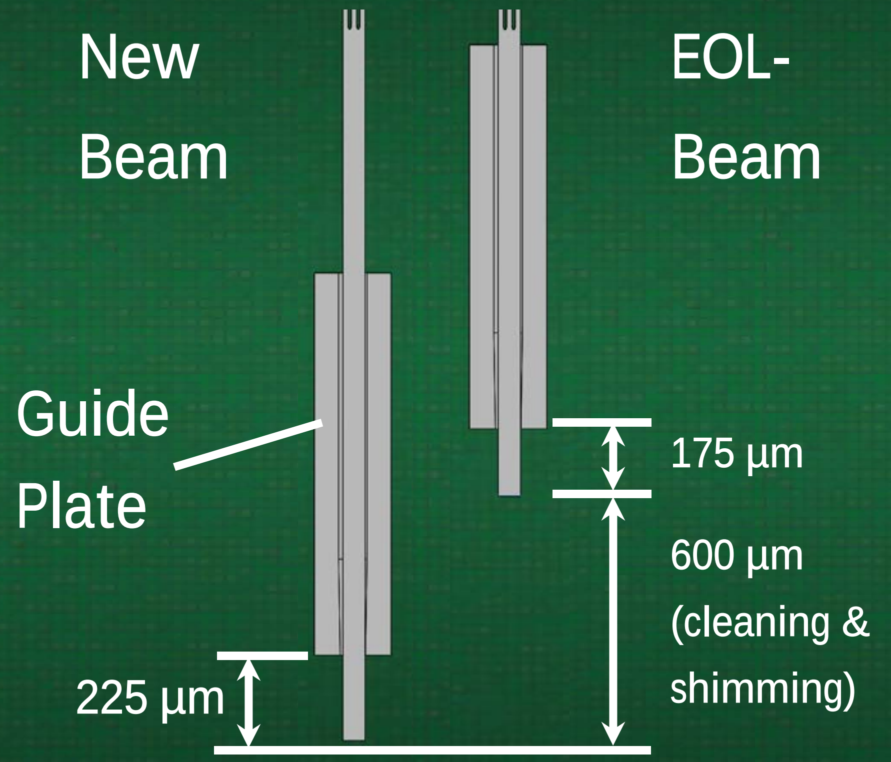




Matthias Schnaithmann

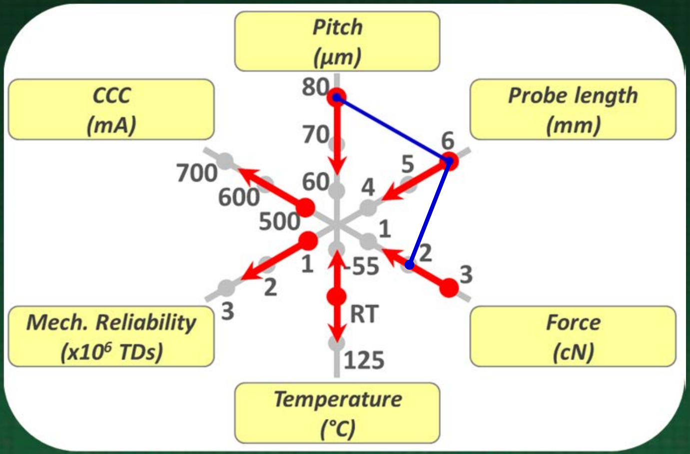
# Qualification Test Results

## Mechanical simulation



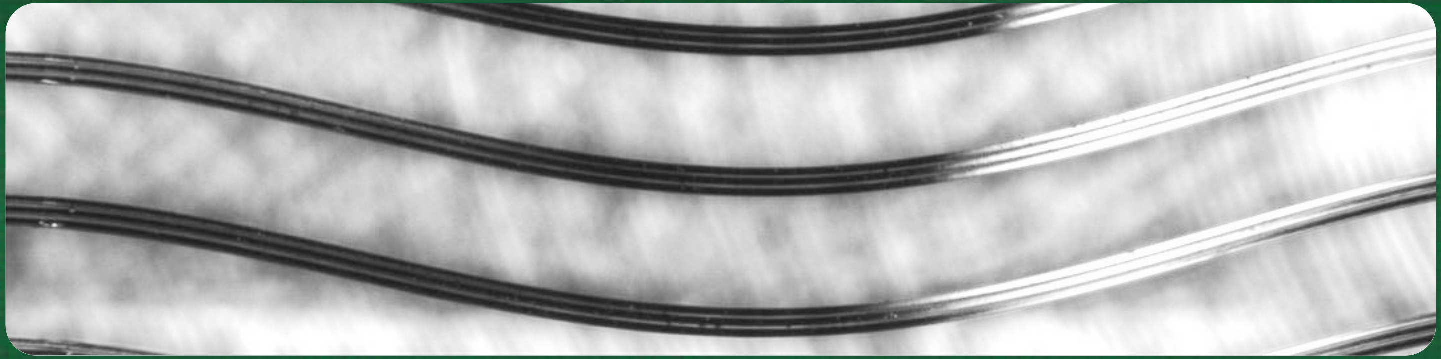



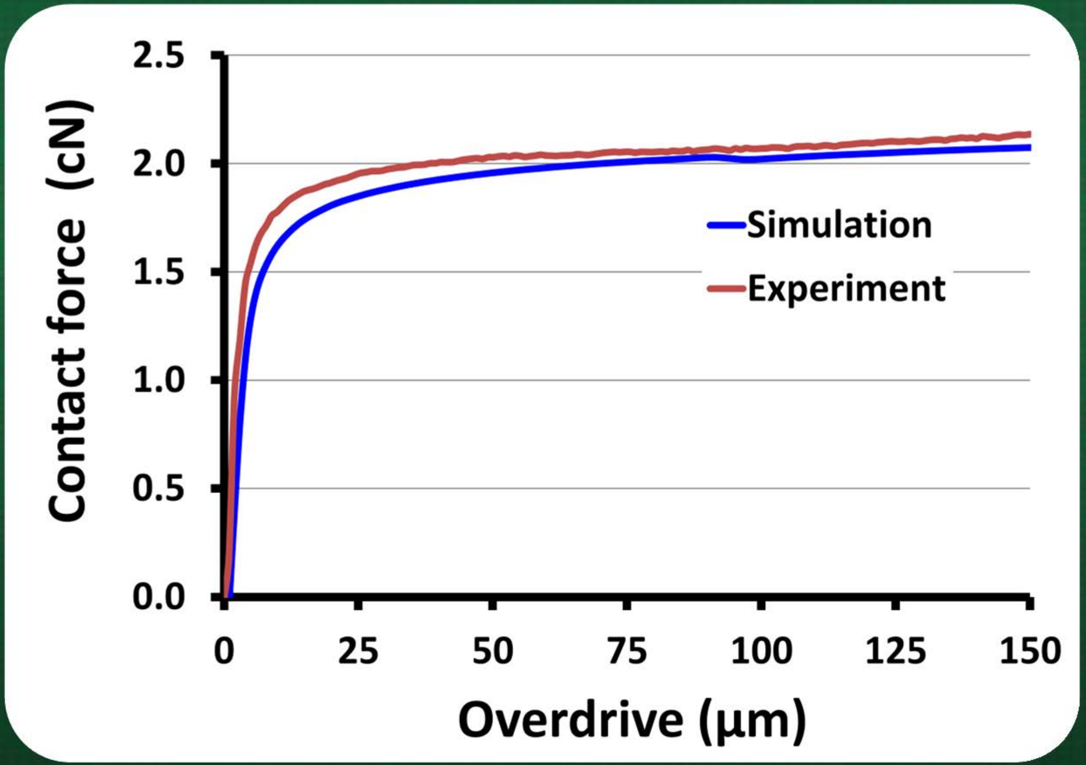
# Qualification Test Results




## Experiment vs. Simulation – Contact Force

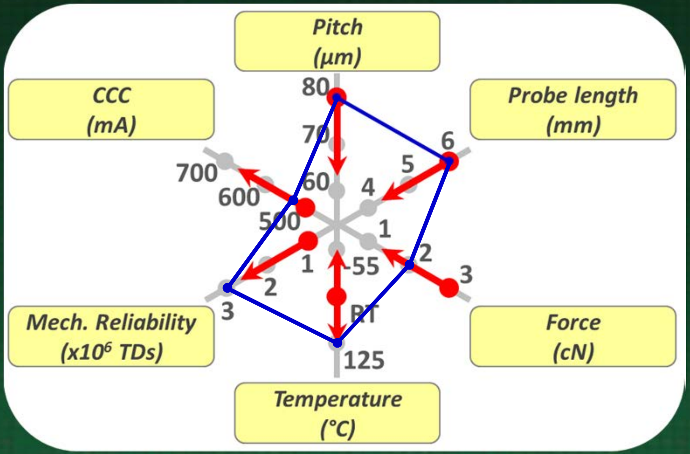
Waferside Testerside






*Good correlation*

*Experiment*
*vs.*
*Simulation*

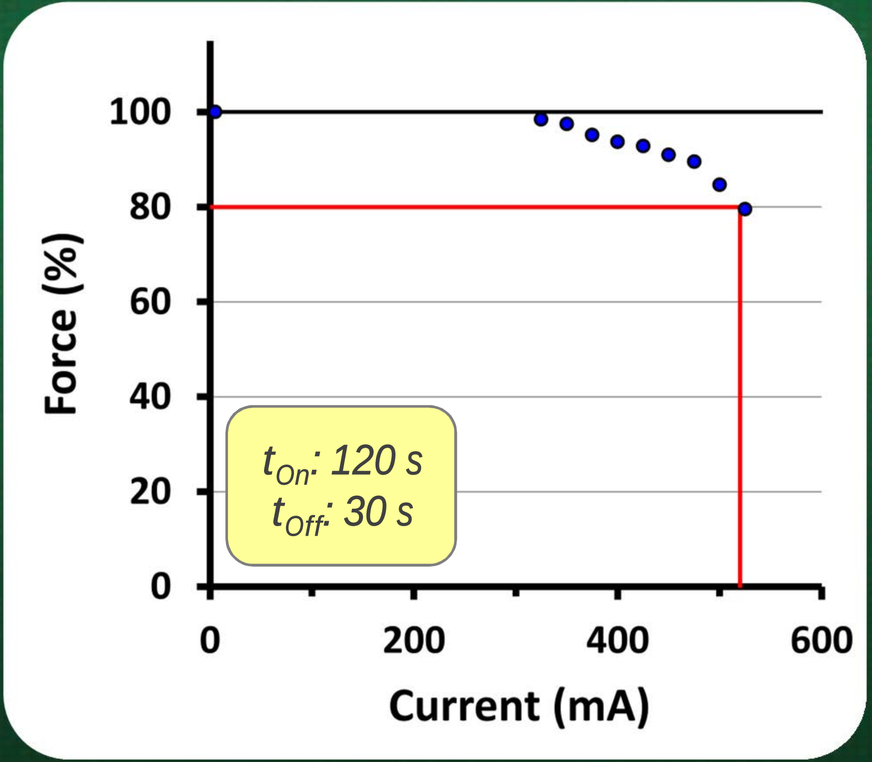


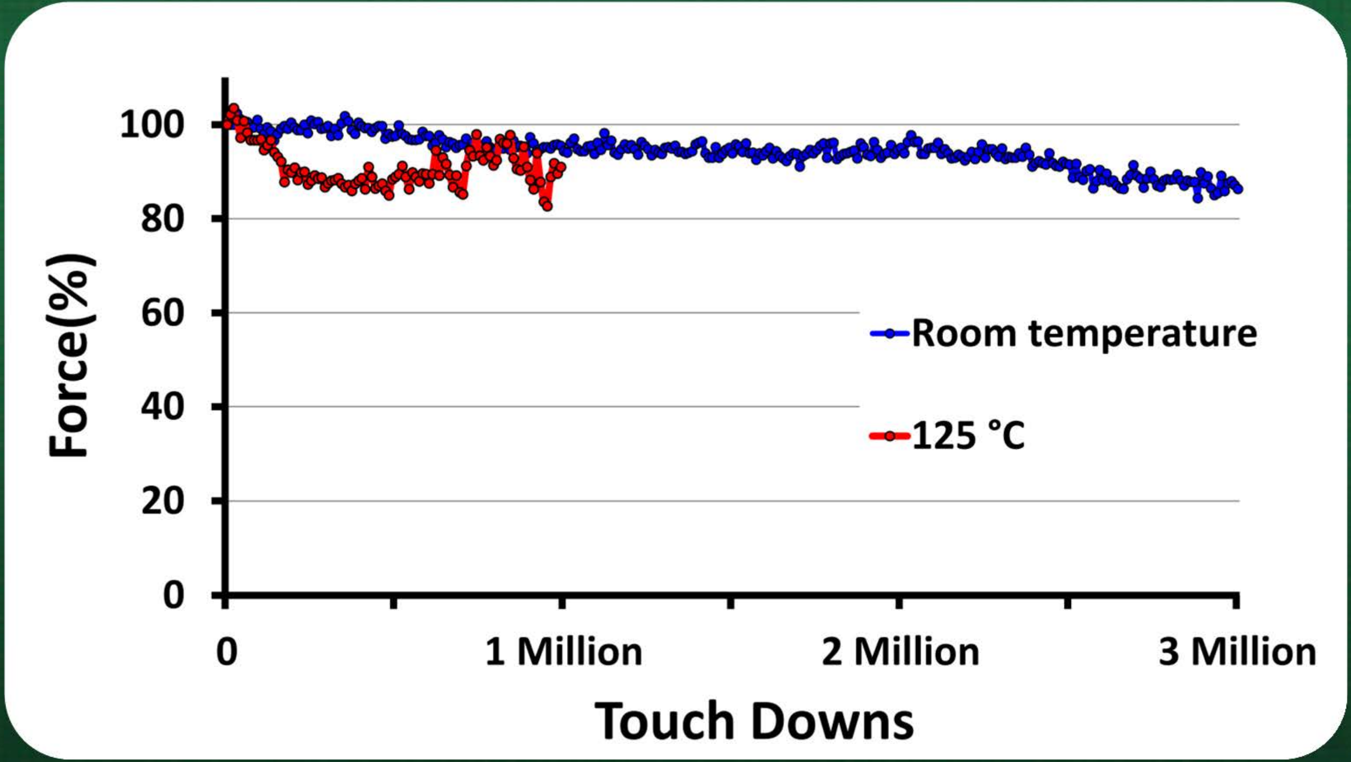

# Qualification Test Results

## Experiment – CCC and Mechanical Reliability

*According to ISMI Guideline*
*Measurement @ 75 µm OD on Rh @ RT*

*Measurement*
*@ 75 µm OD*



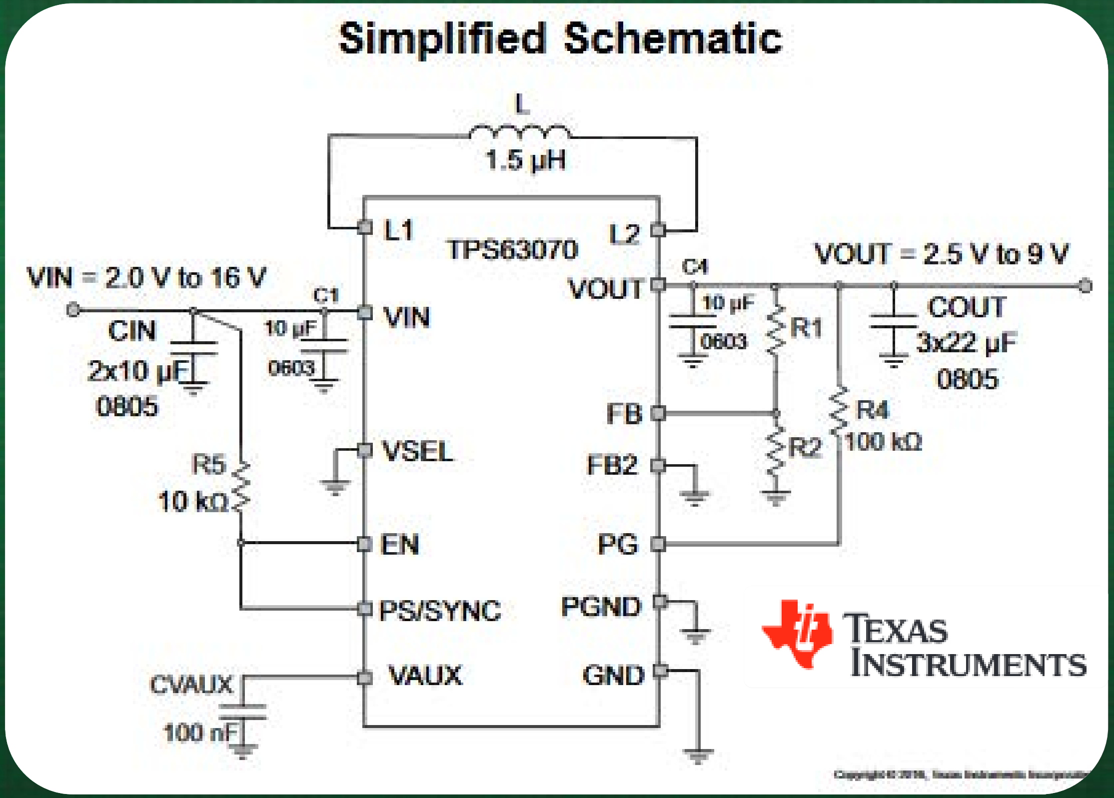
# Preliminary Production Test Results

## Test vehicle: Texas Instruments TPS63070

- 2-V to 16-V Buck-Boost converter with 3.6-A switch current
- Low pin count (23 pins)

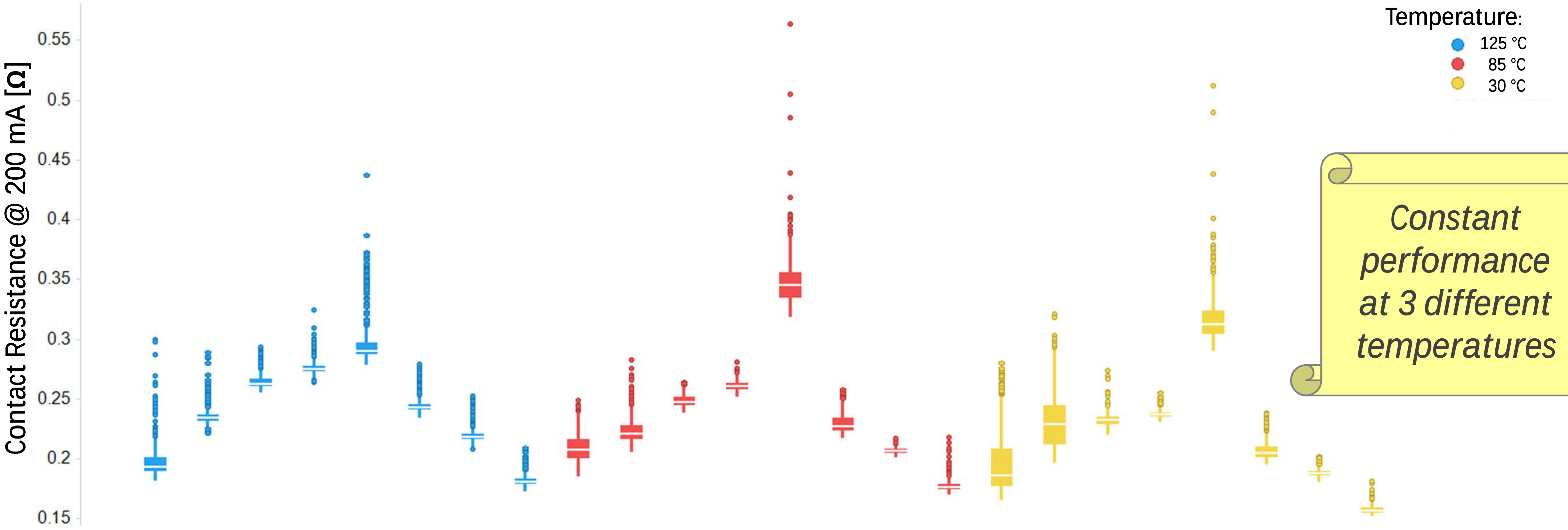
## Probe Test Parameters

- ETS364 with 6.2” probe card
- UF3000 prober (300 mm wafers)
- Octal side (2x4 tight matrix)
- Probe on µ-Bump (diameter ~90 µm)
- Different currents (up to 2 A could be applied)
- Different temperatures (30 °C – 125 °C)



# Preliminary Production Test Results

## Tri-Temp results (Contact resistance per temperature and site)




| Temp. | 125 °C | | | | | | | | 85 °C | | | | | | | | 30 °C | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Avg. [Ω] | 0.198 | 0.235 | 0.264 | 0.276 | 0.296 | 0.244 | 0.219 | 0.182 | 0.209 | 0.224 | 0.248 | 0.261 | 0.348 | 0.229 | 0.206 | 0.177 | 0.194 | 0.231 | 0.232 | 0.237 | 0.317 | 0.207 | 0.188 | 0.158 |
| Std. [Ω] | 0.016 | 0.007 | 0.006 | 0.006 | 0.018 | 0.006 | 0.006 | 0.005 | 0.012 | 0.012 | 0.005 | 0.004 | 0.023 | 0.008 | 0.003 | 0.006 | 0.024 | 0.023 | 0.006 | 0.003 | 0.020 | 0.008 | 0.003 | 0.004 |

*Constant performance at 3 different temperatures*

# Preliminary Production Test Results

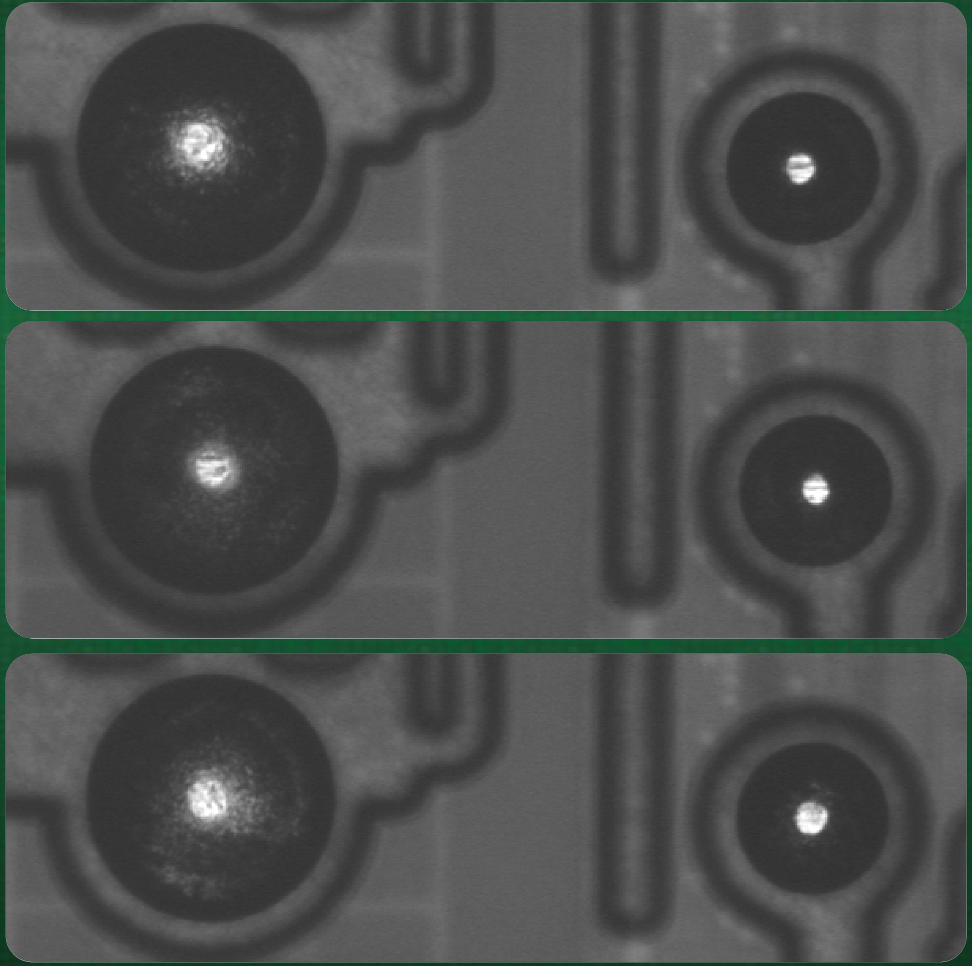
## BUMP deformation @ different temperatures

Temperature:

30 °C

85 °C

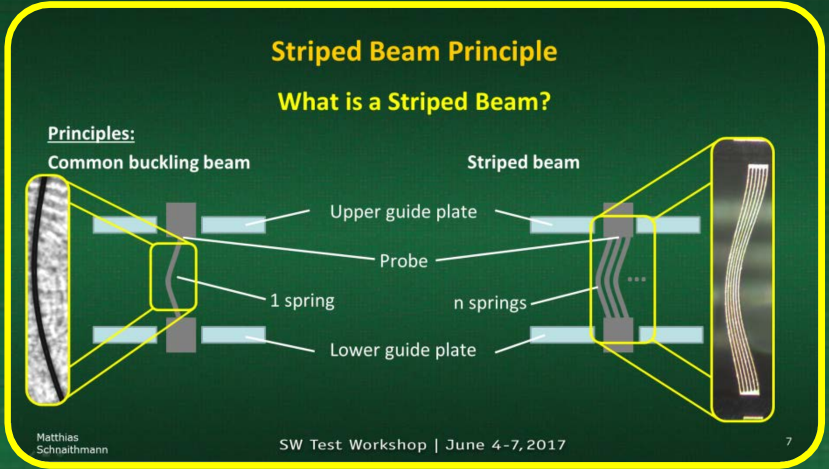
125 °C

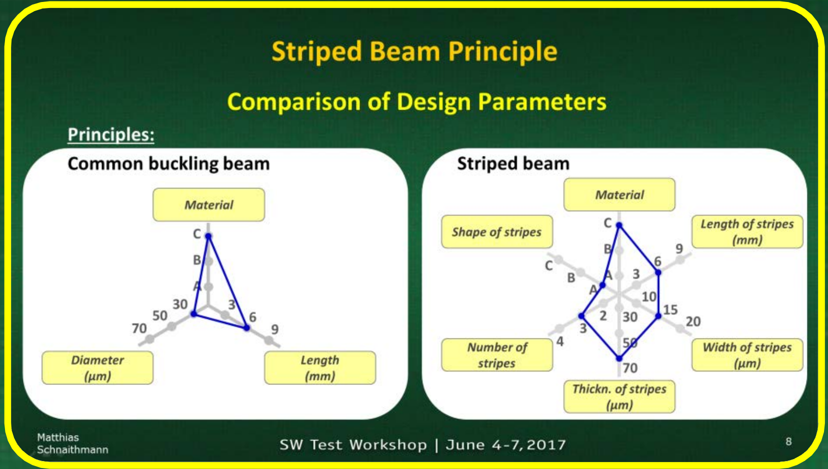


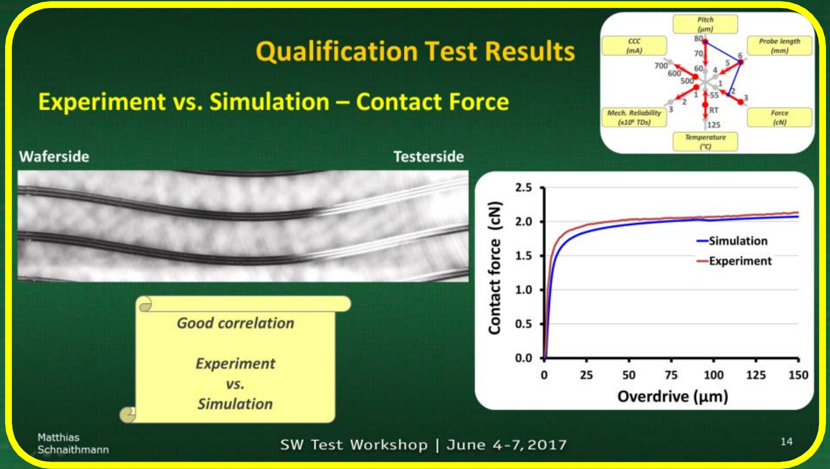
| Impact diameter Large Bump | Impact diameter Small Bump |
|---|---|
| 26 +/- 1 µm | 16 +/- 1 µm |
| 29 +/- 2 µm | 18 +/- 1 µm |
| 31 +/- 3 µm | 22 +/- 2 µm |

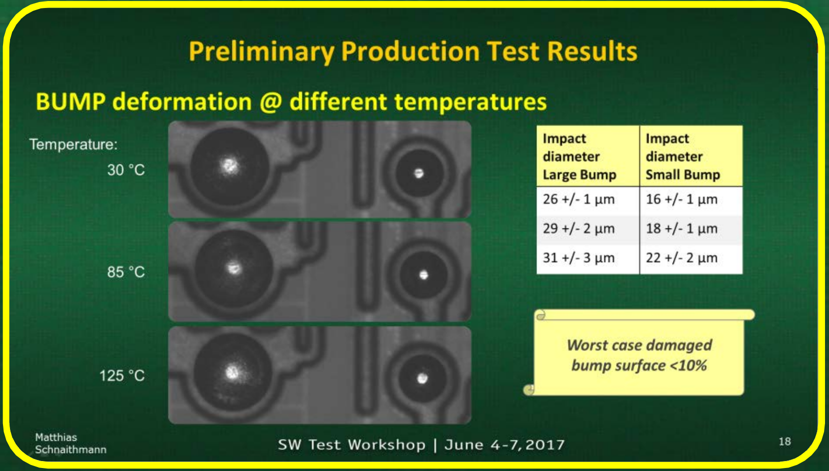
*Worst case damaged bump surface <10%*

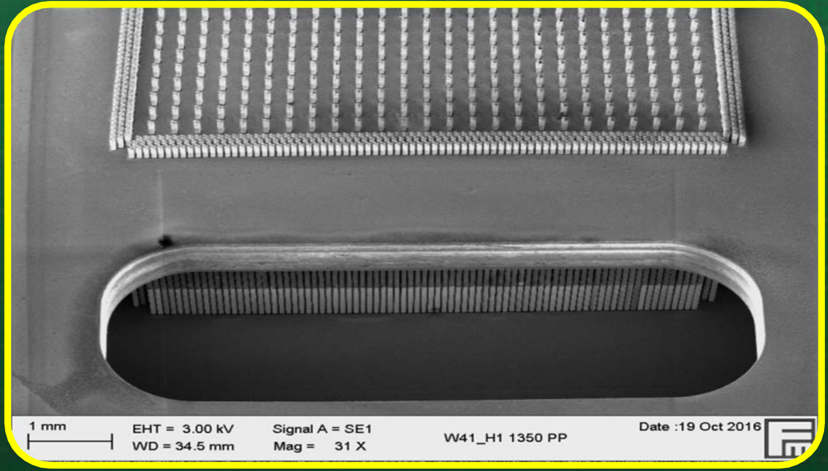
# Summary




FEINMETALL's *Striped Beam technology is covered by patent and patent applications*

# Follow-On Work

## Next Development Steps

- Probes for pads à 50µm Pitch
  à Probe family
  with same length and force

- Probes for pads à 40µm Pitch

- High current applications

# Acknowledgement

Thank you!

| | | |
|---|---|---|
| **Lutz Benedix**<br>**FEINMETALL GmbH** | - | **Head Design** |
| **Panagiotis Vlachakis**<br>**FEINMETALL GmbH** | - | **Head & Probe Assembly,**<br>**Mechanical Reliability Tests** |
| **Peter Stolp**<br>**FEINMETALL GmbH** | - | **Head & Probe Assembly,**<br>**Mechanical Reliability Tests** |
| **Jörg Behr**<br>**FEINMETALL GmbH** | - | **Mechanical FE Simulation** |
| **Annelene Dethlefsen**<br>**FEINMETALL GmbH** | - | **Thermal FE Simulation,**<br>**Force & CCC Measurements** |