SW Test Workshop
Semiconductor Wafer Test Workshop

A Real Life Pad Crack Study

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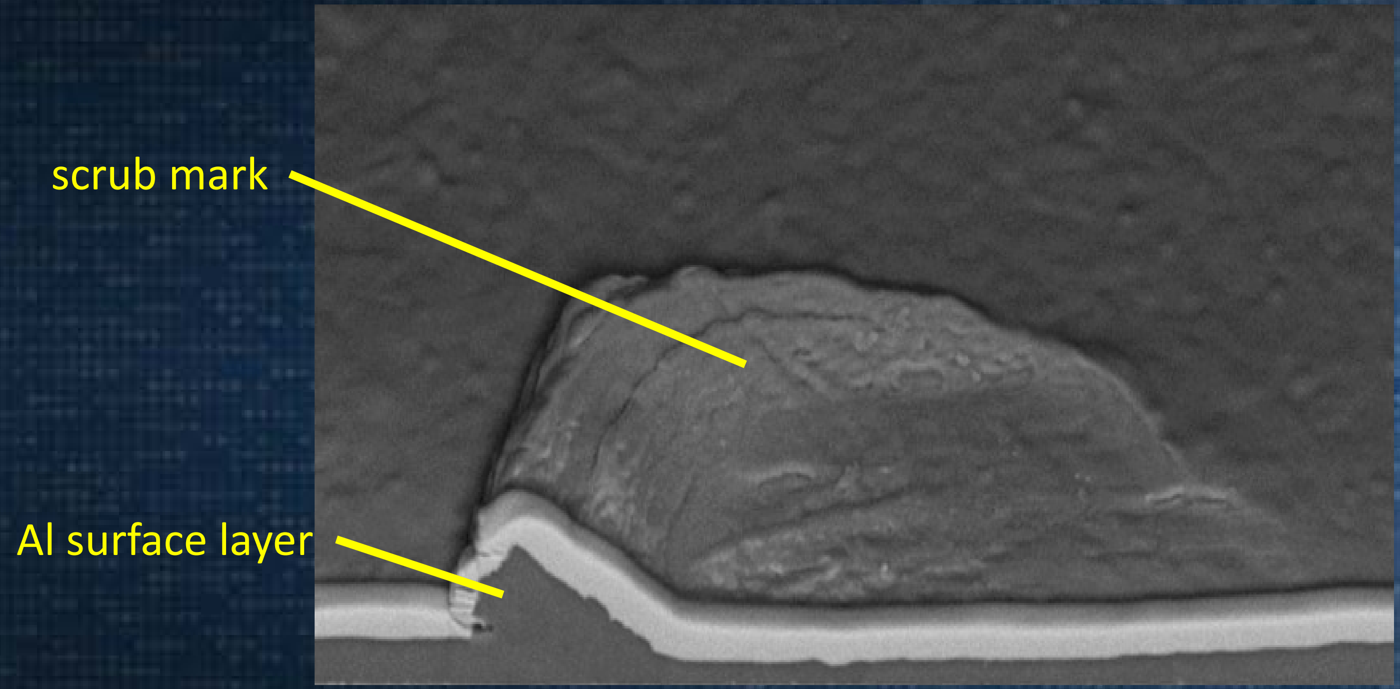
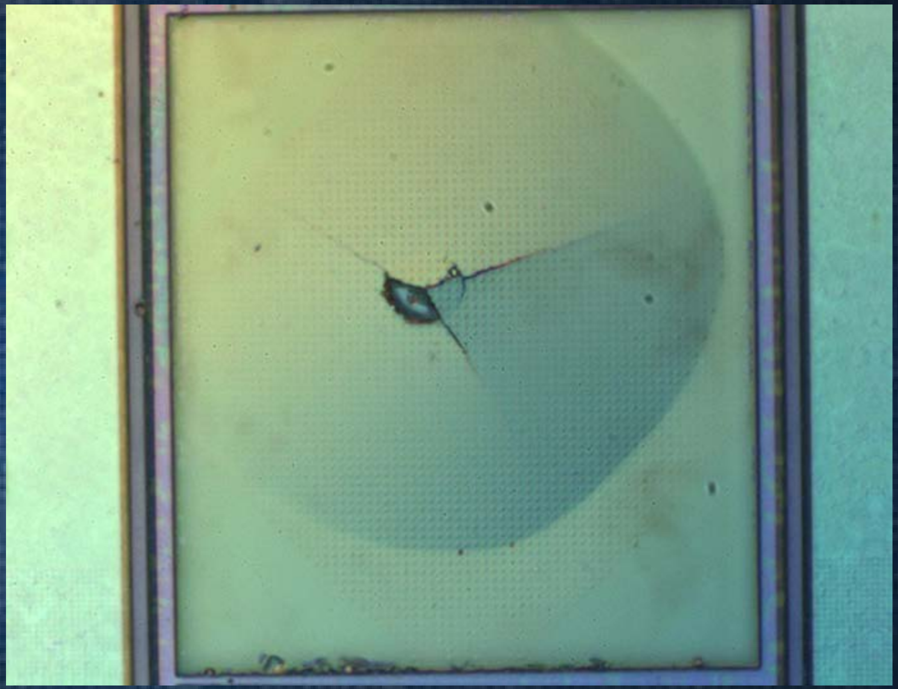
Overview

- What are pad cracks? – Challenge and objective
- Initial Experiment – first qualification run
- Main experiment – digging for the root causes
- Side experiments
- The validation – second qualification run
- Summary

Pad design – Pad Cracks





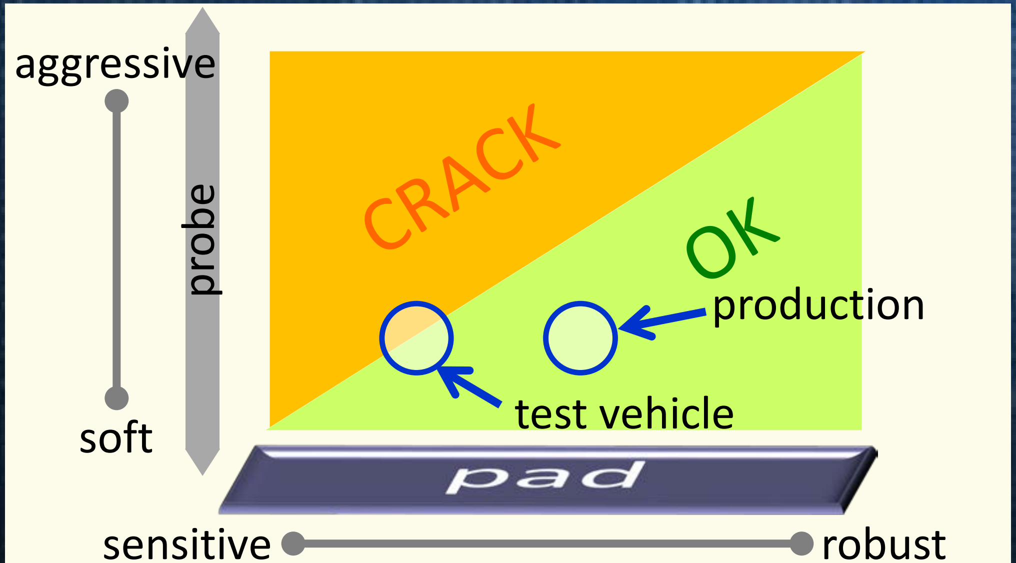
probed pad with substructure
SEM picture

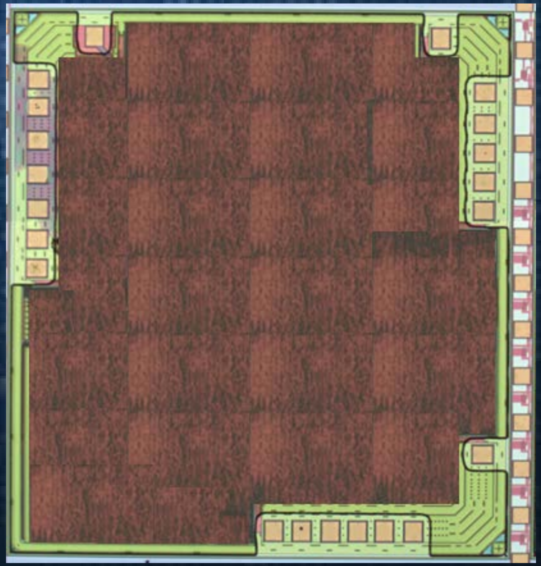
cracked pad
Al surface layer removed

Test Vehicle Selection - Objective

- **NXP wanted to investigate a fine pitch probing solution suited for sensitive pads**
- **A test vehicle has been created that allows to measure pad crack behavior**
- **Objective: To determine FEINMETALL's 1.6mil ViProbe® "S-Type low scrub" probe characteristic with respect to pad cracks.**

a test vehicle with adequate sensitivity is needed to investigate pad cracks



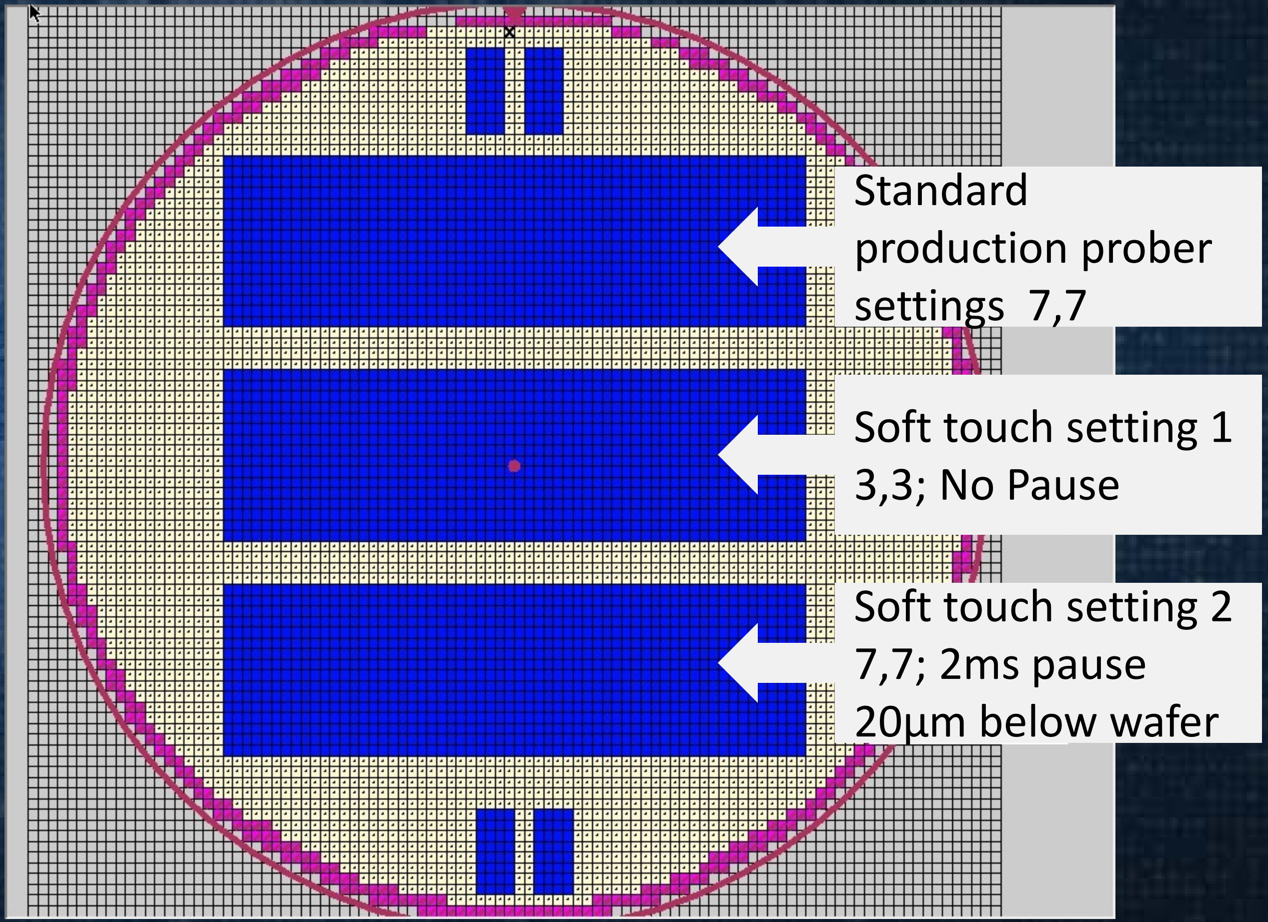


our test vehicle:
- 21 pads
- 2.05 x 2.3 mm

Initial Experiment on the Probe Floor

Experiment Design:

- Adjust TEL P8XL Prober settings to soft touch settings for acceleration/deceleration
- Same wafer has standard production settings and soft touch settings to evaluate how this affects ILD cracking
- 20 consecutive touchdowns



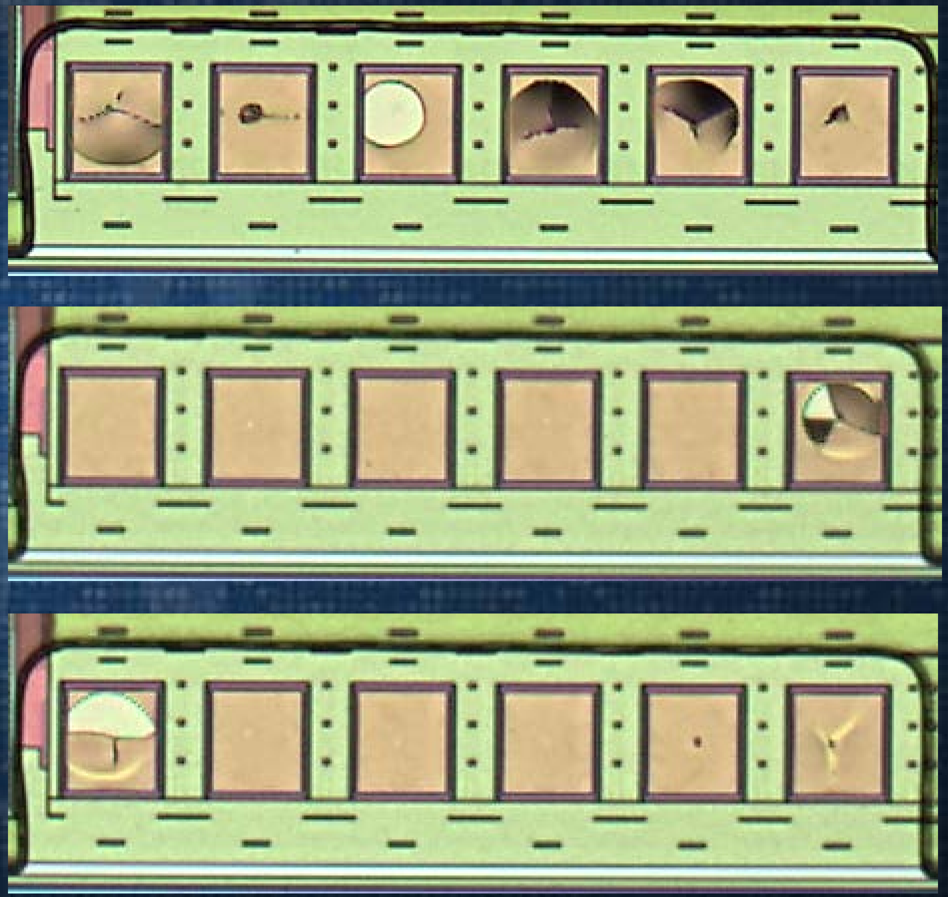
test vehicle stepmap on 200mm wafer

Initial Experiment on the Probe Floor

Outcome:

The results of the experiment were as follows:

- Standard production settings:
  20 out of 20 die contained pad cracking
- Soft touch setting 1:
  10 out of 20 die contained pad cracking
- Soft touch setting 2:
  18 out of 20 die contained pad cracking

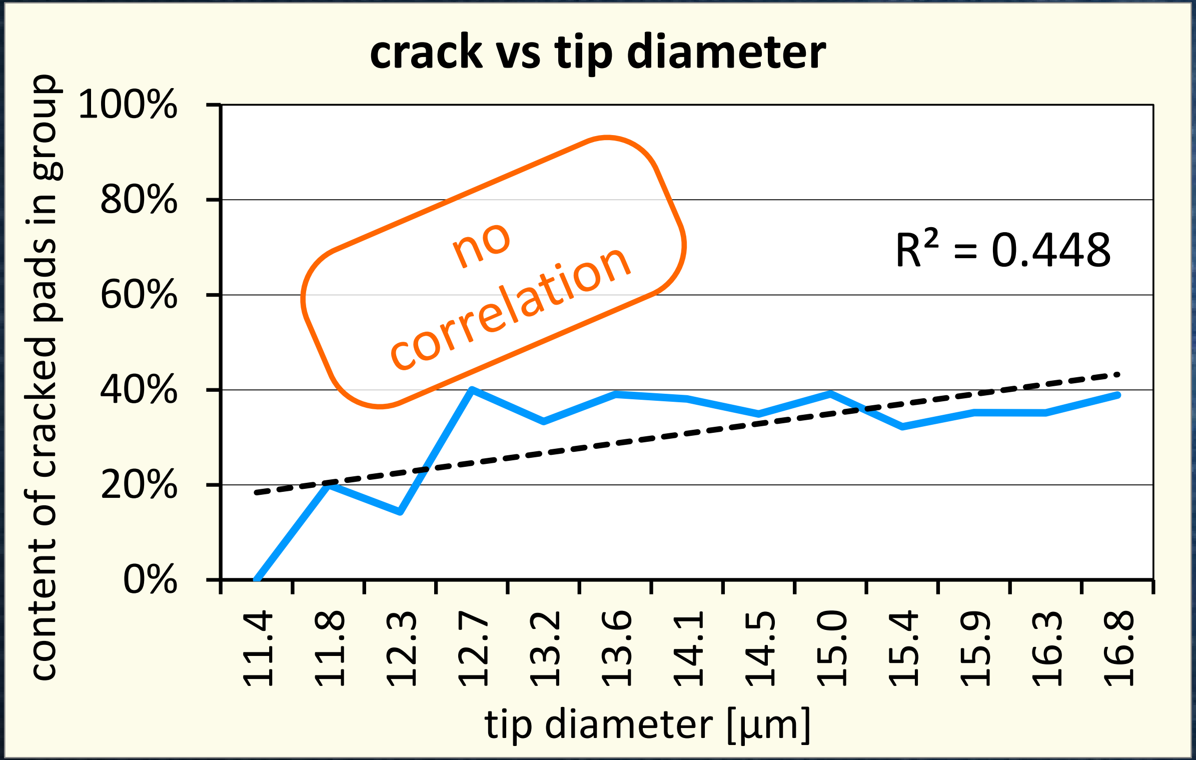


cracked pads from the test vehicle after etching

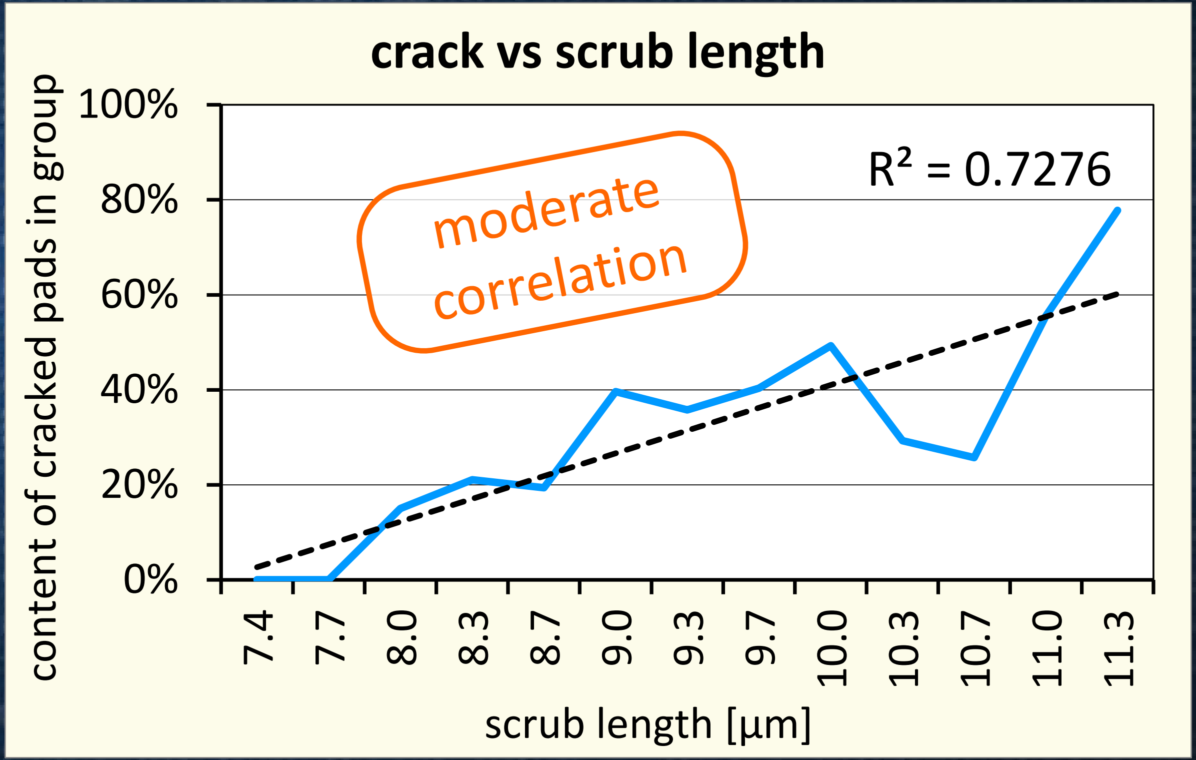
Initial Experiment on the Probe Floor

Subsequent analysis:

Probe card analyzer data have been correlated to the crack data



No correlation for tip diameters from 11 to 17 µm

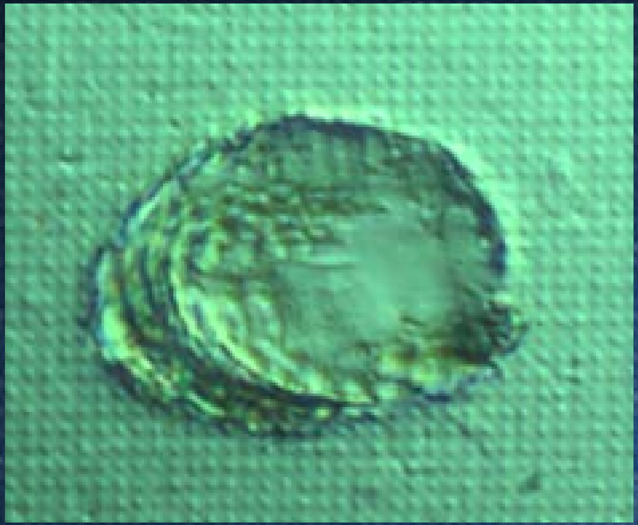


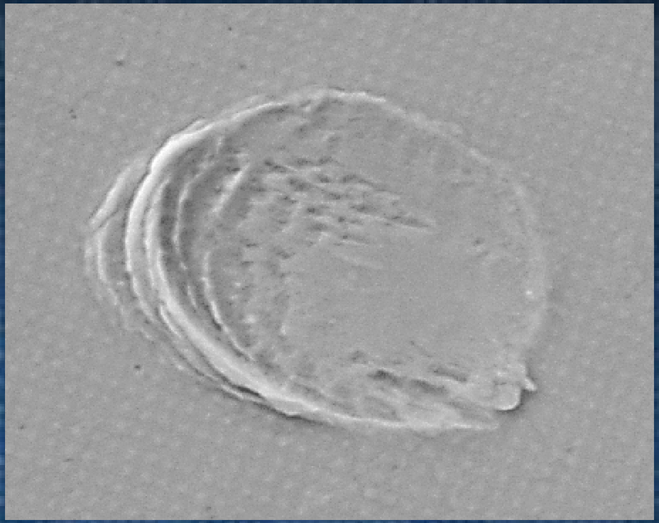
Moderate correlation for scrub length from 7 to 11 µm

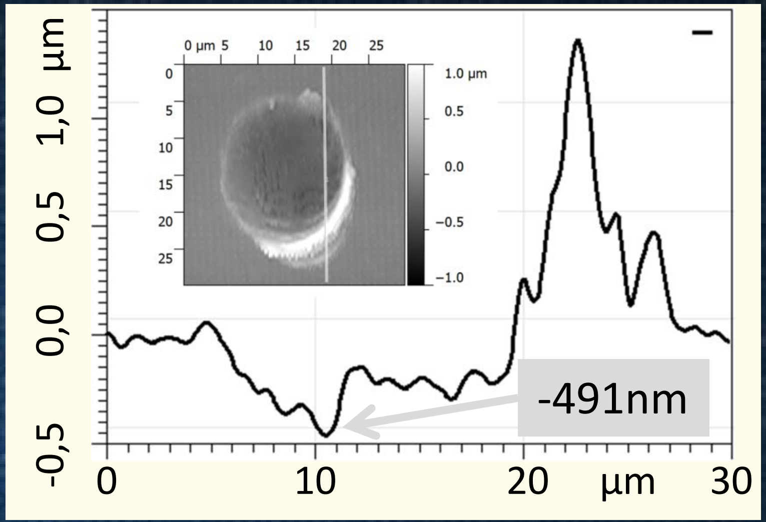
Initial Experiment on the Probe Floor

Subsequent analysis: Light-, scanning electron-, atomic force microscopy

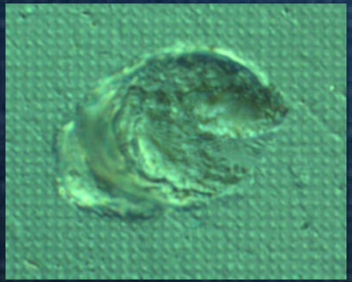
shallow
scrub mark

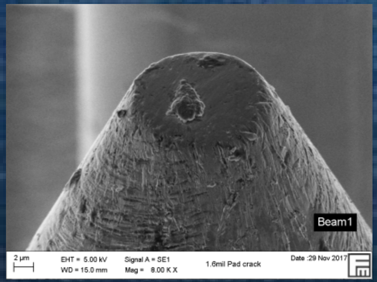


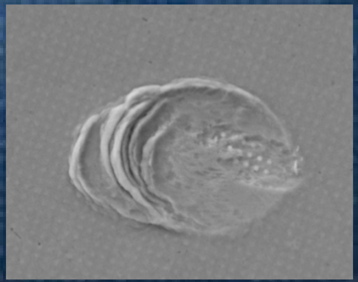


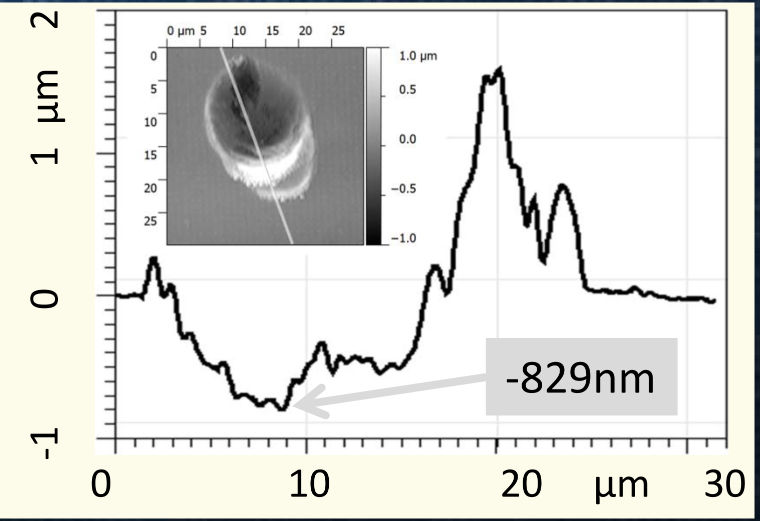


deep
scrub mark





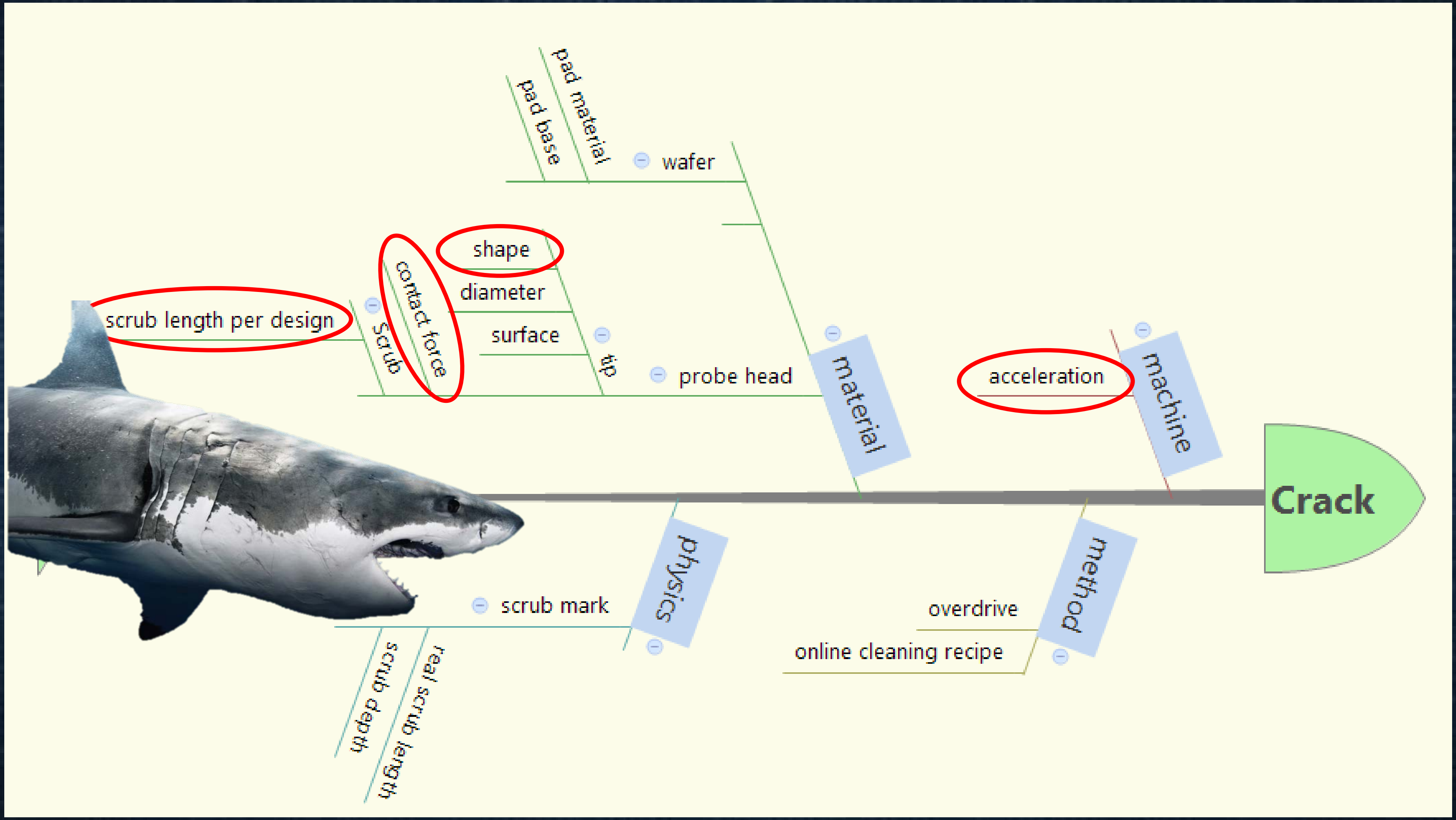




tip contamination can be part of the problem

Main experiment – digging for the root causes

What are the Main Factors to Cause Pad Cracks?



Main Experiment Setup

Objective of main Experiment

To determine the influence of „no-scrub“ and „low force“ variants of Feinmetall‘s 1.6mil probing technology, different prober settings, tip shapes and touchdown counts to the crack behavior of NXP‘s test wafer.

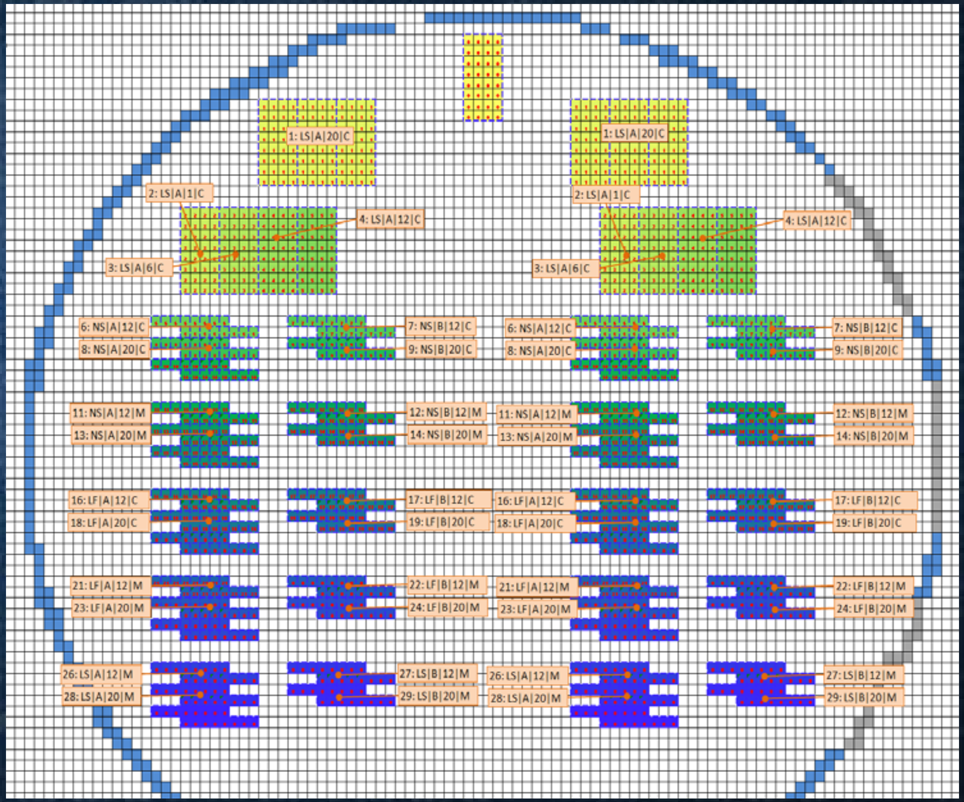
Factors and abbreviations:

- head types („**H**“):
  NS: 1.6mil no scrub
  LF: 1.6mil low force
- prober settings („**P**“):
  slow = acceleration low*
  fast = acceleration high*
- touchdown count („**T**“): 12; 20
- tip shape („**S**“):
  C: truncated cone (FM tip)
  R: rounded (shaped tip)

*low=„3/3“ high= „7/7“

Run No.	Head	Prober	Touchdown count	Tip Shape
6	NS	A	12	C
7	NS	B	12	C
8	NS	A	20	C
9	NS	B	20	C
11	NS	A	12	R
12	NS	B	12	R
13	NS	A	20	R
14	NS	B	20	R
16	LF	A	12	C
17	LF	B	12	C
18	LF	A	20	C
19	LF	B	20	C
21	LF	A	12	R
22	LF	B	12	R
23	LF	A	20	R
24	LF	B	20	R

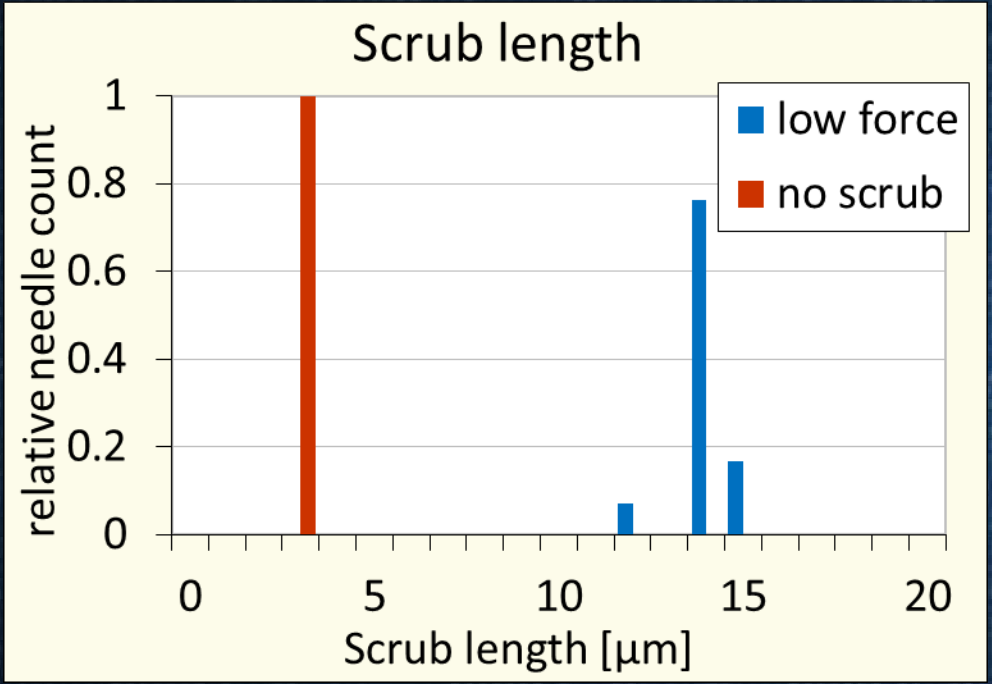
experiment matrix



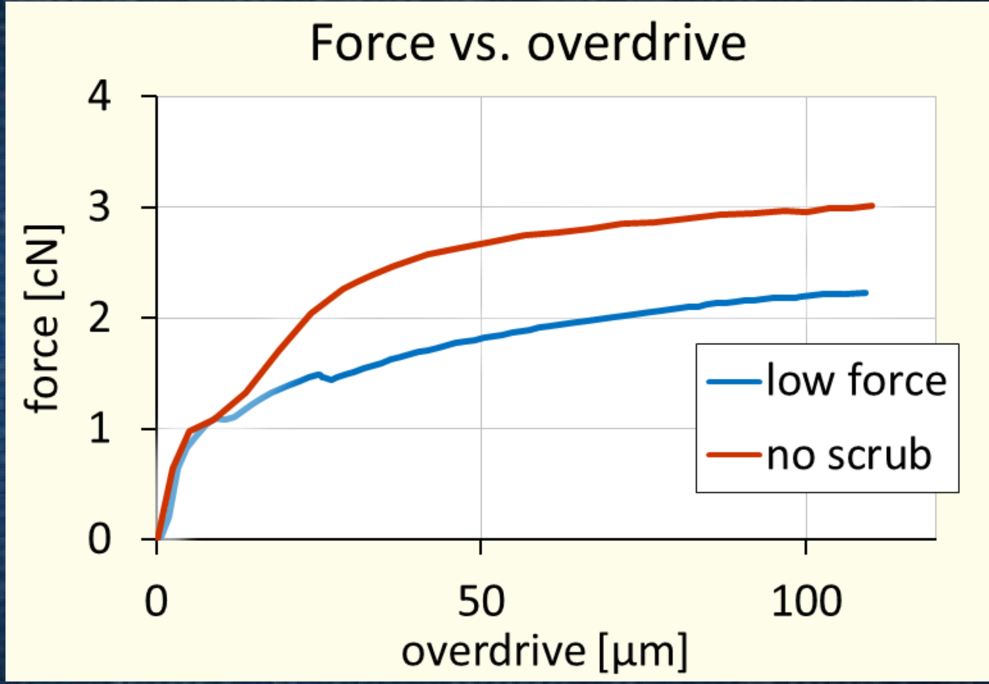
stepmap

Main Experiment Setup

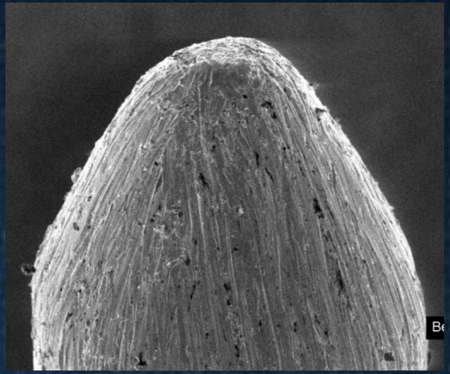
Probe heads: Scrub and force characteristics, tips



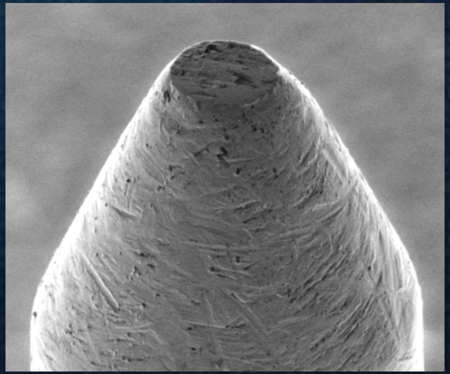
the „no scrub“ design leads also to a very narrow scrub distribution



same needle but different head design leads to different force characteristics



rounded tip



truncated cone tip

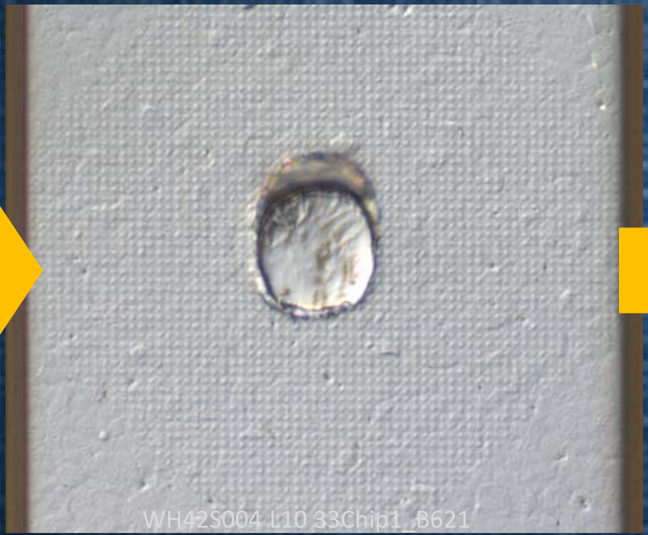
Main Experiment Execution

Brief description of the experiment flow

probing

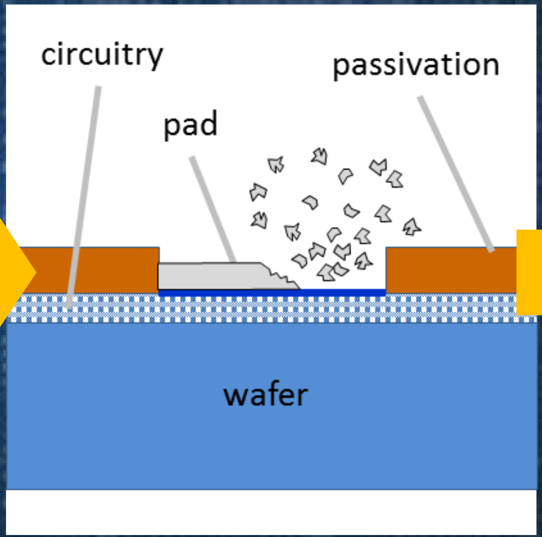
prober
TEL precio octo 200mm

light microscopy



probed pad

etching of the aluminum



only the aluminum
is etched away

light microscopy

cracked pad

ambient temperature; 85µm overdrive; no online cleaning; prober max. speed: 175k; prober init speed: 2k

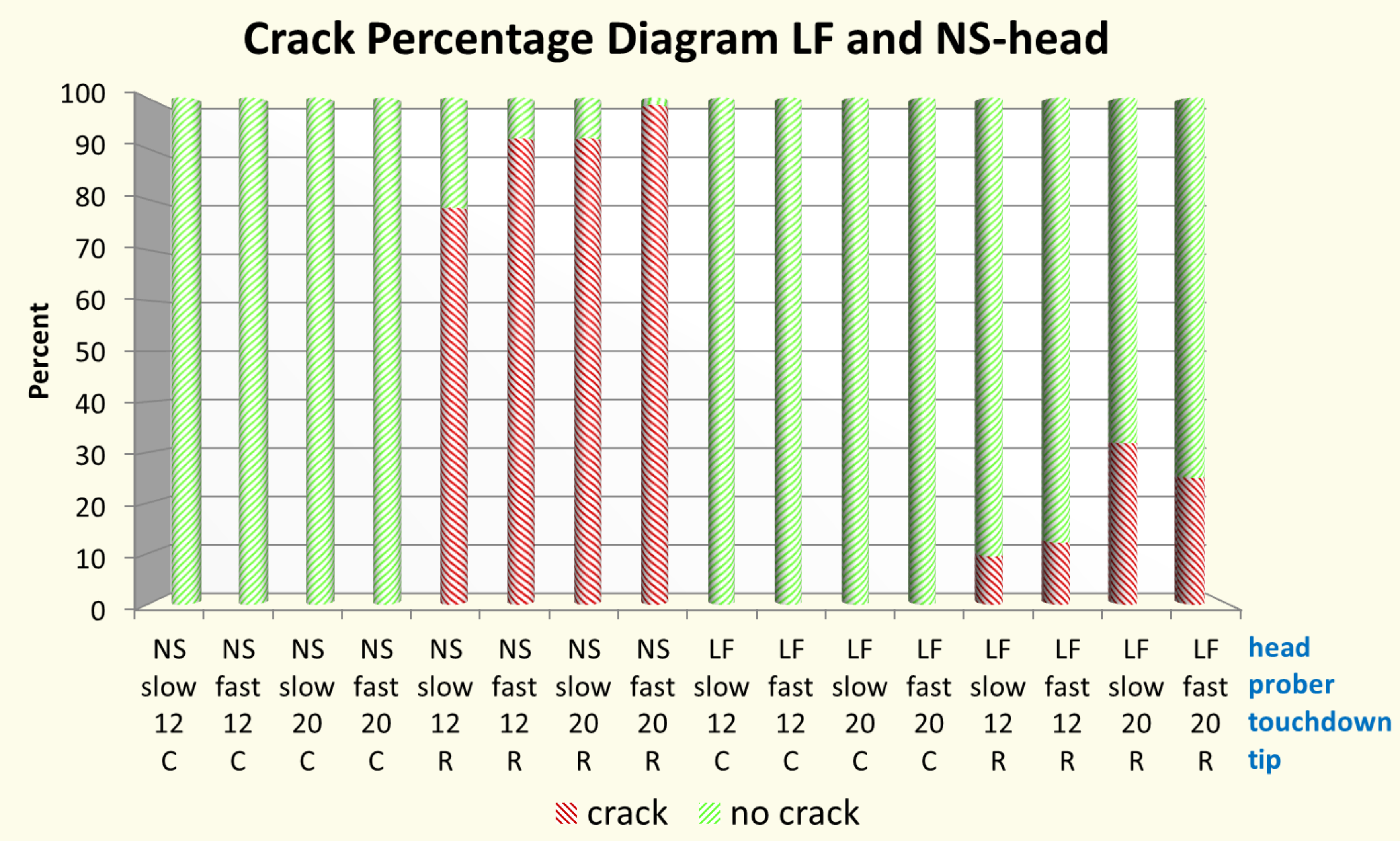
Main Experiment Results

The major effect comes from the tip shape: The truncated cone is much better than the rounded tip.

The Low Force head is significantly better than the No Scrub head.

Very little effect comes from the touchdown count, as expected: 20 is worse than 12.

No effect comes from the prober speed.



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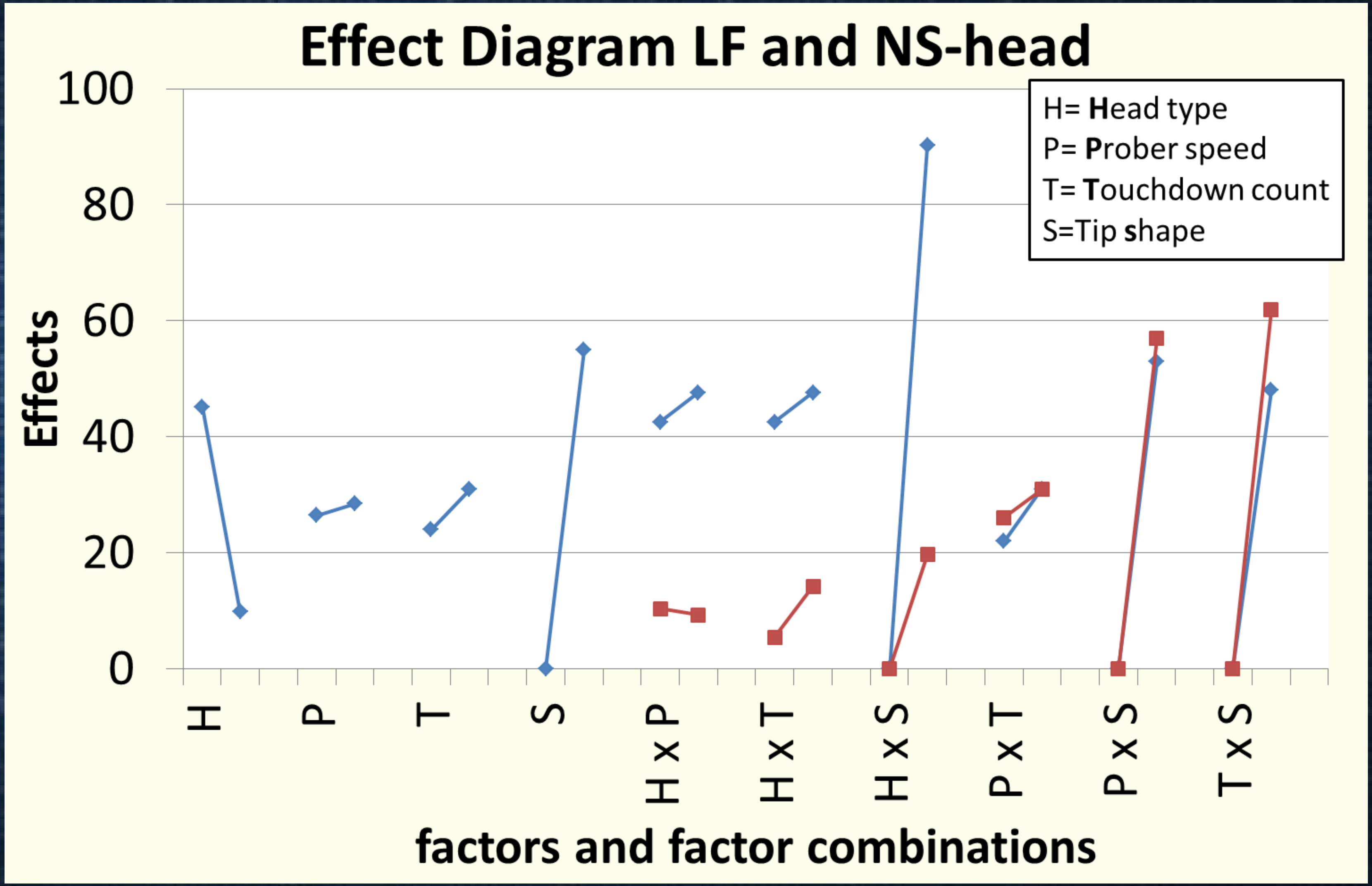
No effect comes from the prober speed.

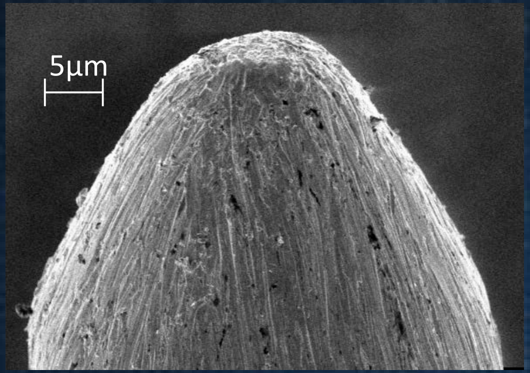
The No Scrub head seems to react more to the tip shape change than the Low Force head.



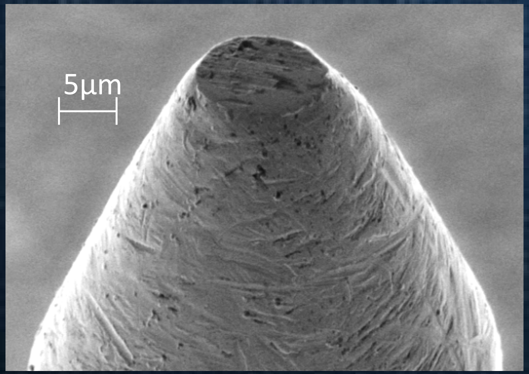
Main Experiment Results

Typical Scrub Marks (Prober = 3/3   Touchdowns = 12)

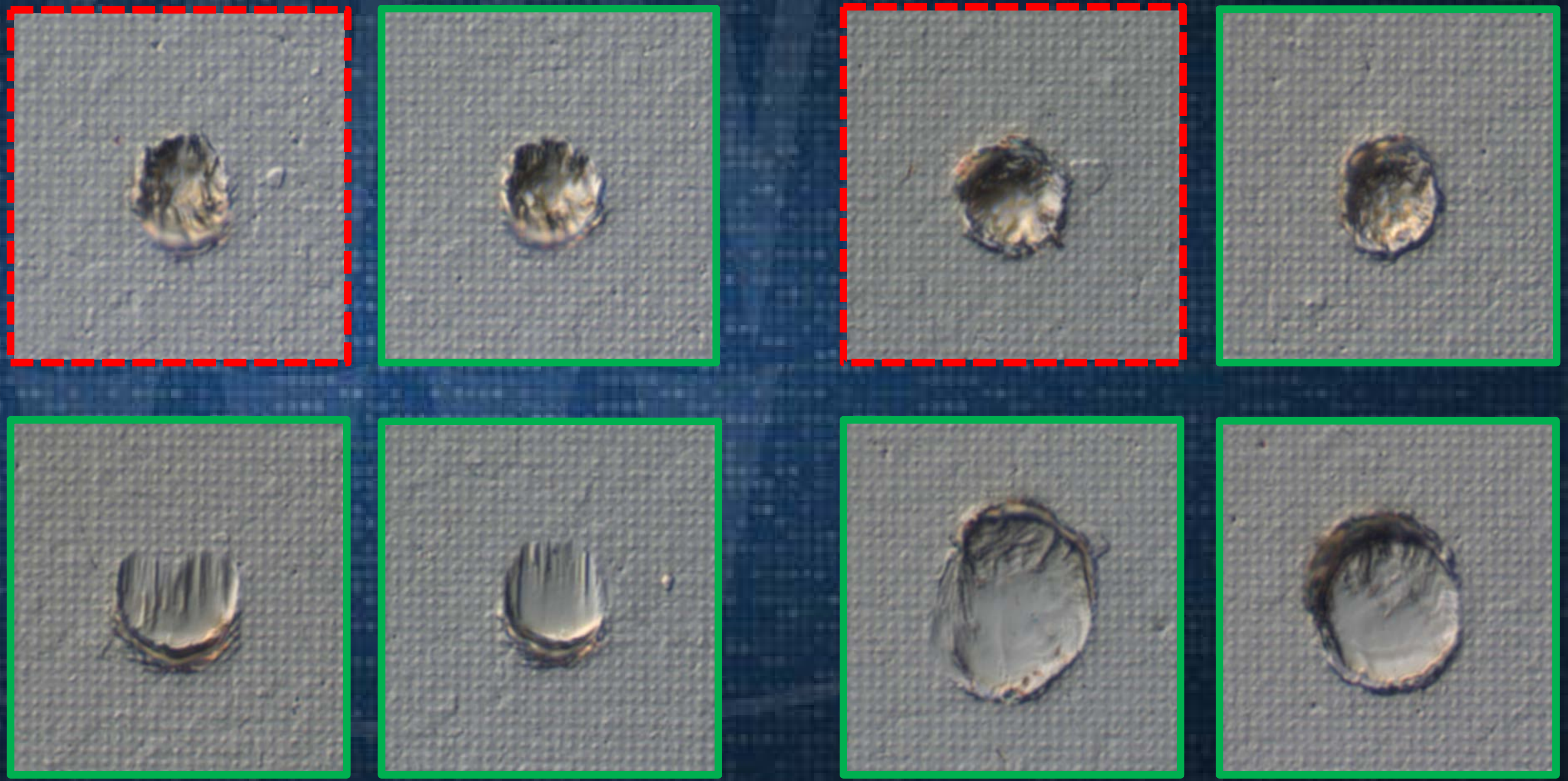
scale: 10µm x 10µm



rounded tip



tuncated cone tip



low force head

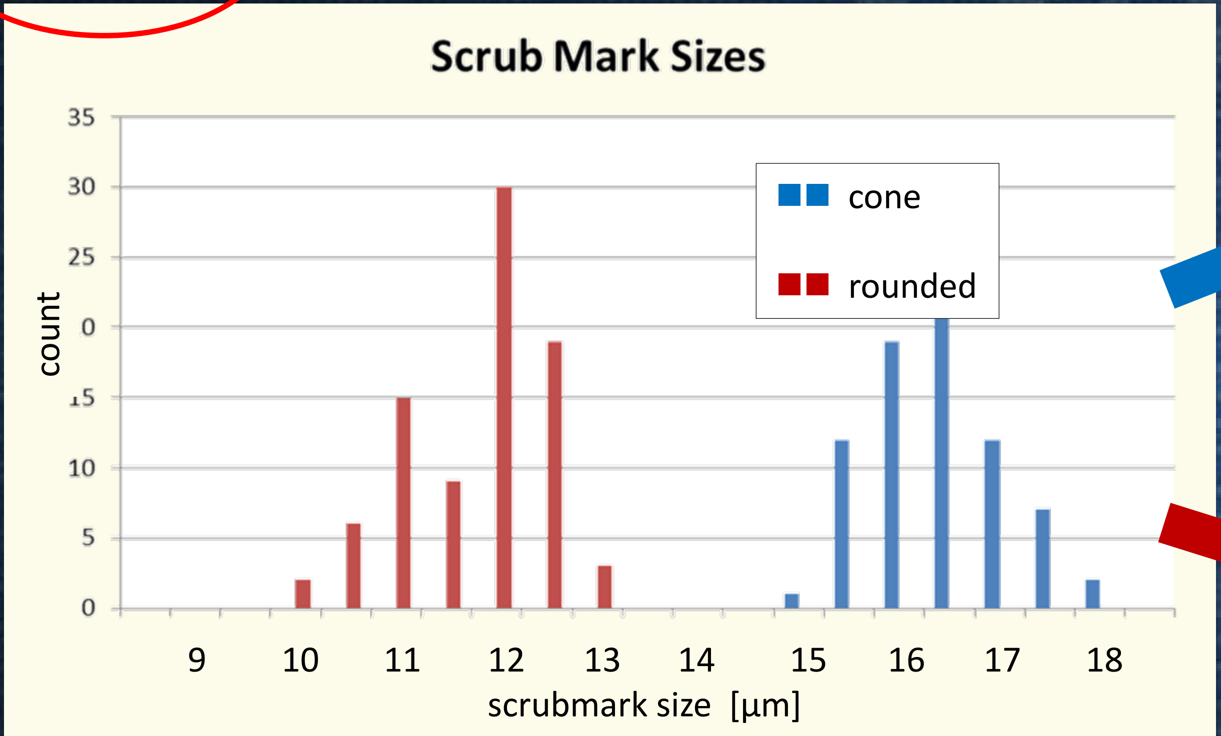
no scrub head

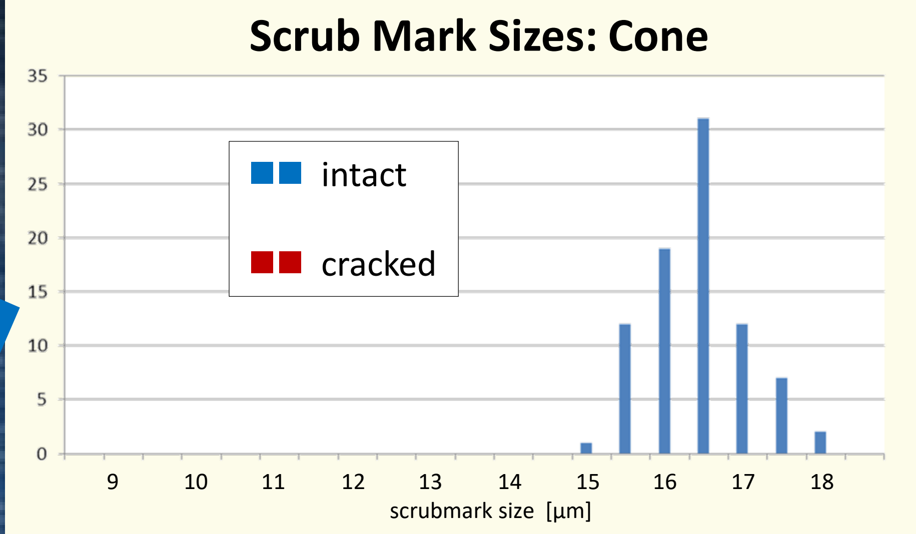
cracked

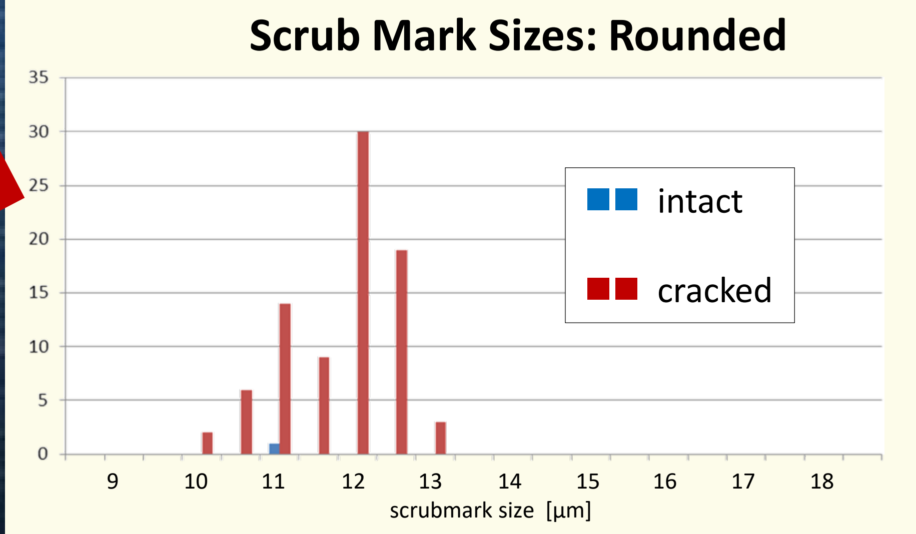
not cracked

Main Experiment Results

No Scrub Head: Crack vs. scrub mark size





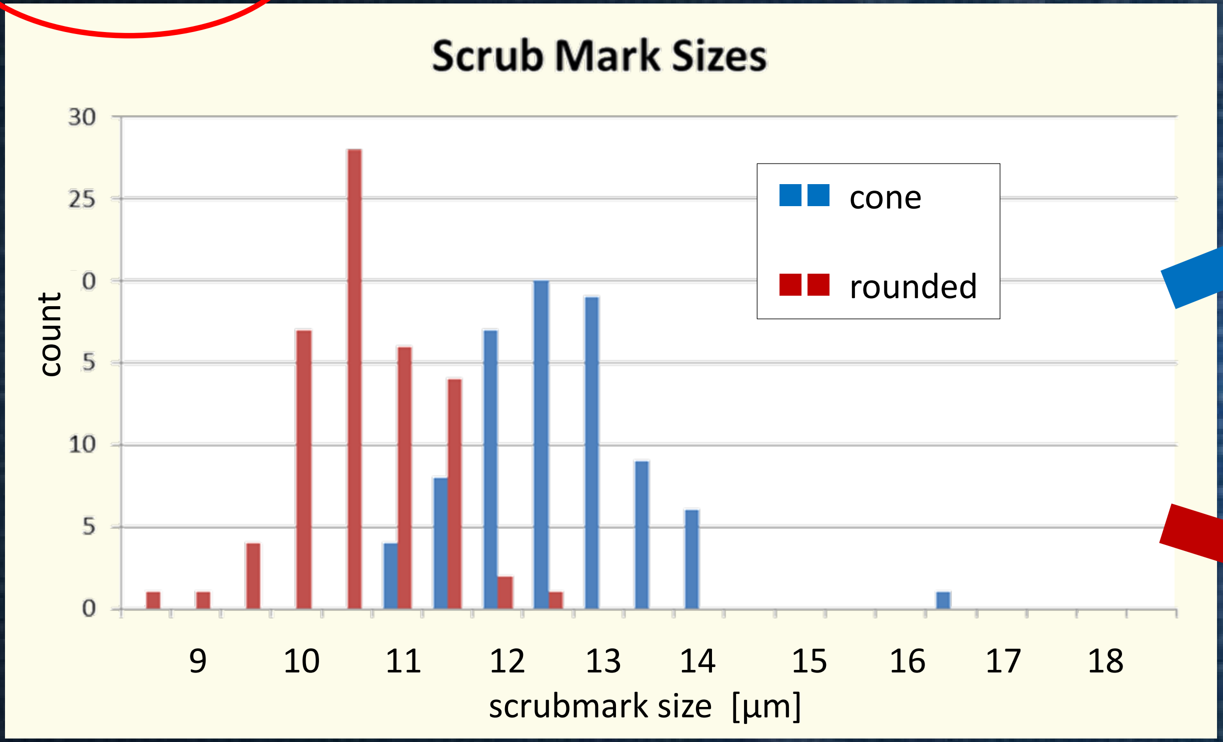


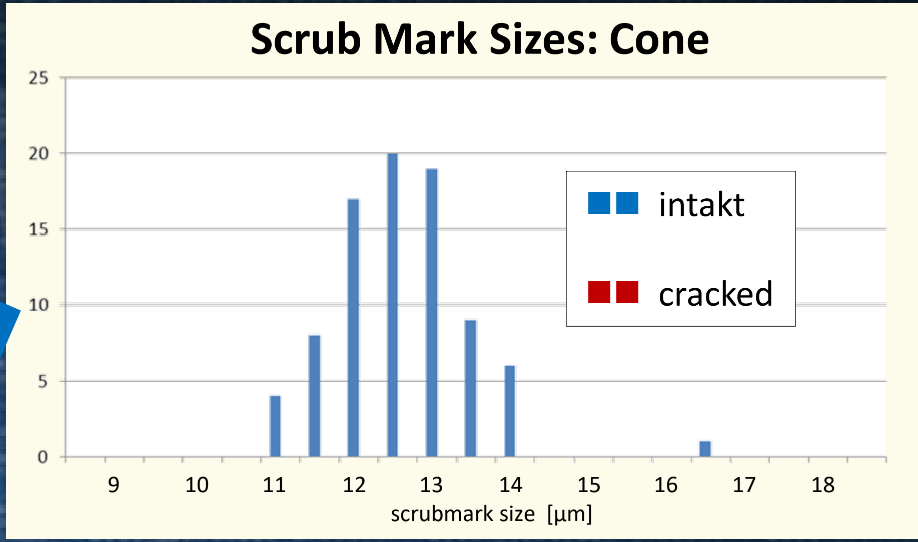
➔ no cracks with the cone tip, 98% cracks with the rounded tip

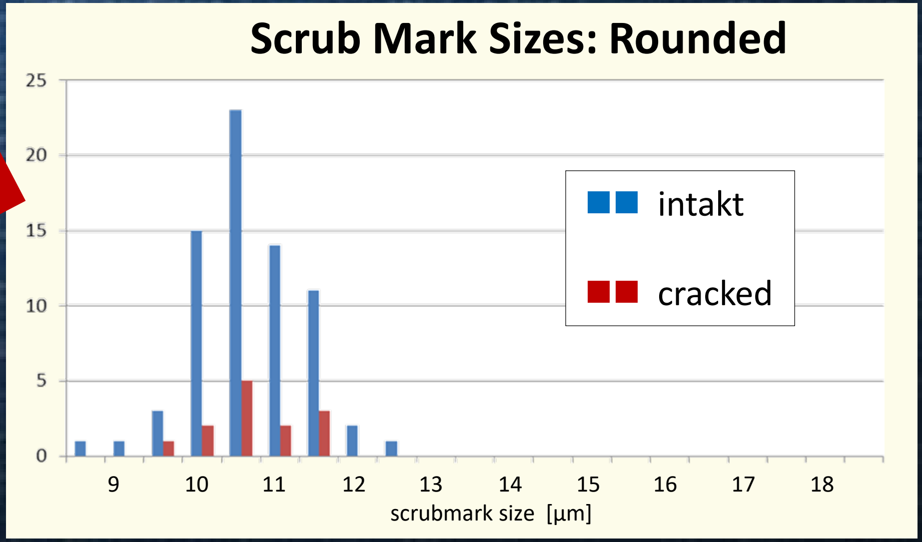
➔ possible dependency from scrub mark size

Main Experiment Results

Low Force Head: Crack vs. scrub mark size





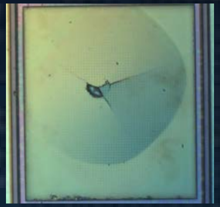


➔ no cracks with the cone tip

➔ cracks with the rounded tip but no scrub mark size dependency

Main Experiment Summary

- Major effect is the tip shape: rounded cracks more than the cone



- Low force is more important than low scrub to reduce cracks

- Scrub mark size may be not as important as assumed

- Touchdown count (12|20) has a little influence

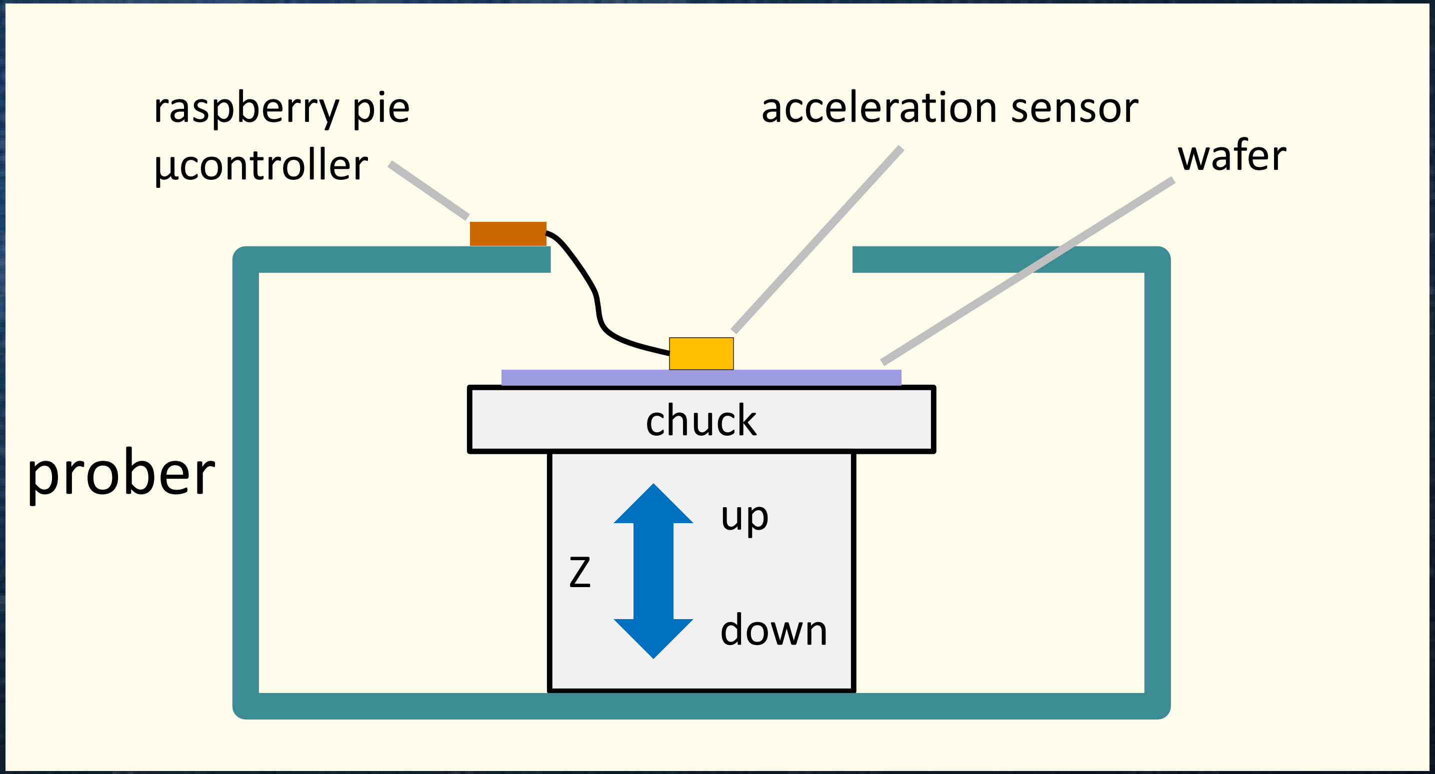
- No effect from the prober speed

Side Experiment One: Prober Z-Movement

Why don't we see differences from the prober movement?

Measurement of the prober* Z-movement using an acceleration sensor

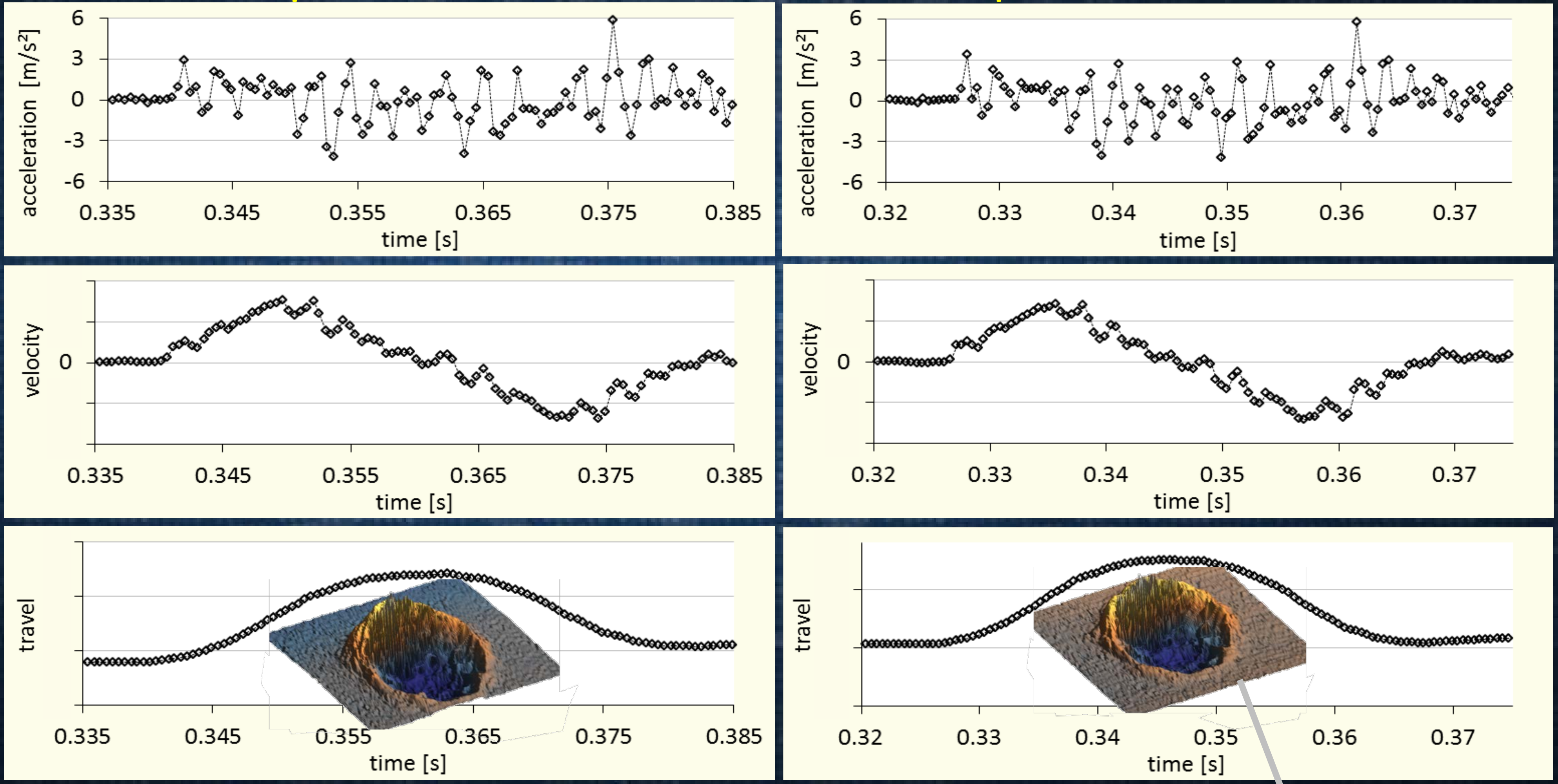
device:	BMA280
measurement frequency:	2000 Hz
resolution:	0,002 m/s^2
metering range:	±40 m/s^2



*TEL precio octo 200mm

Side Experiment One: Prober Z-Movement

prober = fast　　　　prober = slow



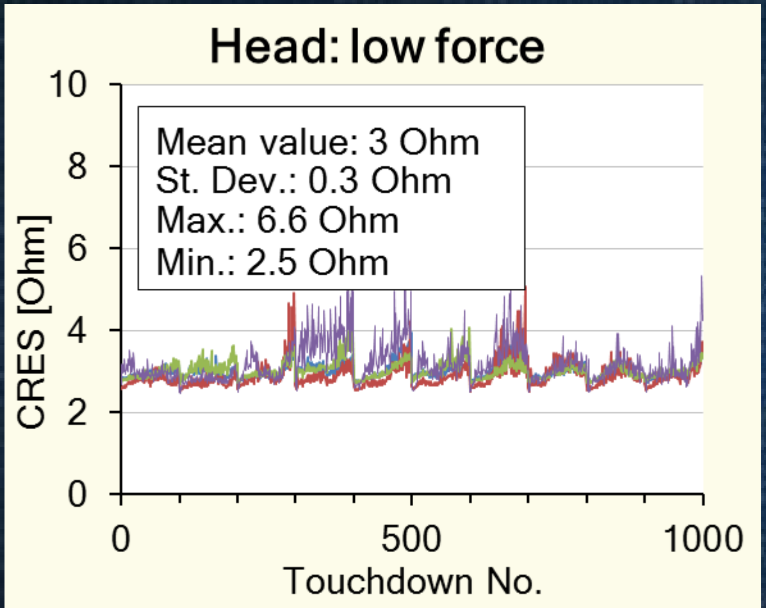
AFM-scan, single TD

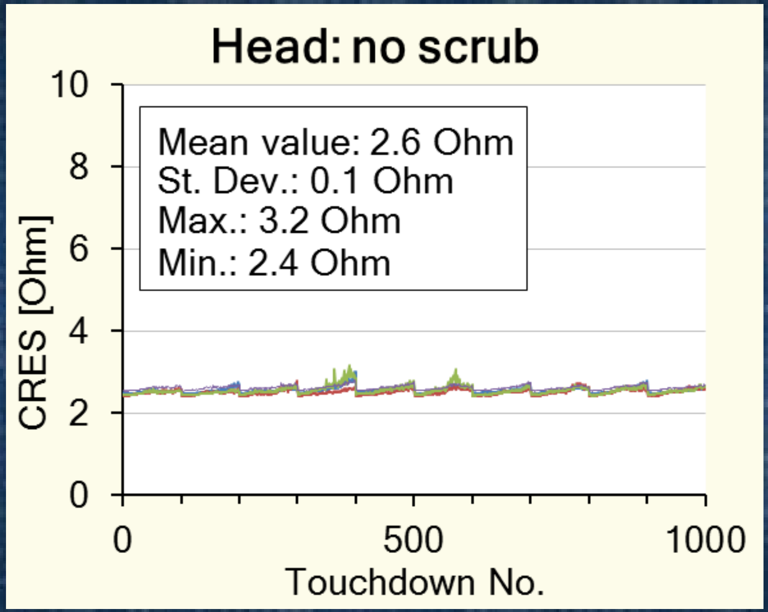
Both prober settings behave almost identically

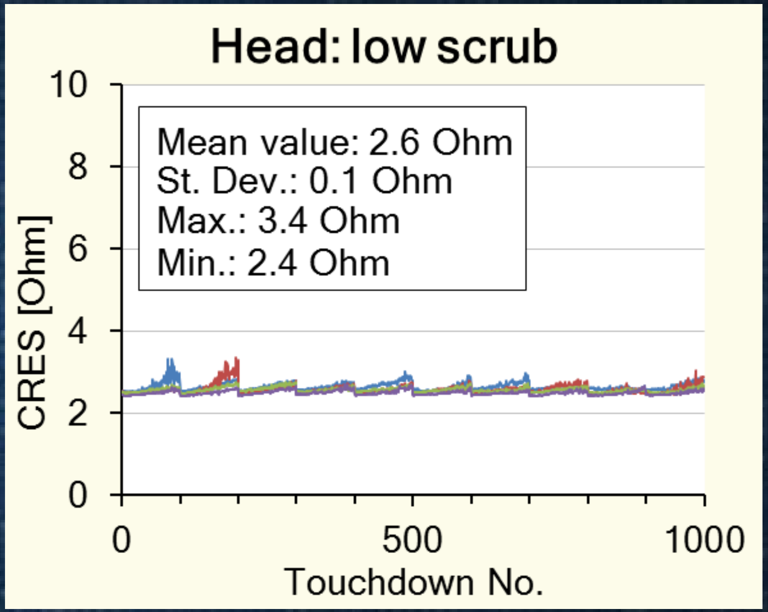
➔ we still have to learn how to change prober Z-kinetics effectively

Side Experiment Two: Contact resistance

No crack is only one side of the medal …. contact resistance is the other







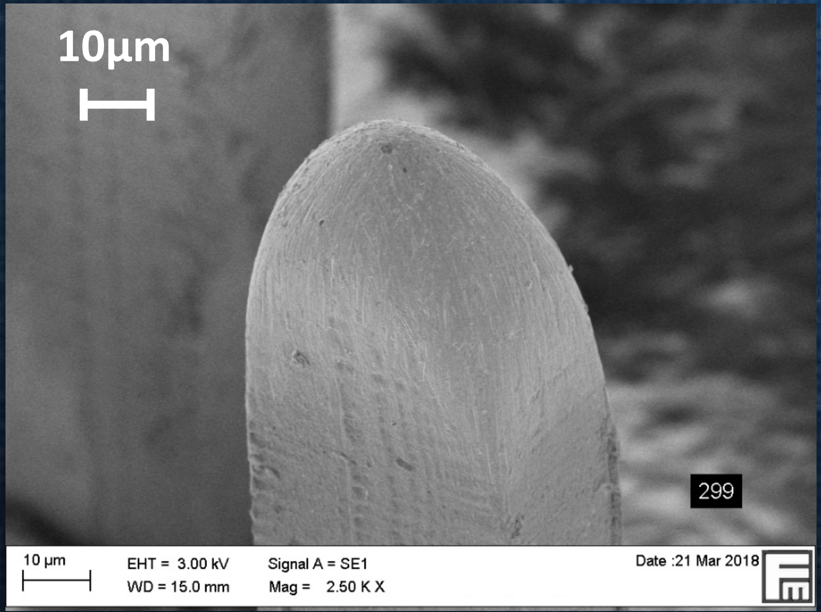
- 85µm overdrive
- 2V / 20mA
- cone tips
- bare Al-wafer
- TEL prober (full speed)
- online cleaning intervall: 100TD

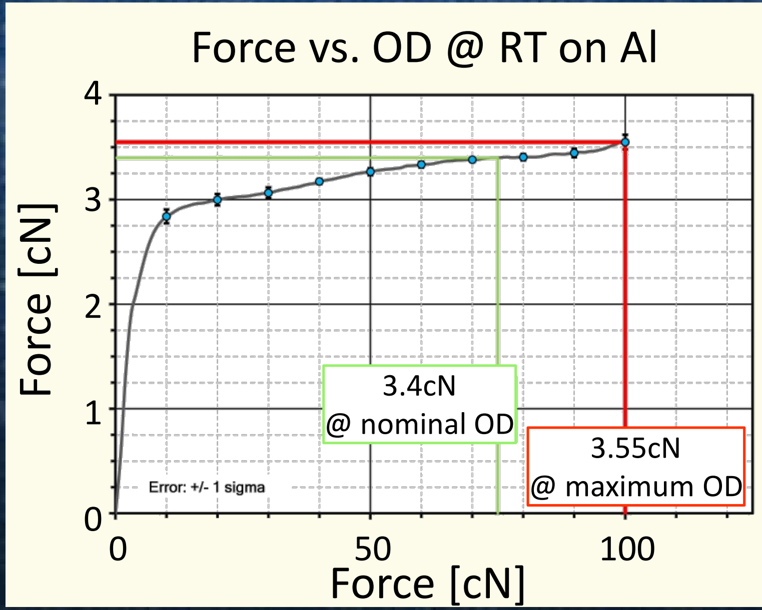
Force is more important than scrub for a stable contact

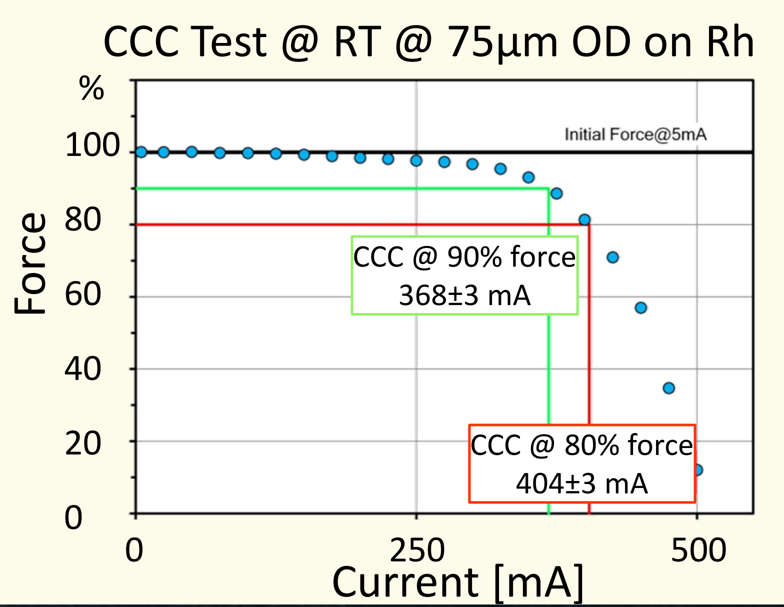
Side Experiment Three: MµProbe® probing

To verify if a rounded tip can probe this device w/o causing cracks

- Using “MµProbe®” (60µm pitch) probing technology
  - Vertical MEMS probe
  - Rounded tip
  - Very high current material



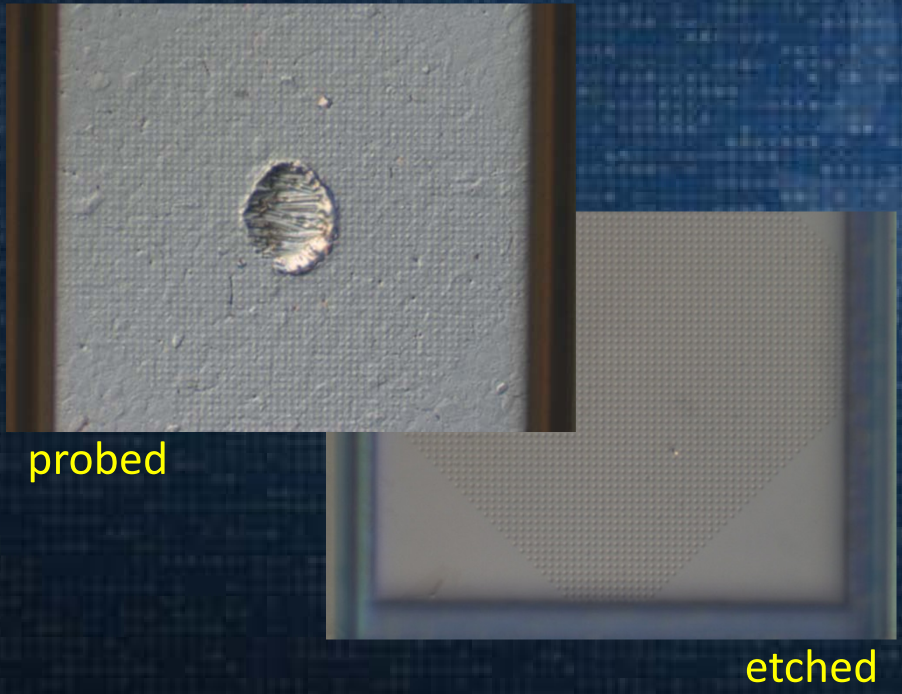


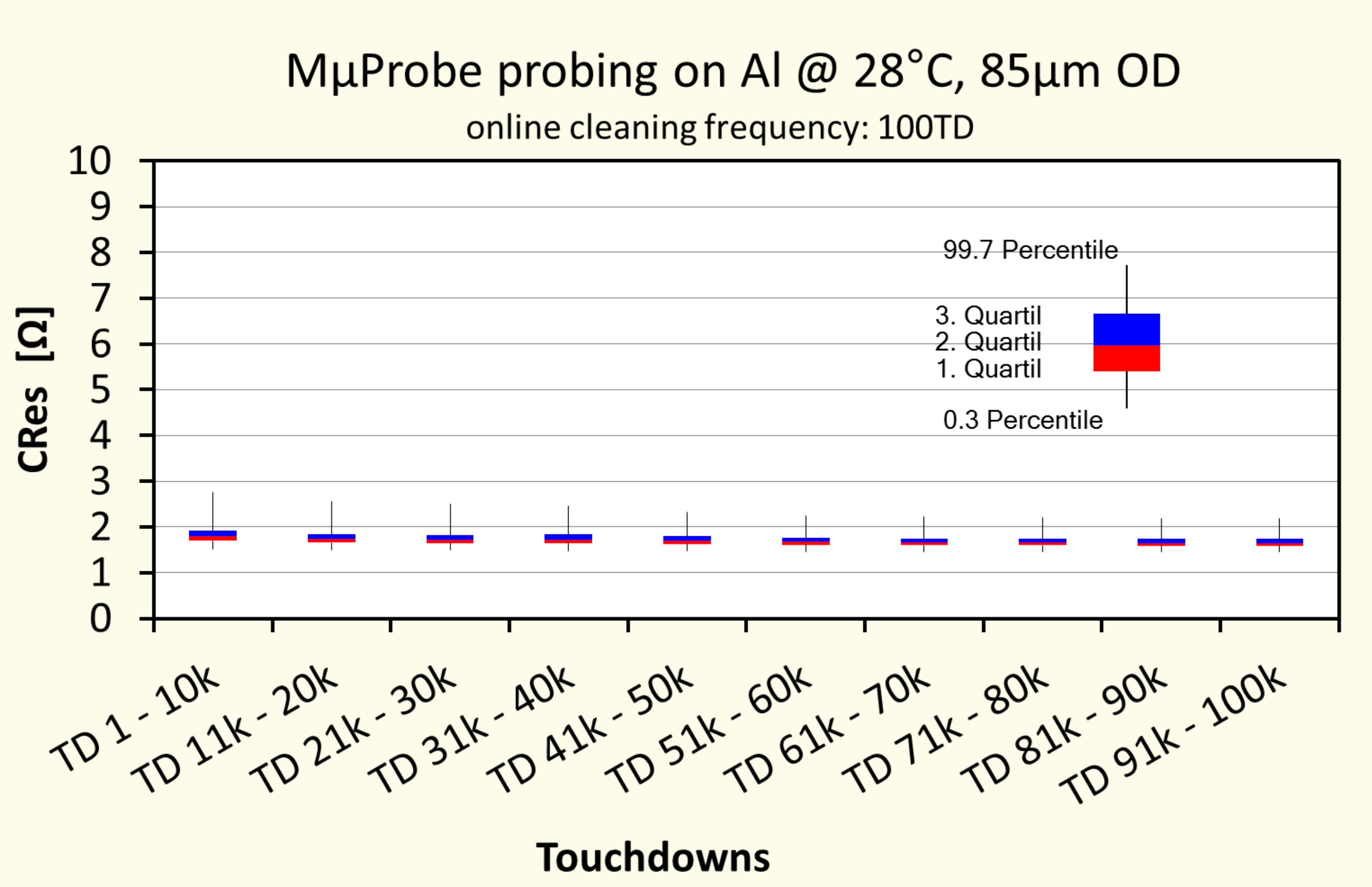


Side Experiment Three: MµProbe® probing

Results:

- No pad cracks (few TD only, 20x TD)
- Very stable contact resistance



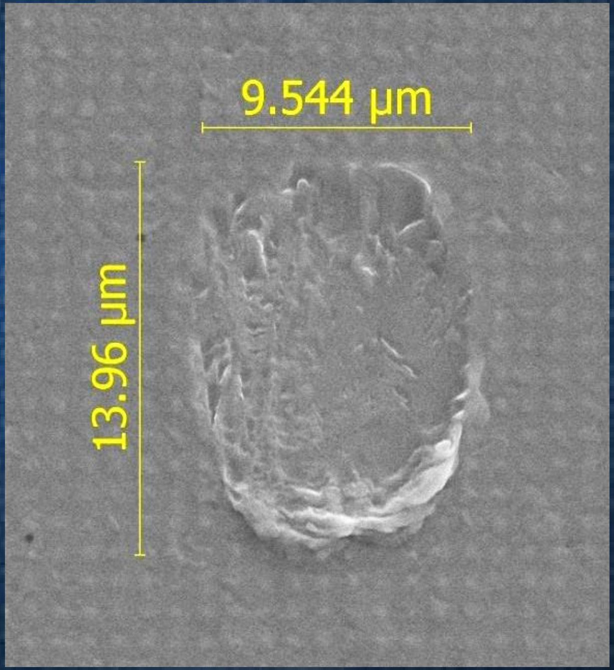


Validation Experiment on the Probe Floor

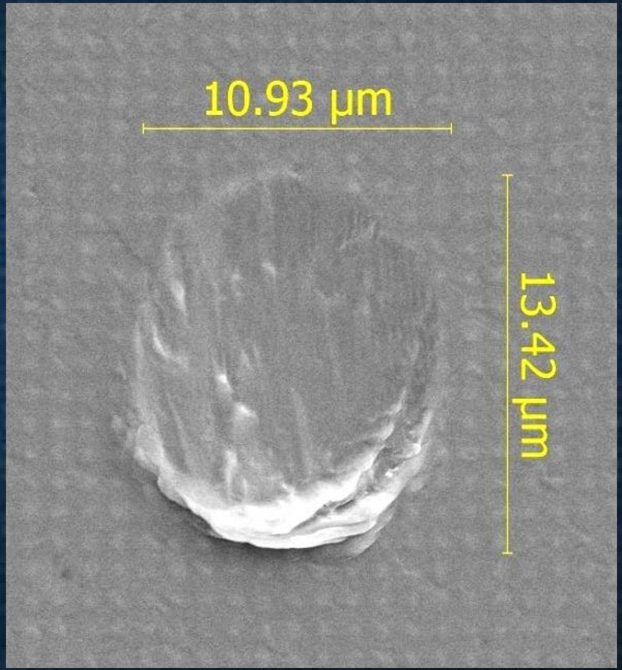
Objective: To verify if an improved prober Z-stage makes a difference.

Experiment design:

- Same Probe card: "S-Type low scrub"
- Overdrive: 70|85|100 µm
- Consecutive touchdowns: 8|12|20
- Experiment flow: like initial test
- TEL P8XL – Same as original condition but updated Z-motor driver
- Speed setting 7/7



8 TD; 70µm OD



20 TD; 100µm OD

Validation Experiment on the Probe Floor

Outcome:

The results of the experiment were as follows:

- No cracking observed during any of the overdrive conditions or touchdown counts.

Test platform	Probe Stresses		ILD Inspection Results	
	Overdrive	Probe Events (Touchdowns)	Pads Inspected	% of Pads Failing for ILD Cracking Inspection
J750	70um	8	100%	0%
		12	100%	0%
		20	100%	0%
	85um	8	100%	0%
		12	100%	0%
		20	100%	0%
	100um	8	100%	0%
		12	100%	0%
		20	100%	0%

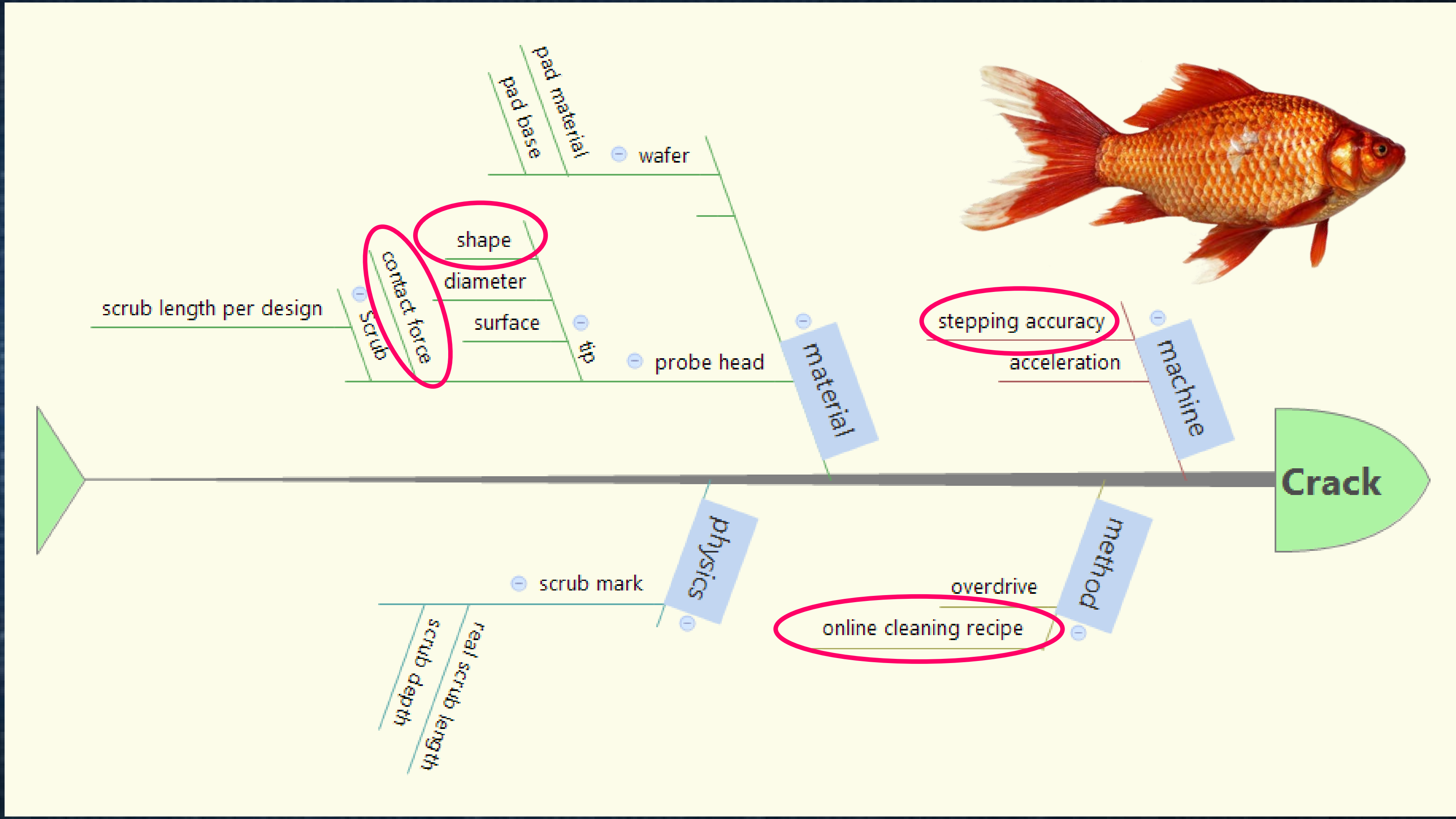
Validation Experiment on the Probe Floor

- **Precise Z installed on TEL P8XL probers**
  - Precise Z on the TEL P8XL consists of a hardware change (Motor Driver) and also settings update.
  - The P8XL probers are no longer supported so Precise Z, if not already installed, may no longer be available due to hardware upgrade
- **Z drivers on TEL Precio Probers**
  - The Z drivers on the Precio/Octo probers is much improved over Precise Z on TEL P8XL.
  - The difference is a factor of 0.2 for Precise Z on P8XL and 0.0625 on Precio probers for stepping accuracy.

Top Factors to Pad Cracks

- **Most important factors**
  - tip condition: shape, contamination
  - contact force
  - step accuracy
- **Finally, all factors on this diagram are still in the game.**

Take care!

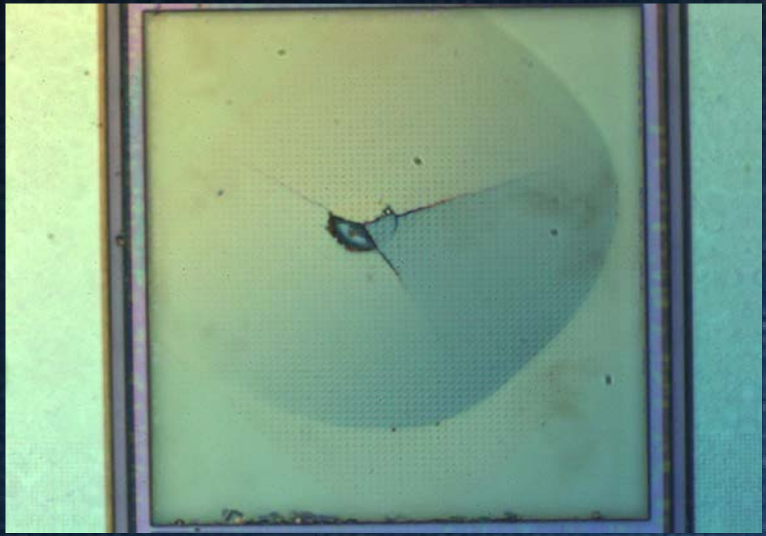


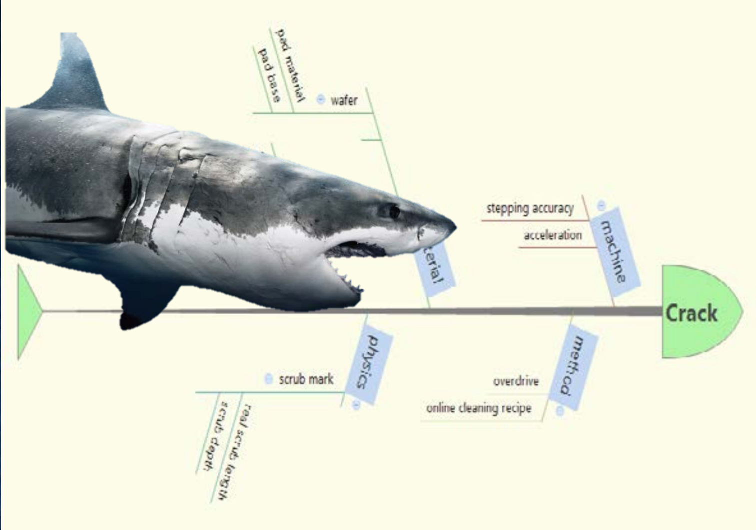
Follow-On Work

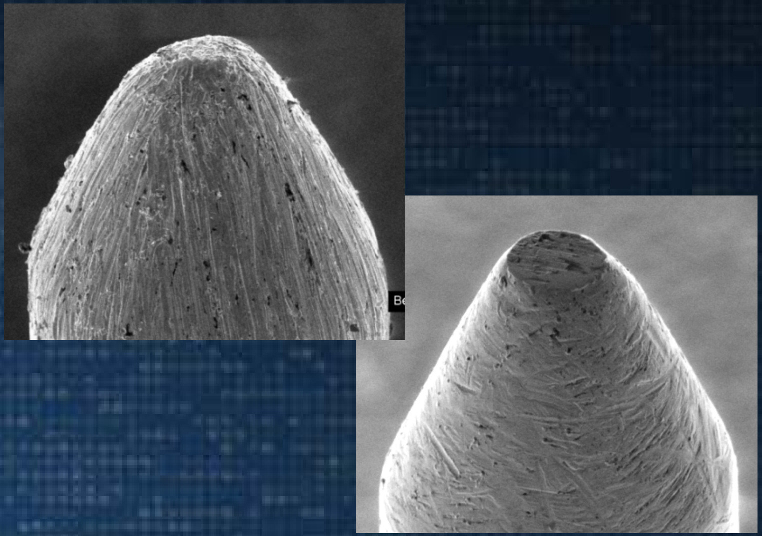
- **Future actions on Feinmetall’s 1.6 mil technology**
  - Identify products which have sensitive ILD layers and verify if this is a viable solution
  - Review solution for bond pads with pad pitch of 56µm
  - Review on bond pads of size <40µm
  - Review at automotive temperature requirements
  - Determine lifetime characteristics
- **Basic work**
  - Understand prober settings and their influence on the kinematics
  - Correlate prober settings to pad crack occurrence

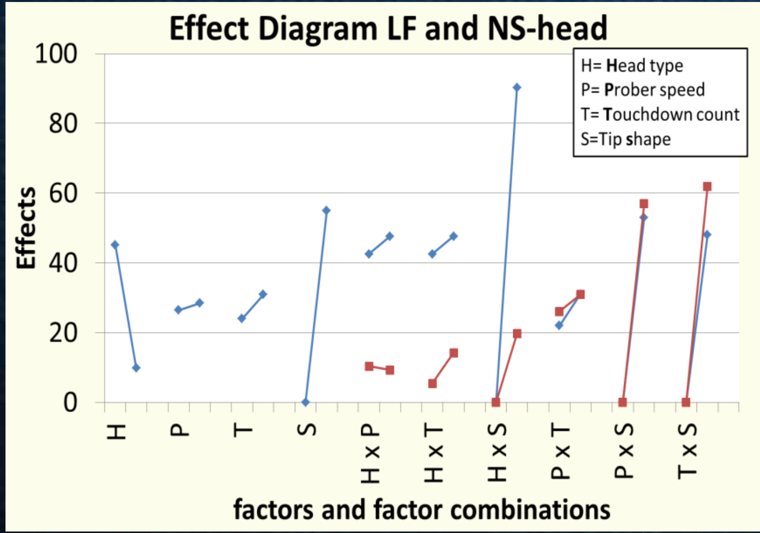
The Finish

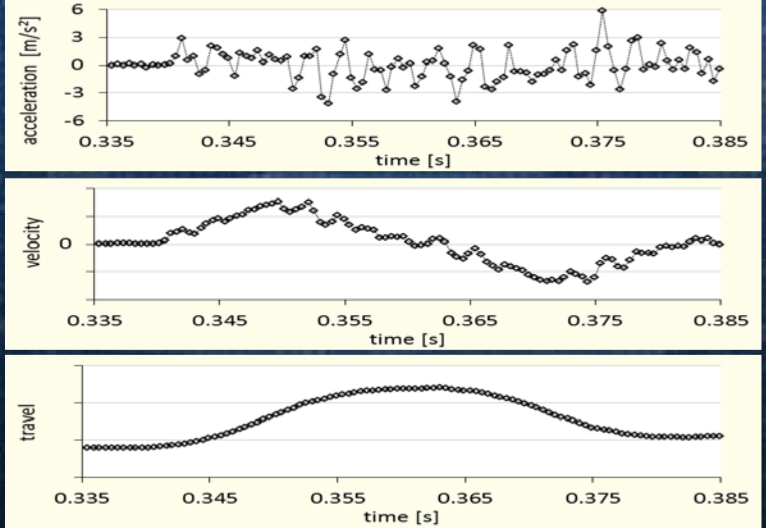
Presentation Highlights











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		12	100%	0%
		20	100%	0%
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The Finish

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