FEINMETALL
Contact technologies for electronics

Effect of different Wafer Pad Metallizations on ViProbe® Scrub Marks

by

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Introduction

IC pad functions:

- provide defined contact to ensure test of a device
- establish surface area for connection

Trends:

- Pad pitch and pad area gets smaller, area for electrical test also
- Structures underneath the pads
- Wide variety of pad metallizations

IC pad metallizations

Aluminium-based alloys

- actually still most widely used pad metallization group
- alloys with various percentages of Si (0.5 - 1% typically) to prevent Al-diffusion into Si and of Cu (up to 2%) in order to avoid electromigration
- both raising number and higher content of alloyed elements increases hardness
- pure Al and Al alloys form an Al oxide layer at the surface

IC pad metallizations

Gold:

- very soft
- no oxidation of the surface
- mono-metal system with Au-bonding wires

Copper:

- driven by Cu-bonding (mono-metal system) due to the advantageous electrical and mechanical properties, and the cost of Cu compared to Au
- application both by electroplating and vapour deposition possible

IC Probe Card Requirements

- low resistance between IC pad and interface of probe card to the tester, this includes all of the inevitable contact resistances
- position and size of testmark has to be in exactly defined limits in x- and y-direction
- test marks never may destroy structures underneath the pads

Objective of Investigation

It was the objective to find out the influence of

- overtravel
- number of touchdowns
- pad metallization
- test temperature
- beam diameter

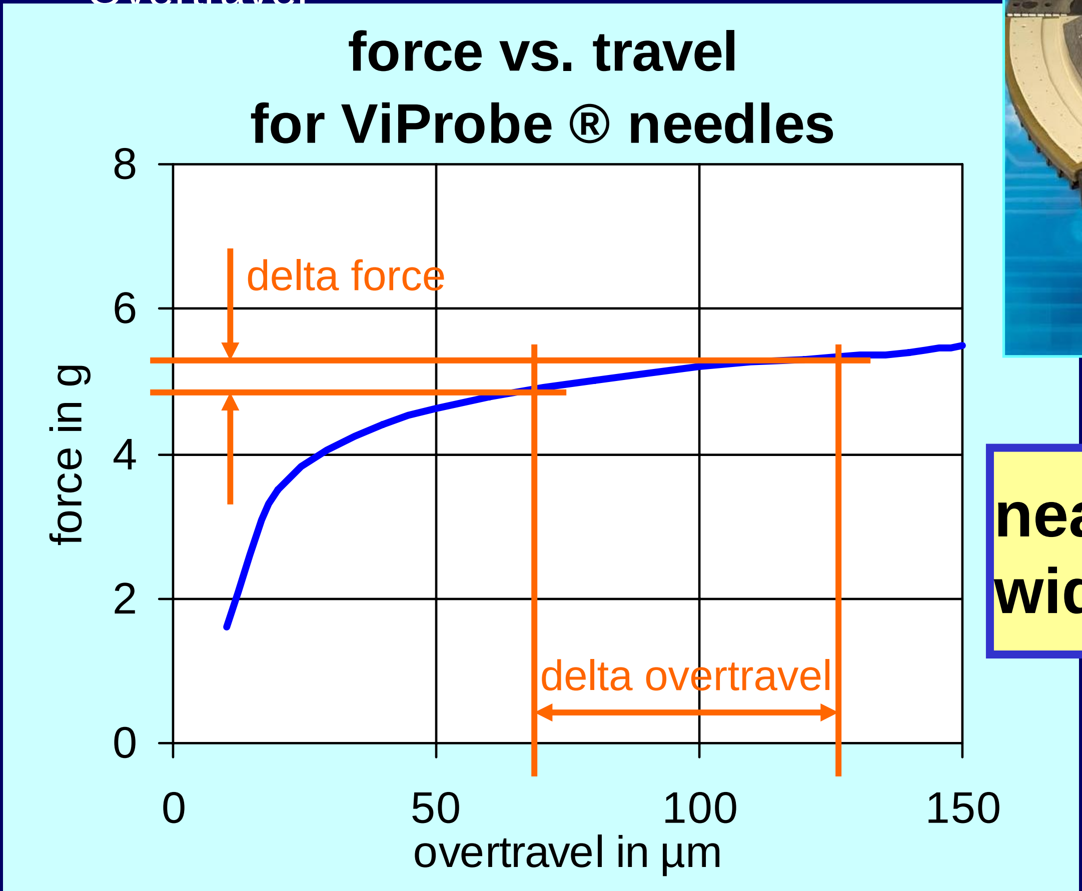
on ViProbe® scrub marks.

Test Plan

Parameter		**Pad metallization**	**Beam diameter**	**Overtravel**	**Temperature**	**Number of Touchdowns**
Parameter Settings		AlCu2% Al Cu	2 mil 2.5 mil 3 mil	100 µm 130 µm 160 µm	RT (22°C) 90 / 95°C 120°C 150°C 200°C	1 x 2 x 4 x 8 x

Test Vehicle

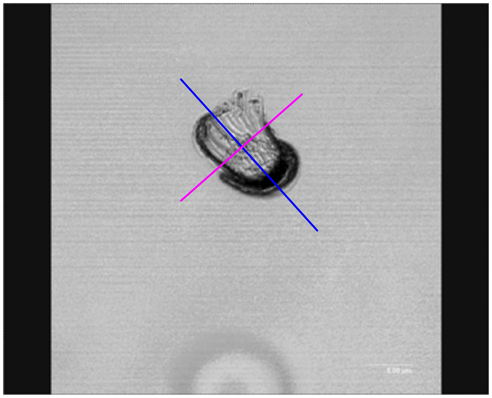
ViProbe® Force vs. Overtravel

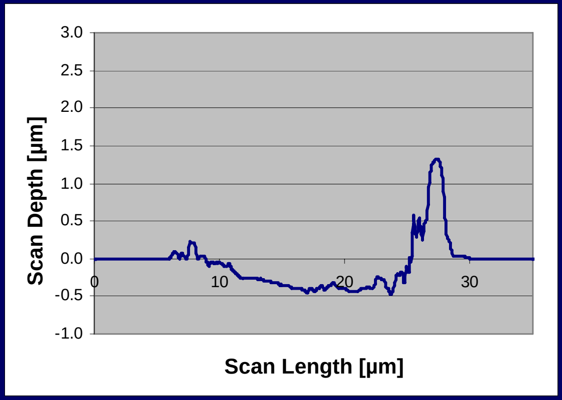


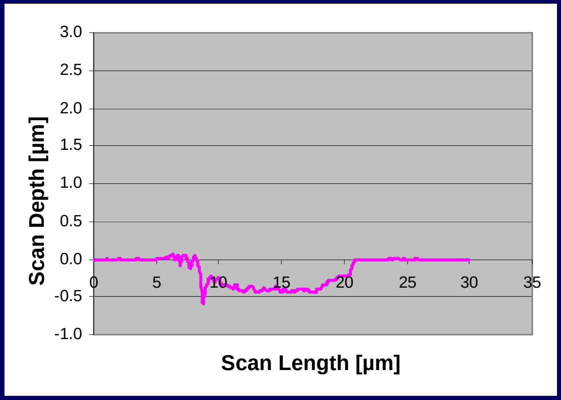
nearly constant force in a wide range of overtravel

Tests and Evaluation

- special test head for each beam diameter
- parameter settings for each of the planned test cells
- scrub marks inspected visually and measured by Laser Scanning Microscope
- 20 scrub marks measured per test cell







Scrub mark on AlCu 2% Scanning profile, lengthwise Scanning profile,
crosswise 2.5 mil beam, 100 micron overtravel
RT (22°C), 1 touchdown

Results

Influence of Overtravel on Scrub Marks

2 mil beams, RT (22°C), 1

Pad metal-lization	Over-travel micron	Scrub mark length micron		Scrub mark width micron		Scrub mark depth micron		Pile-up height micron	
		Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
AlCu2%									
1.2 µm	100	26.2	2.4	12.9	1.5	0.35	0.10	0.79	0.47
	130	34.3	2.9	10.2	1.4	0.49	0.11	1.67	0.84
Al									
1.4 µm	100	23.8	2.5	17.8	2.5	1.46	0.43	4.00	1.12
	130	28.7	2.8	19.9	2.3	1.41	0.23	4.88	1.46
Cu									
10 µm	100	22.6	2.4	12.9	2.0	1.30	0.30	2.00	0.80
	130	24.4	1.5	15.2	2.0	1.40	0.40	2.70	0.80

Results

Influence of Overtravel on Scrub Marks

2.5 mil beams, RT (22°C), 1

Pad metal-lization	**Over-travel micron**	**Scrub mark length micron**		**Scrub mark width micron**		**Scrub mark depth micron**		**Pile-up height micron**	
		Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
AlCu2%									
1.2 µm	100	23.5	3.6	14.5	1.1	0.83	0.22	2.62	0.85
	160	25.2	2.1	16.7	2.1	0.97	0.19	2.76	0.69
Al									
1.4 µm	100	25.0	3.8	18.5	1.7	1.49	0.19	3.71	0.94
	160	30.9	2.8	22.4	2.8	1.47	0.22	4.55	0.46
Cu									
10 µm	100	22.5	3.0	16.5	2.0	1.50	0.60	1.70	0.70
	160	26.8	2.0	16.8	2.0	1.80	0.30	1.80	0.60

Results

Influence of Overtravel on Scrub Marks

AlCu2%, 1.2 µm pad metallization, RT (22°C), 1 touchdown

Beam diameter mil	Over-travel micron	Scrub mark length micron		Scrub mark width micron		Scrub mark depth micron		Pile-up height micron	
		Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
2	100	26.2	2.4	12.9	1.5	0.35	0.10	0.79	0.47
2	130	34.3	2.9	10.2	1.4	0.49	0.11	1.67	0.84
2.5	100	23.5	3.6	14.5	1.1	0.83	0.22	2.62	0.85
2.5	160	25.2	2.1	16.7	2.1	0.97	0.19	2.76	0.69
3	100	22.5	1.3	14.5	0.9	0.47	0.09	1.28	0.37
3	160	27.2	4.3	14.9	1.5	0.54	0.11	0.85	0.35

- raising overtravel causes significantly increasing scrub mark length and depth
- no significant influence of overtravel on scrub mark width
- larger values of scrub mark length and depth result in higher pile-ups

Results

Influence of Number of Touchdowns on Scrub Marks

AlCu2%, 1.2 µm pad metallization, 2.5 mil beams, RT (22°C), 160 µm

Number of touch-downs	**Scrub mark length micron**		**Scrub mark width micron**		**Scrub mark depth micron**		**Pile-up height micron**	
	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
1 x	28.9	3.7	14.5	2.3	0.41	0.10	0.54	0.14
2 x	30.5	3.2	15.4	1.6	0.61	0.13	1.53	0.91
4 x	32.3	4.0	16.6	2.0	0.74	0.16	2.18	1.42
8 x	34.0	2.0	15.6	1.8	1.00	0.19	2.79	1.40

number of touchdowns influences

- scrub mark length: gradual increase
- scrub mark depth: significant increase
- pile-ups

Results

Influence of Number of Touchdowns on Scrub Marks

AlCu2%, 1.2 µm pad metallization, 3 mil beams, RT (22°C), 160 µm overtravel

Number of touch-downs	**Scrub mark length micron**		**Scrub mark width micron**		**Scrub mark depth micron**		**Pile-up height micron**	
	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
1 x	27.2	4.3	14.9	1.5	0.54	0.11	0.85	0.35
2 x	30.3	3.2	17.1	1.2	0.60	0.09	0.79	0.46
8 x	39.2	4.5	21.8	2.5	0.91	0.07	1.49	1.13

- raising number of contacts causes gradual increase of scrub mark length and significant increase of scrub mark depth
- raising scrub mark width with increasing number of TDs
- larger values of scrub mark length and depth result in higher pile-ups, but pile-up growth not only in z-direction

Results

Influence of Number of Touchdowns on Scrub Marks

Cu, 10 µm pad metallization, RT (22°C), 130 / 160 µm overtrav

Beam diameter mil	Number of TDs	Overtravel micron	Scrub mark length micron		Scrub mark width micron		Scrub mark depth micron		Pile-up height micron	
			Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
2	1 x	130	24.4	1.5	15.2	2.1	1.8	0.4	2.7	0.8
	2 x	130	25.8	2.5	14.4	1.9	2.3	0.8	3.0	1.2
2.5	1 x	160	26.8	2.0	16.8	1.8	1.5	0.3	1.3	0.6
	2 x	160	29.0	3.0	19.9	2.0	2.4	0.6	2.2	0.9

- gradual increase of scrub mark length and significant increase of scrub mark depth with raising number of touchdowns confirmed
- no significant influence of number of TDs on scrub mark width
- higher pile-ups due to larger values of scrub mark length and depth

Results

Influence of Pad Metallization on Scrub Marks

2 mil beams, RT (22°C), 1 touchdown

Pad metallization, thickness	Hardness (MPa)	Over-travel micron	Scrub mark length micron		Scrub mark width micron		Scrub mark depth micron		Pile-up height micron	
			Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
Al, 1.4 micron	171 ± 21	100	23.8	2.5	17.8	2.5	1.46	0.43	4.00	1.12
Cu, 10 micron	343 ± 11	100	22.6	2.4	12.9	2.0	1.50	0.30	2.00	0.80
AlCu2%, 1.2 micron	583 ± 55	100	26.2	2.4	12.9	1.5	0.35	0.10	0.79	0.47
Al, 1.4 micron	171 ± 21	130	28.7	2.8	19.9	2.3	1.41	0.23	4.88	1.46
Cu, 10 micron	343 ± 11	130	24.4	1.5	15.2	2.0	1.80	0.40	2.70	0.80
AlCu2%, 1.2 micron	583 ± 55	130	34.3	2.9	10.2	1.4	0.49	0.11	1.67	0.84

- highest values of scrub mark length with AlCu2% pad metallization
- gradual decrease of scrub mark width with raising metallization hardness
- softer pad metallization causes deeper scrub marks and higher pile-ups

Results

Influence of Pad Metallization on Scrub Marks

2.5 mil beams, RT (22°C), 1

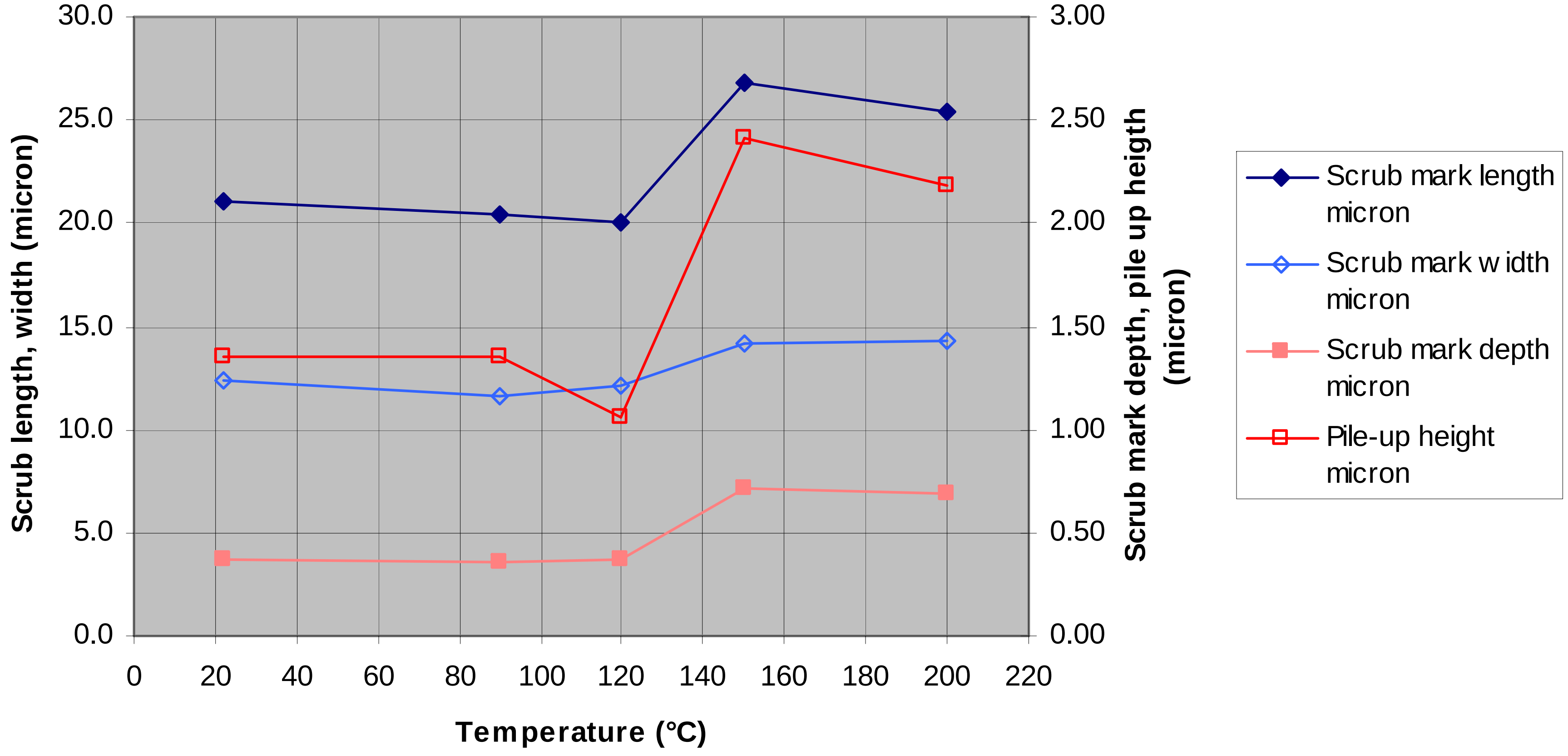
Pad metallization, thickness	Hardness (MPa)	Over-travel micron	Scrub mark length micron		Scrub mark width micron		Scrub mark depth micron		Pile-up height micron	
			Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
Al, 1.4 micron	171 ± 21	100	25.0	3.8	18.5	1.7	1.49	0.19	3.71	0.94
Cu, 10 micron	343 ± 11	100	22.5	3.0	16.5	2.0	1.40	0.60	1.70	0.70
AlCu2%, 1.2 micron	583 ± 55	100	23.5	3.6	14.5	1.1	0.83	0.22	2.62	0.85
Al, 1.4 micron	171 ± 21	160	30.9	2.8	22.4	2.8	1.47	0.22	4.55	0.46
Cu, 10 micron	343 ± 11	160	26.8	2.0	16.8	2.0	1.30	0.30	1.30	0.60
AlCu2%, 1.2 micron	583 ± 55	160	25.2	2.1	16.7	2.1	0.97	0.19	2.76	0.69

- no significant influence of pad metallization on scrub mark length
- lower hardness of pad metallization causes significantly deeper and slightly wider scrub marks
- highest pile-up values for pure Al pad metallization

Results

Influence of Temperature on Scrub Marks

AlCu2%, 2.5 mil beams, 160 micron



Results

Influence of Temperature on Scrub Marks

Cu, 10 µm pad metallization, 1

Beam diameter mil	Overtravel micron	Temperature °C	Scrub mark length micron		Scrub mark width micron		Scrub mark depth micron		Pile-up height micron	
			Average	Std. deviation	Average	Std. deviation	Average	Std. deviation	Average	Std. deviation
2	130	RT	24.4	1.5	15.2	2	1.8	0.4	2.7	0.8
2	130	95	23.1	2.2	16.8	1.9	2	0.6	2.7	0.8
2	130	150	25	4.2	16.3	2.1	2.5	0.5	3	0.5
2.5	160	RT	26.8	2	16.8	1.8	1.5	0.3	1.3	0.6
2.5	160	95	27.6	2.6	19.2	1.8	1.9	0.5	1.8	0.5
2.5	160	150	28.4	3	16.3	2	2.1	0.5	2.2	0.6

- tendency toward higher scrub mark lengths with raising temperature
- no significant influence of temperature on scrub mark width
- increasing temperature causes deeper scrub marks, which result in higher pile-ups

Summary

- **All investigated parameters influence the scrub marks and pile-ups.**

  - overtravel
  - number of touchdowns
  - pad metallization
  - test temperature
  - beam diameter

- **Based on these findings it is necessary to consider pad metallizations in the list of remaining parameter settings.**
- **By this it is possible to ensure both**

  - save electrical contacting of the pads and

  - minimum position and scrub mark size tolerance.

Thank You !

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