SWTEST

PROBE TODAY, FOR TOMORROW

2024 CONFERENCE

Introducing TIPS' new RzBeam and a universal metric for scrub

T. I. P. S.

Technical Innovation Physical Solution

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Overview

- Metric for Probe Scrub
  - Motivation and Concept
  - New metric of scrub potential
  - Cantilever technology characteristics
  - Buckling beam technology characteristics

- New RzBeam Technology
  - Overview of main advantages and applications
  - Characterization of CCC
  - Measurement results of CRES
  - Contact force and Scrub potential

Motivation

- Help test engineer decide on technology selection
- Characterize capability to produce a scrub mark
- Correlate that capability with measured scrub
- Predict scrub length for other probe technologies

Concept

Capability of probe technology

- quantitative measure for capability to scrub
- characteristic value for each probe technology
- independent from pad material and tip shape

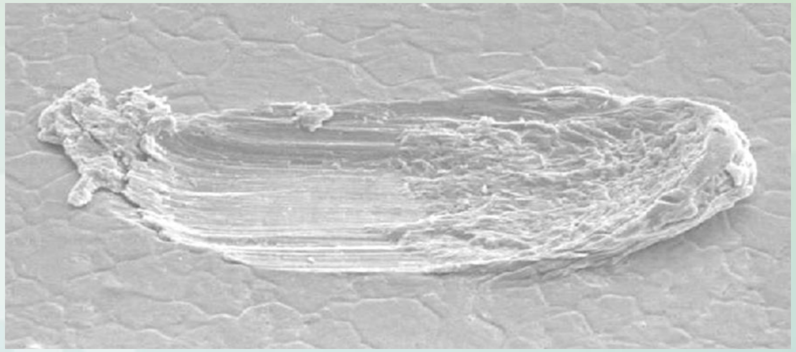


image: Hwang et al., SWTW 2006

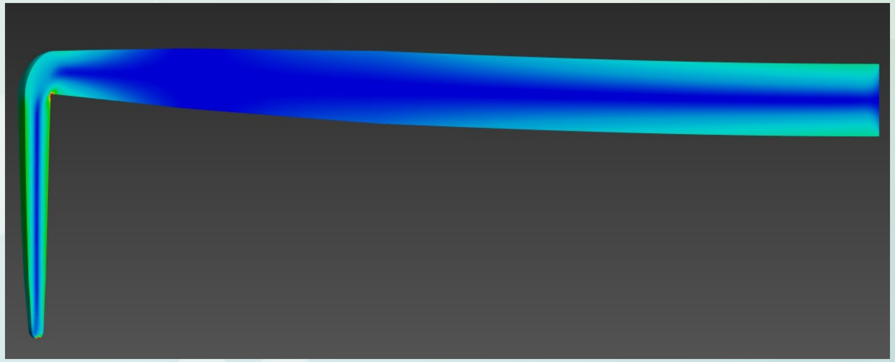
Correlation with actual scrub

- measure actual scrub length for a specific pad and probe
- correlate with simplified „friction“ (material properties, roughness, tip shape, ...)
- predict scrub length for other probe technologies

Concept

Quantitative measure based on energy

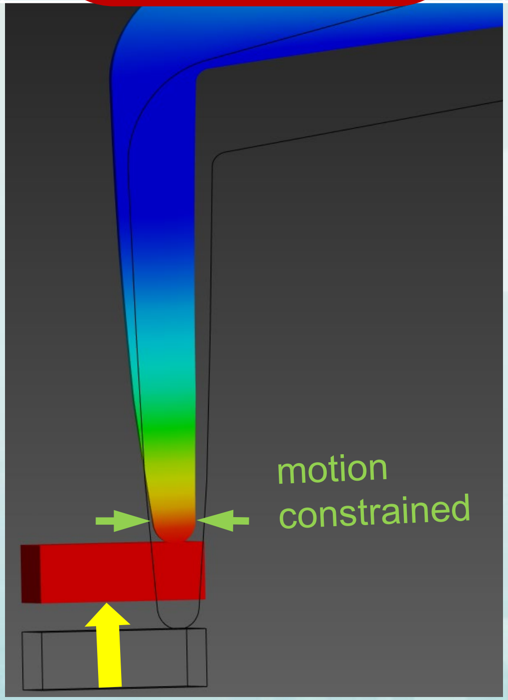
- overtravel tensions the probe like a spring
- elastic energy of tension
- energy calculated by FEM
- part of that energy is used for scrub
- ratio of scrub-usable vs total energy

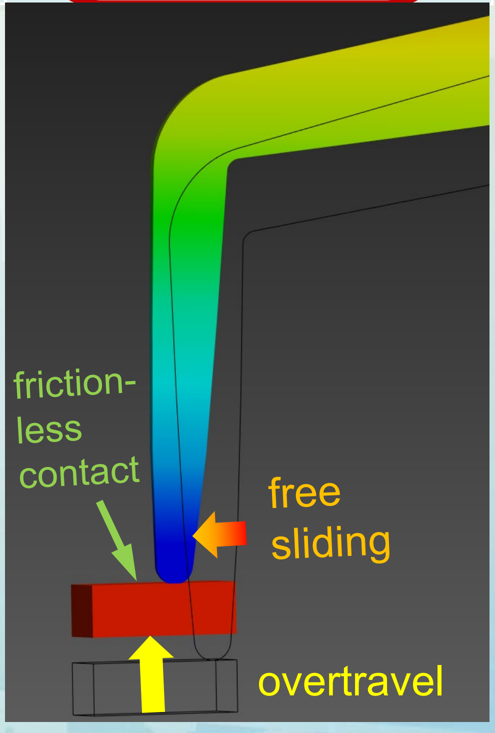


Stress distribution in probe

Modeling Scrub

	Perfectly sticking	Real probe mark	Perfectly sliding
Lateral probe motion	none	small	large
Lateral probe force	large	small	none
Lateral tension in probe	fully retained	partly spent for scrub mark	fully spent
Equivalent "friction" coefficient	μ=infinite	μ≈ 0.2 … 1	μ=0

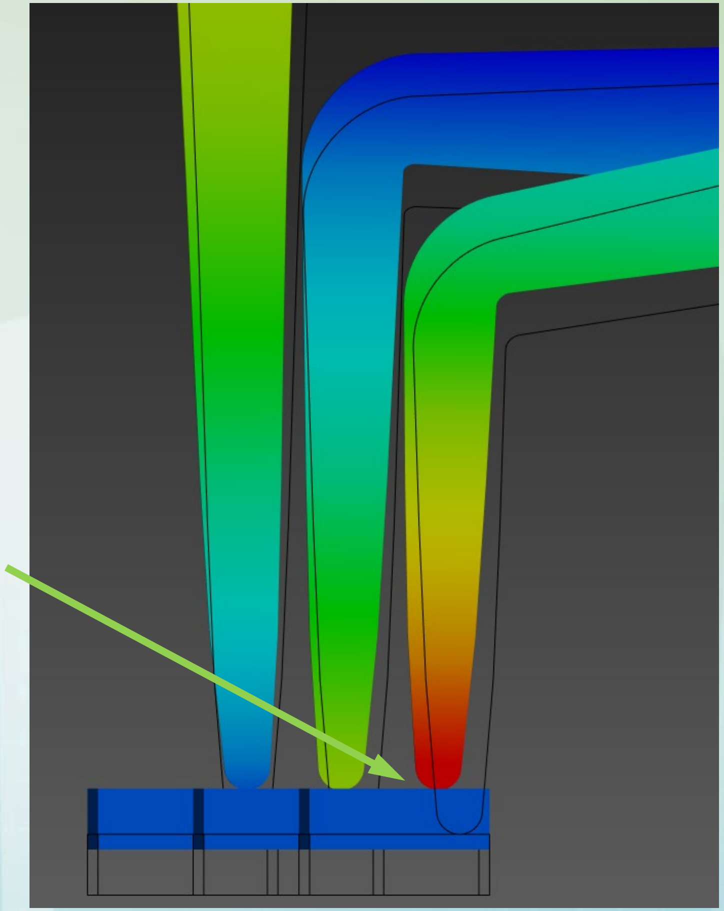




Model Verification

Verify model against probe card analyzer

- optical scrub measurement
- sapphire window
- known constant friction
- vision overtravel
- measured scrub length



friction μ=0.15
measured=10.5 μm
calculated=11.5 μm

Correlates well with FEM results

✓

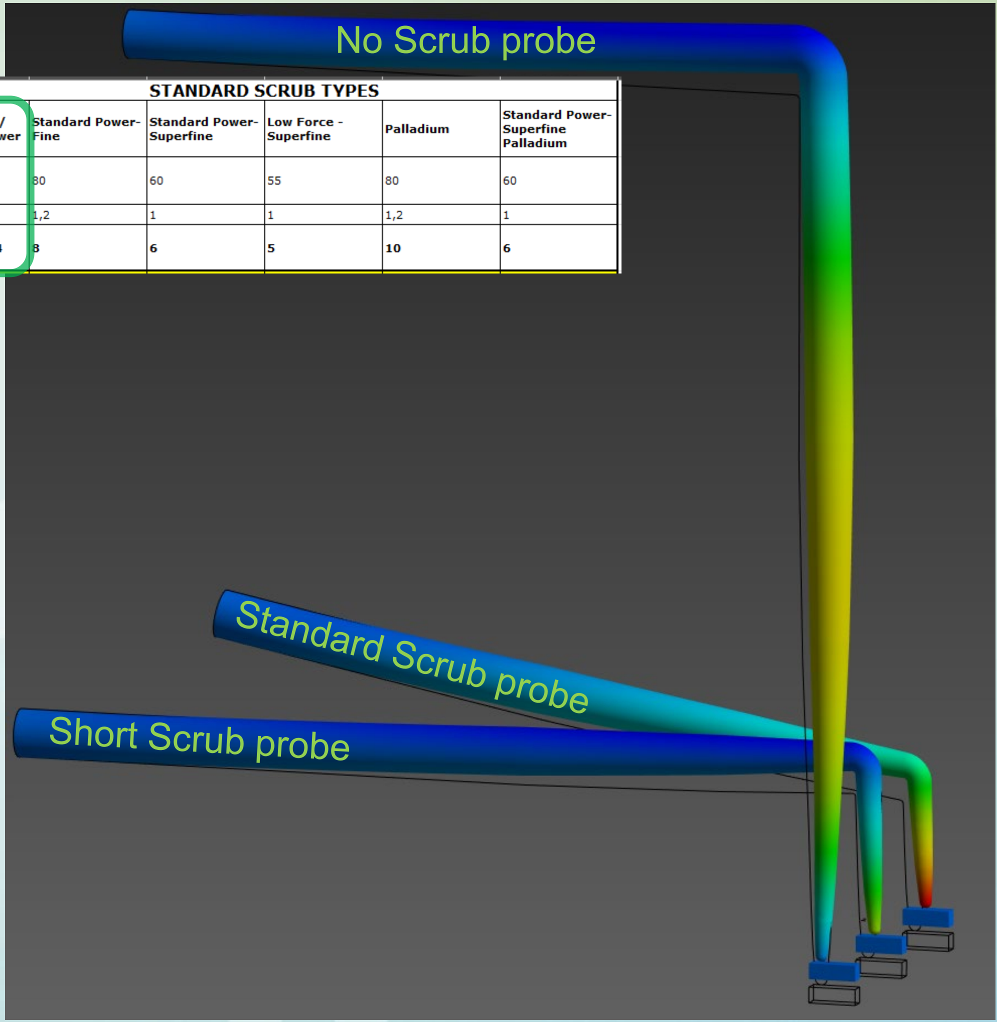
Probe Technologies

	NO SCRUB TYPES		SHORT SCRUB TYPES						STANDARD SCRUB TYPES					
Technology Name	High Voltage / Pressure Sensors (LuPo)	High Voltage / Pressure Sensors (LuPo) Berylium copper	Short Scrub Power	ShortScrub-Fine	ShortScrub-Superfine	ShortScrub-Low Force	Palladium	ShortScrub-Superfine Palladium	Standard / Complex Power	Standard Power-Fine	Standard Power-Superfine	Low Force - Superfine	Palladium	Standard Power-Superfine Palladium
Pitch-continuous [µm]	from 150	from 150	from 100	80	60	55	from 80	60	from 100	80	60	55	80	60
Tip Diam [mil]	1,6 / 3 / 5 / 8	4 / 10	1,6 / 3 / 5	1,2	1	1	1,2	1	1,6 / 3 / 5	1,2	1	1	1,2	1
Available Shaft Diam [mil]	**10-14**	**15**	**10-14**	**8**	**6**	**5**	**10**	**6**	**10, 12, 14**	**8**	**6**	**5**	**10**	**6**

Select probes for analysis model

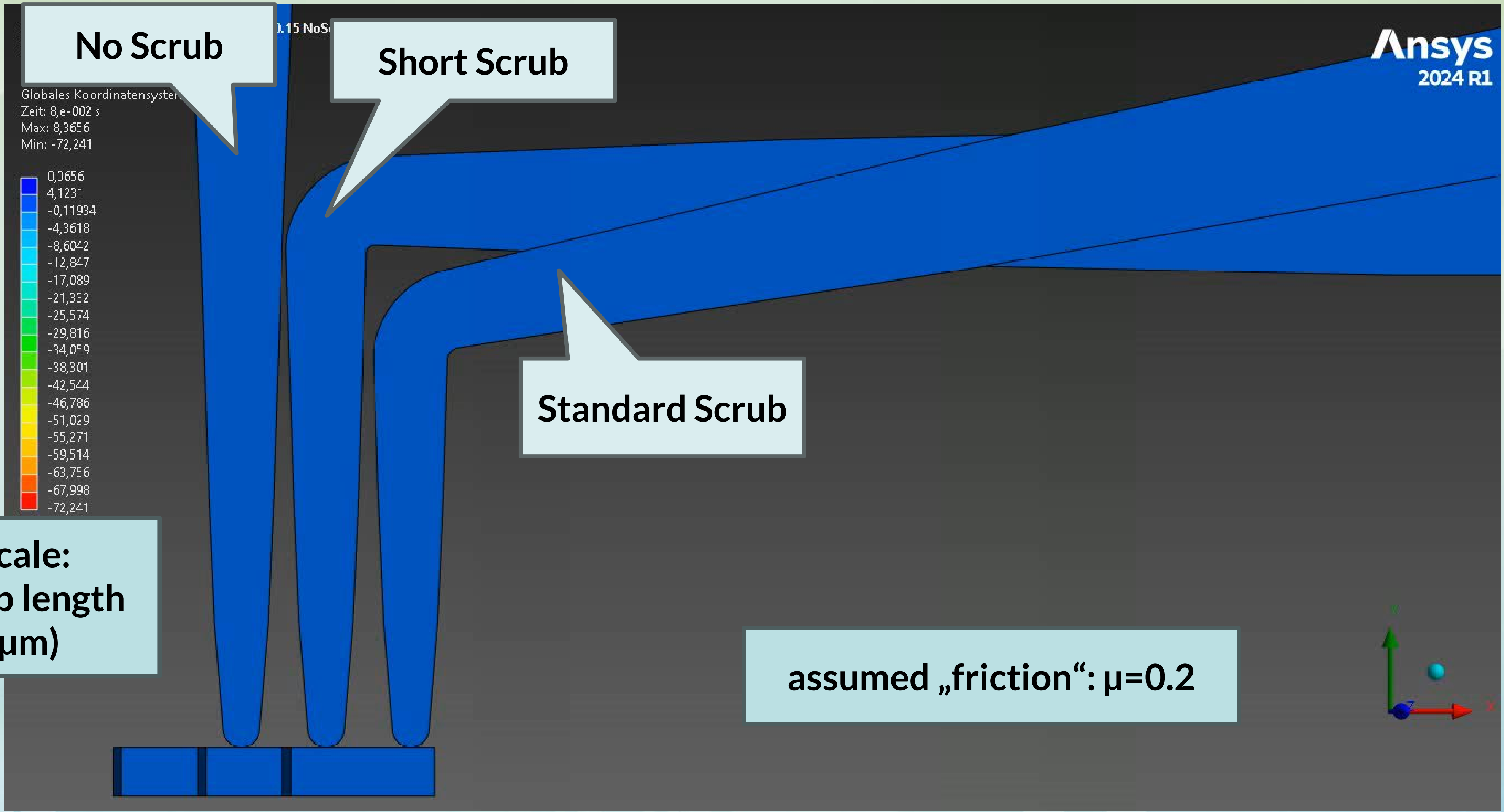
- 3 main groups of cantilever technologies by scrub types:
- Standard Scrub
- Short Scrub
- No Scrub

- Select types widely used
- Select one representative size per type



G.Franz, D.Damian

Scrub Simulation Cantilever



No Scrub

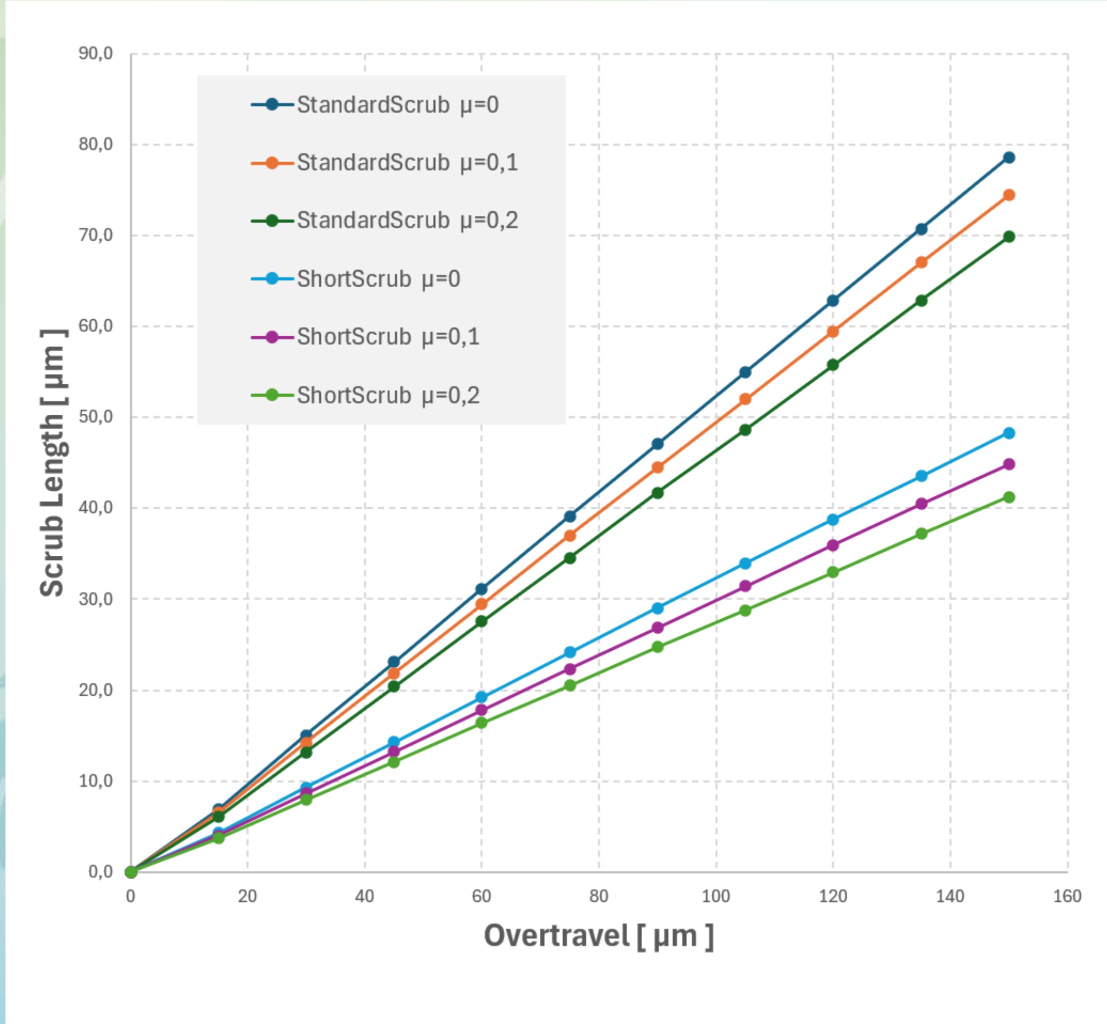
Short Scrub

Standard Scrub

Scale:
Scrub length
(µm)

assumed „friction“: µ=0.2

Scrub Lengths



Simulation results

- 3 friction levels
- scrub decreases with friction
- scrub increases with overtravel

- NoScrub technology: special case

  - observed scrub very small

  - long tip bends considerably

  - small „scrub“ by tilting motion

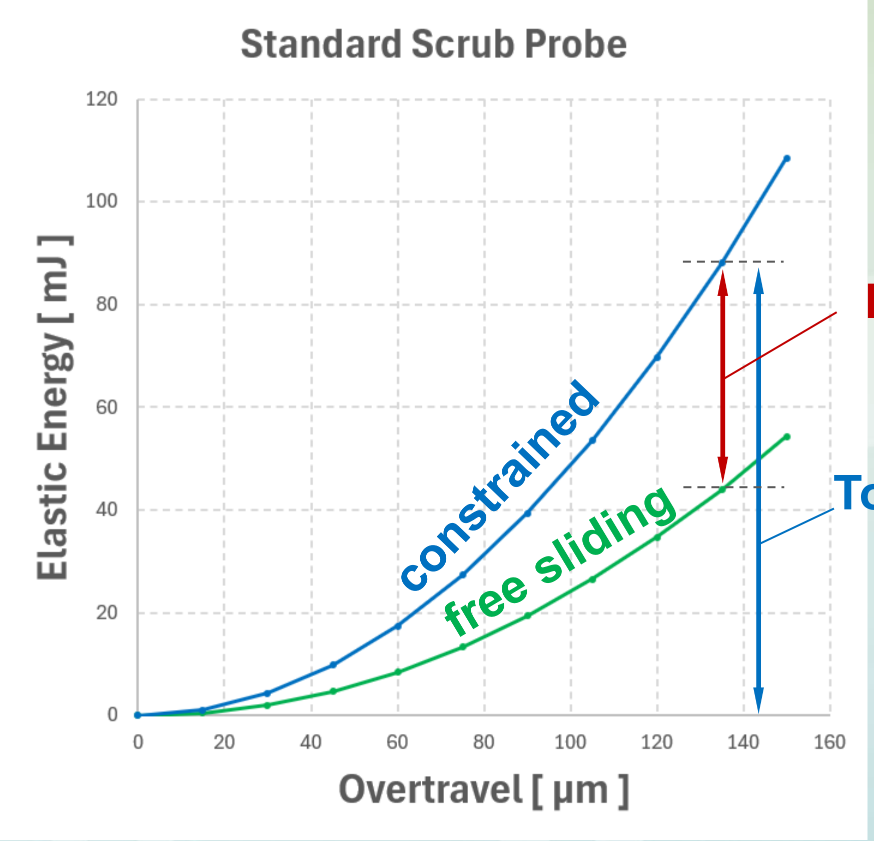
Scrub Potential

Definition

Ratio of energy available for scrub to total elastic energy

Scrub Potential „SP“

SP = E_scrub / E_total



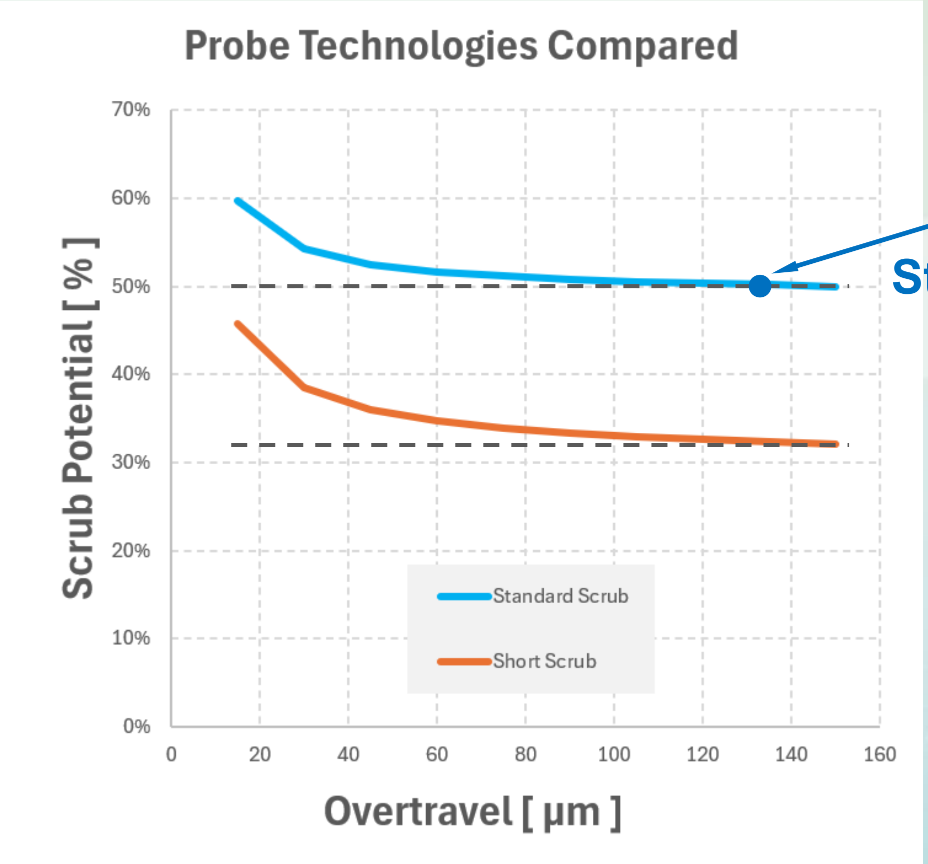
Energy available for scrub

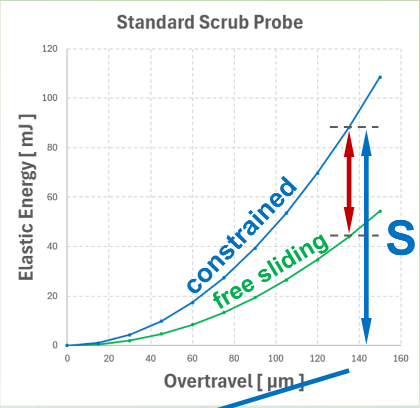
Total elastic energy at no scrub

Scrub Potential

Scrub Potential

- varies with overtravel
- asymptotic
- typical value per probe technology





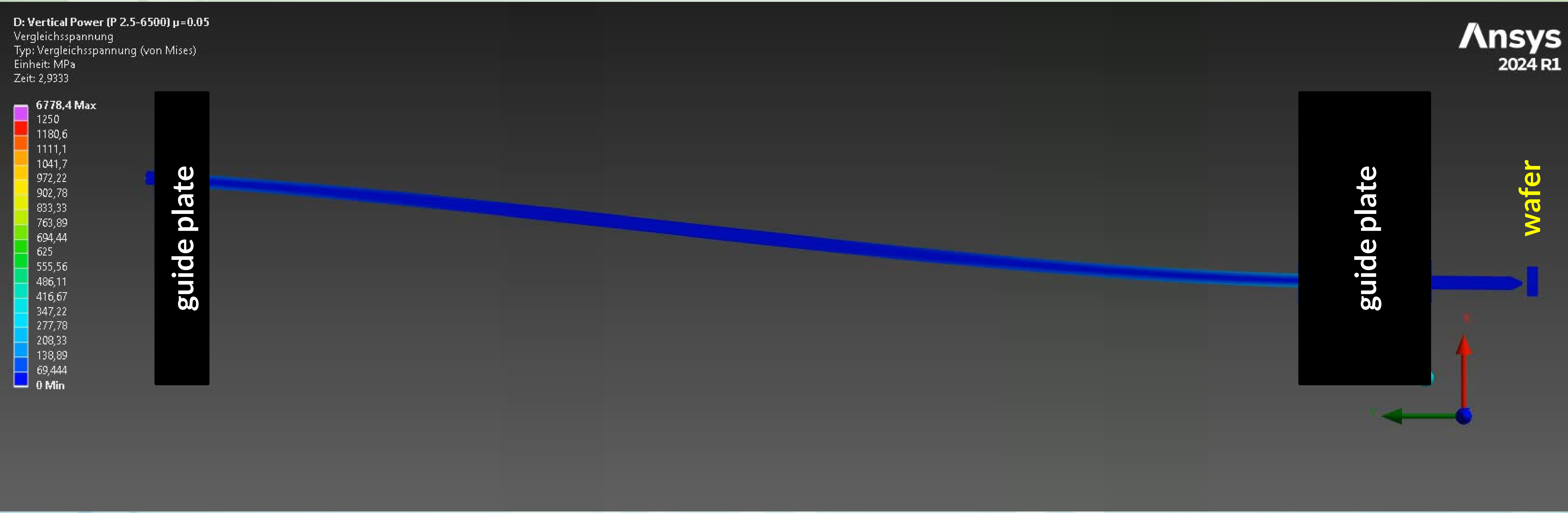
SP≈50%

Standard Scrub Technology
SP=50%

Short Scrub Technology
SP=32%

Scrub Simulation Vertical

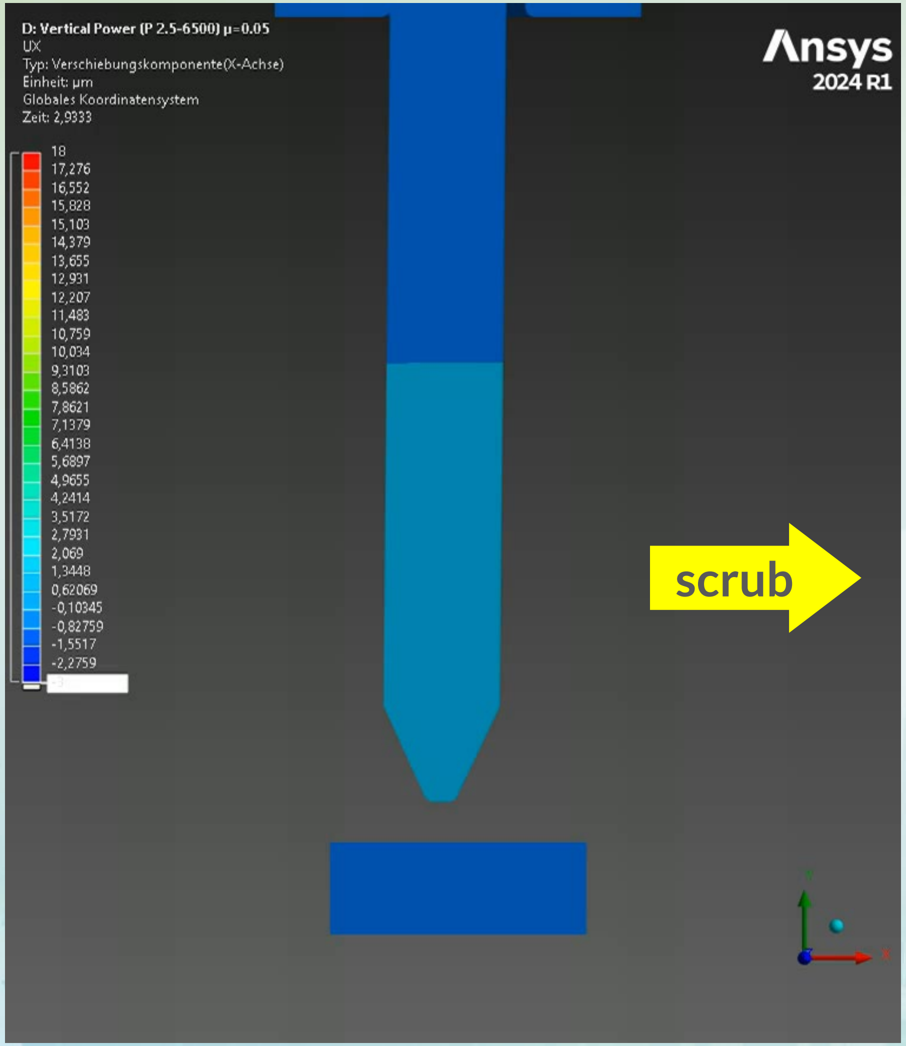
Stress distribution in buckling beam probe



D: Vertical Power (P 2.5-6500) μ=0.05
Vergleichsspannung
Typ: Vergleichsspannung (von Mises)
Einheit: MPa
Zeit: 2,9333

Scrub Simulation Vertical

Coloring: Displacement in scrub direction



Scrub Motion

- short scrub motion
- scrubs at once
- right at beginning of beam buckling

Scrub Potential Vertical

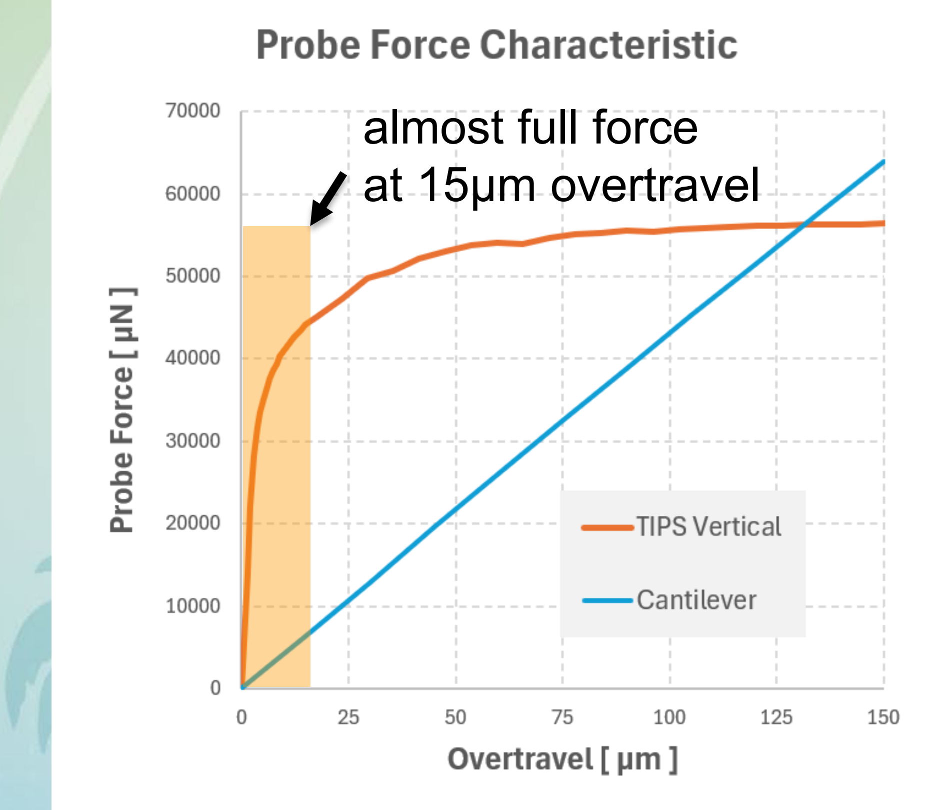
Scrub Potential

- scrub motion is mainly driven by kinematic constraints
- neglectable difference in elastic energy for different „friction“ levels
- model not applicable

Scrub Characteristics

- defined by „play“ between probe and guide plates
- maximum scrub length : limited by kinematics to 16 µm
- maximum scrub force : calculated for infinite friction, $F_{scrub} < 0.35 * F_{normal}$

Contact force



almost full force
at 15µm overtravel

Technology Comparison

- Cantilever: linear rise of contact force
- TIPS Vertical / buckling beam:
  - almost full force @ 15 µm overtravel
  - scrub motion only in first 15 µm
  - more overtravel ≠ more scrub !

Summary and Outlook

- Concept works well for cantilever probes
- Not yet useful for vertical probes

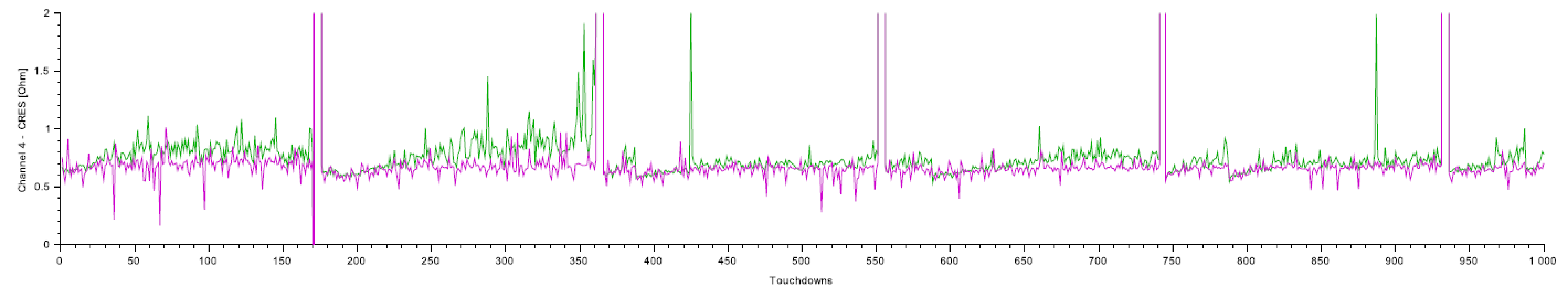
Further work

- More detailed analysis of “small scrub” cases
- Validate results with more measurements
- Evaluate modified concepts

RzBeam – Vertical Probe Technology
Wire style buckling beam

- Motivation
- Measurement results of CRES
- Characterization of CCC
- Characteristics – Overview
- Outlook on further developments

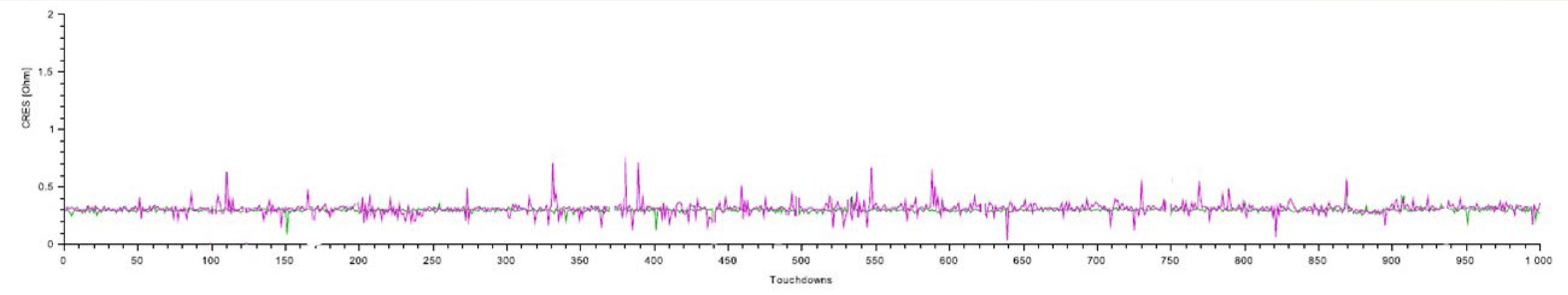
Motivation



- Green – CRES before current pulse
- Pink – CRES after current pulse

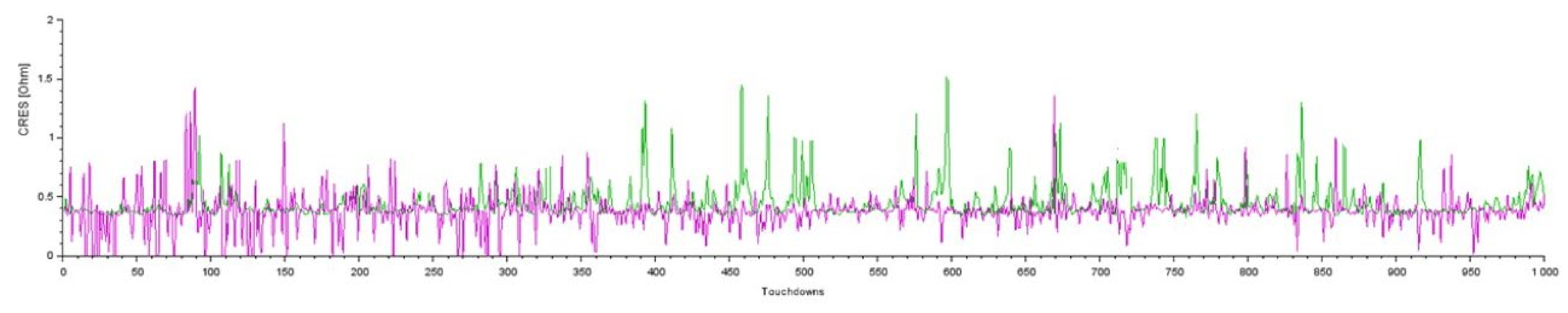
- ➢ Unstable Contact Resistance when probing on copper pads
- ➢ 2,5mil - Palladium probes show degrading CRES over time
  - „Sawtooth" curve with online cleaning cycles
  - Intensive online cleaning → quicker wear out of probes
  - Pronounced contact fritting as sign of increasing film resistance

Measurement results of CRES



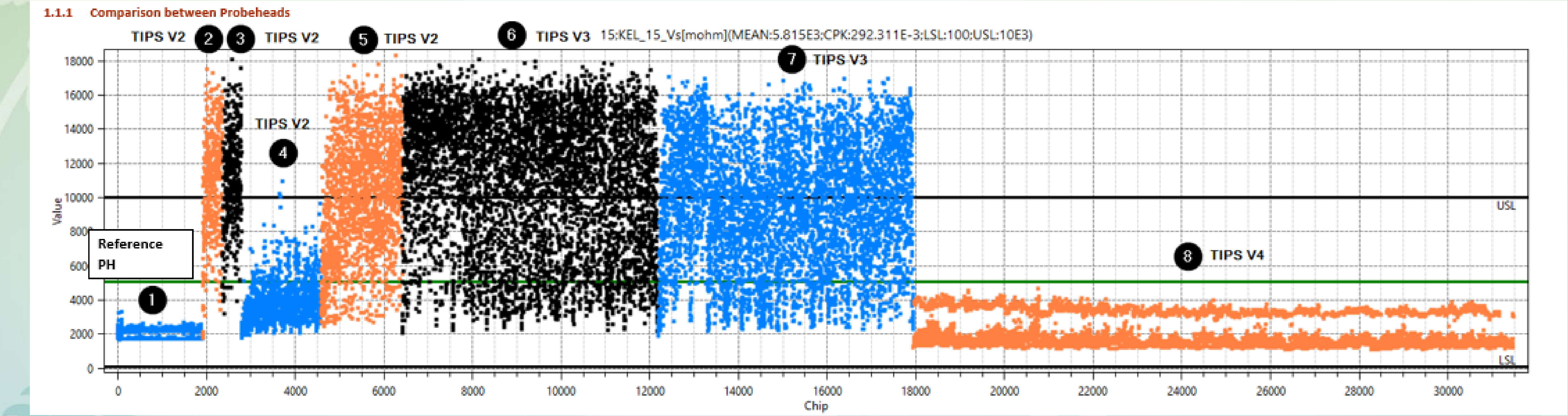
- 2,0mil - RzBeam on Copper pads
  – stable CRES
  – no contact fritting

Measurement results of CRES



- 2,0mil - RzBeam on Aluminium pads
  - less stable CRES than on Copper, but low level of CRES
  - little contact fritting

Main advantages



Palloy probes

RzBeam probes

- Contact resistance – customer qualification

CRES measurements by Mr. Michael Horn, Infineon Technologies, Munich

Main advantages

Stable CRES

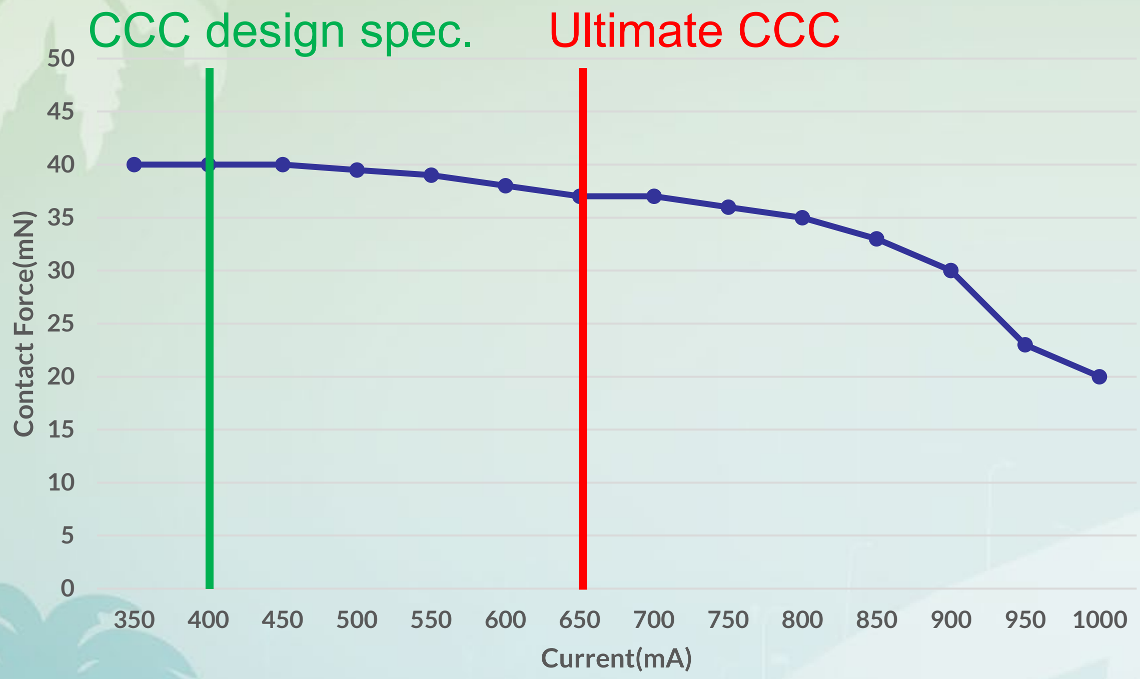
10 VIIIB	11 IB	12 IIB	13 Al Aluminum
28 Ni Nickel	29 ~~Cu~~ Copper	30 Zn Zinc	31 Ga Gallium
46 ~~Pd~~ Palladium	47 ~~Ag~~ Silver	48 Cd Cadmium	49 In Indium
78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium

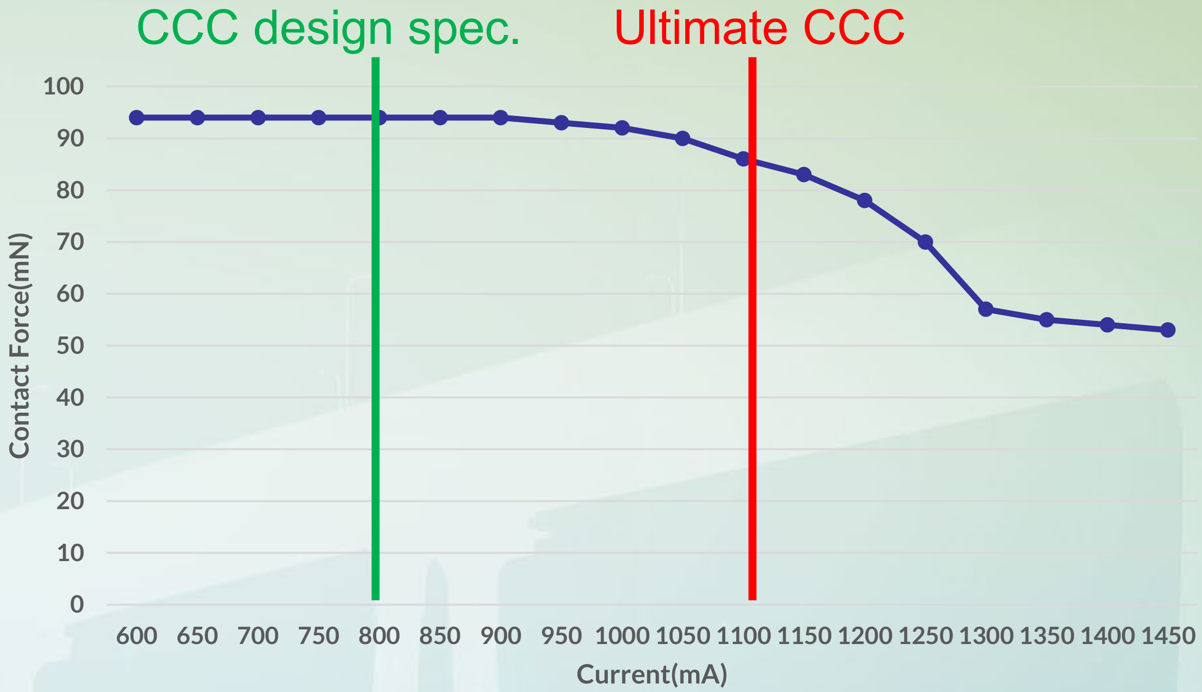
Higher CCC for same probe diameter

Probed wafers going back to sensitive CMOS process

⇨ Avoiding 'risk element' contamination

Main advantages – Current Carrying Capabilities





Max. DC current (A)	Max. pulsed current (A) (10 ms on / 200 ms off)
0,4	0,8

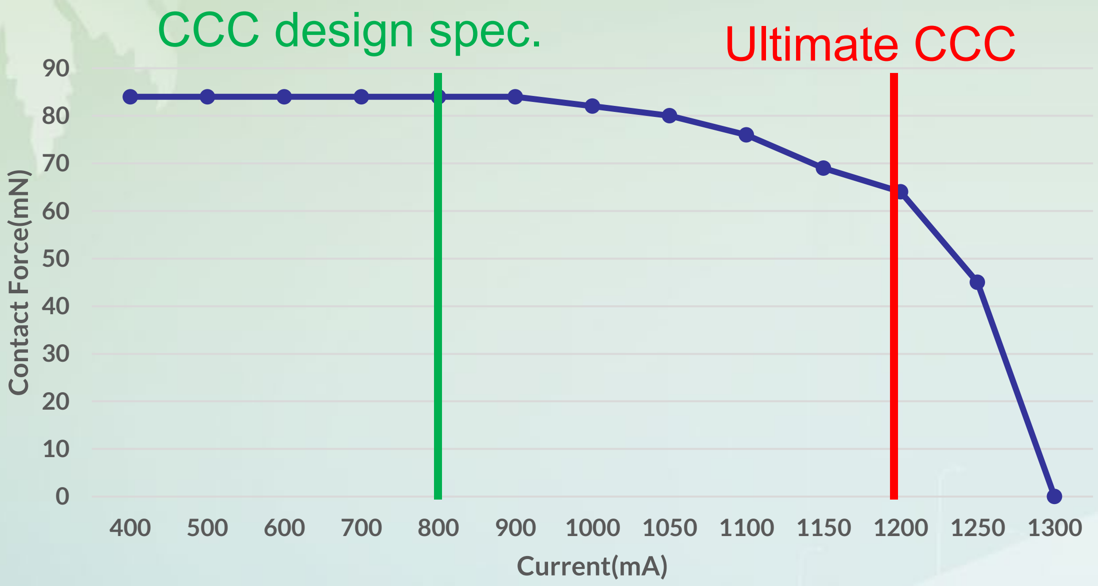
Palloy probe - 2,0mil

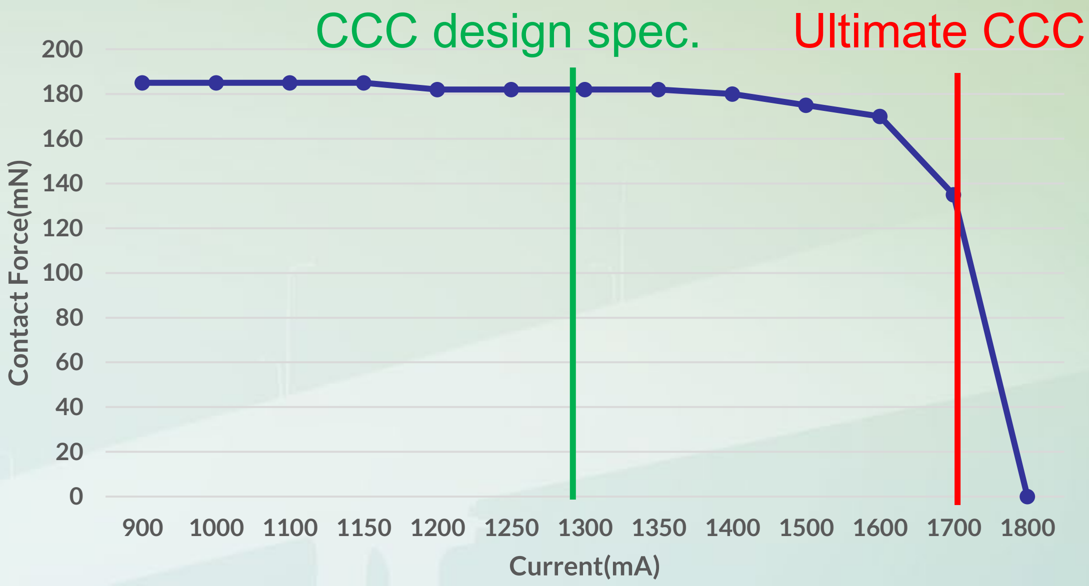
Max. DC current (A)	Max. pulsed current (A) (10 ms on / 200 ms off)
0,8	1,5

Palloy probe - 2,5mil

CCC measurements by Dr. Oliver Nagler, Infineon Technologies, Munich

Characterization of CCC for RzBeam





Max. DC current (A)	Max. pulsed current (A) (10 ms on / 200 ms off)
0,8	1,6

RzBeam probe - 2,0mil

Max. DC current (A)	Max. pulsed current (A) (10 ms on / 200 ms off)
1,3	2,6

RzBeam probe - 2,5mil

- ✓ Possibility for smaller probe pitch at same current level

Characteristics - Overview

Probe Technology	Probe diameter (mil)	Probe force (cN)	Resistance (mOhm)	Max. DC current (A)	Max. pulsed current (A) (10 ms on / 200 ms off)
Palloy	2,5	9,5	369	0,8	1,5
RzBeam (Power)	2,5	17,6	138	1,3	2,6
Palloy	2,0	3,8	585	0,4	0,8
RzBeam(Fine)	2,0	9,1	192	0,8	1,6

- Contact force and Scrub potential
- RzBeam Fine / RzBeam Power

Outlook on further developments

- RzBeam low force
- RzBeam superfine
- High current at 60µm pitch
    - Precise and stable contacts
- Power - KGD applications
    - RzBeam non-wetting material
    - Higher test currents per probe → higher current density

Questions

Thank you for your attention!

For further questions, please contact:

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