IEEE SW Test Workshop

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"ARGON": a new Epoxy Technology for probing POA power devices

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Table of contents

- **Problem description**
- **Methodology followed**
  - Probing Process DOE
  - Needle geometries and materials
  - Electrical and mechanical needle characterization
  - Probe Modeling
- **Production results**
- **New developments**

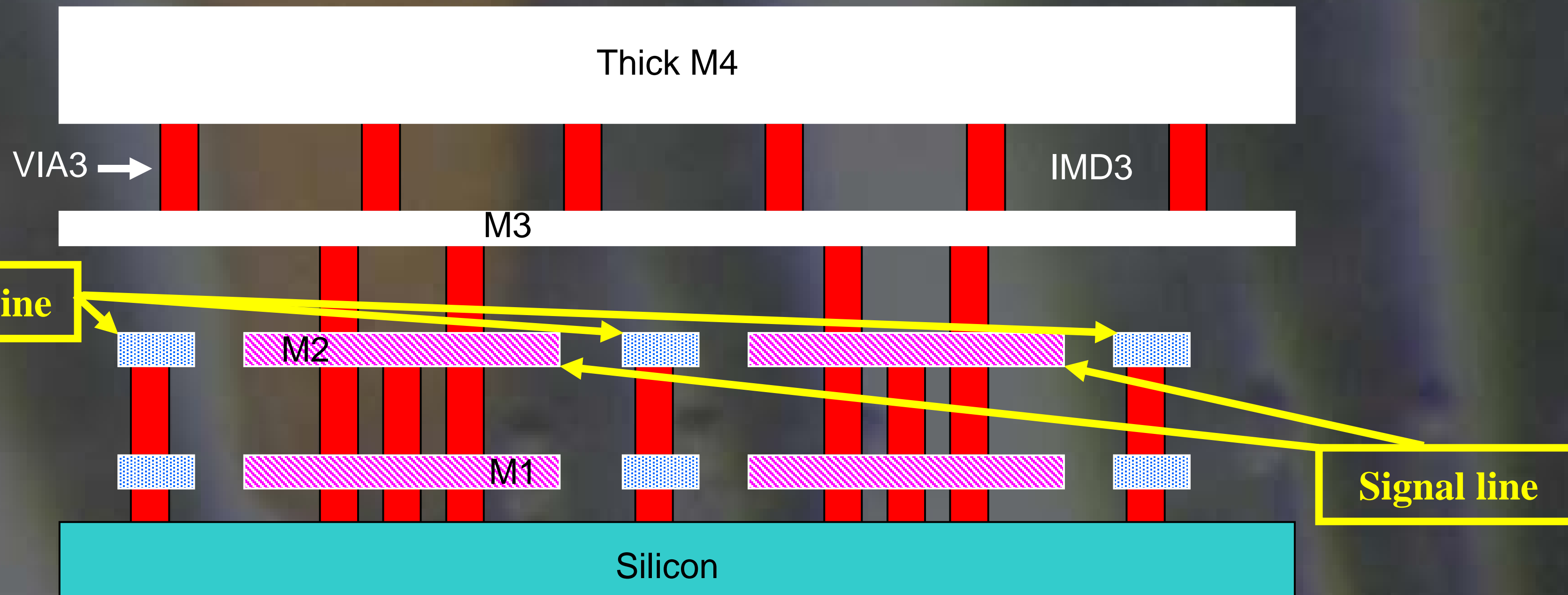
Problem description

- **The product involved** is a very critic mass production Power device

- **Problem:**
  - **A too narrow probing process window**
  - **Yield and productivity losses** due to **contact issues**
  - **Reliability issues** due to **damages** induced in the pad structure

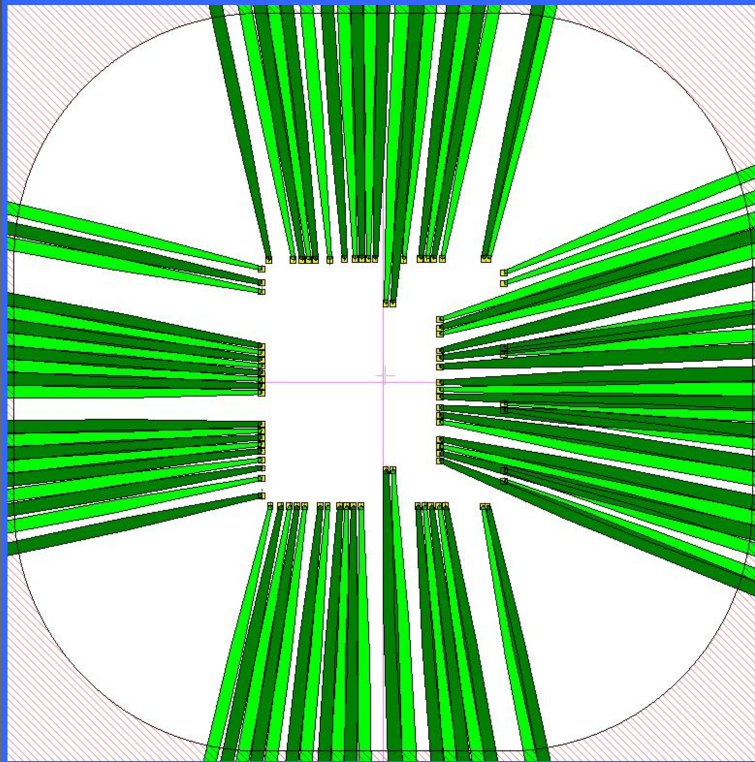
- **Main process criticalities:**
  - **4M1T POA** pad structure
  - **Electrical Contact** stability
  - **Current carrying capability** (up to 1.2 – 1.4 A for up to 10 ms on a single needle)
  - **Test T**: +70°C
  - **Pad opening**: 81 x 96 µm

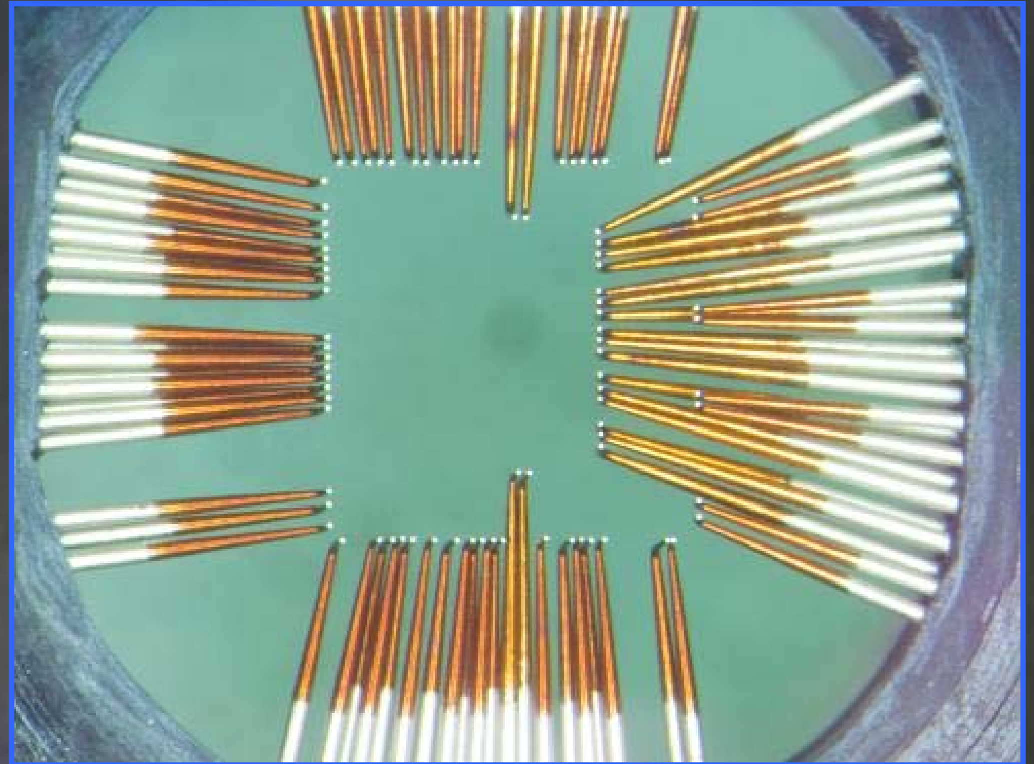
4M1T POA Pad Structure



- The last two metals (M4 and M3) are short-circuited by design

Probe Card Layout





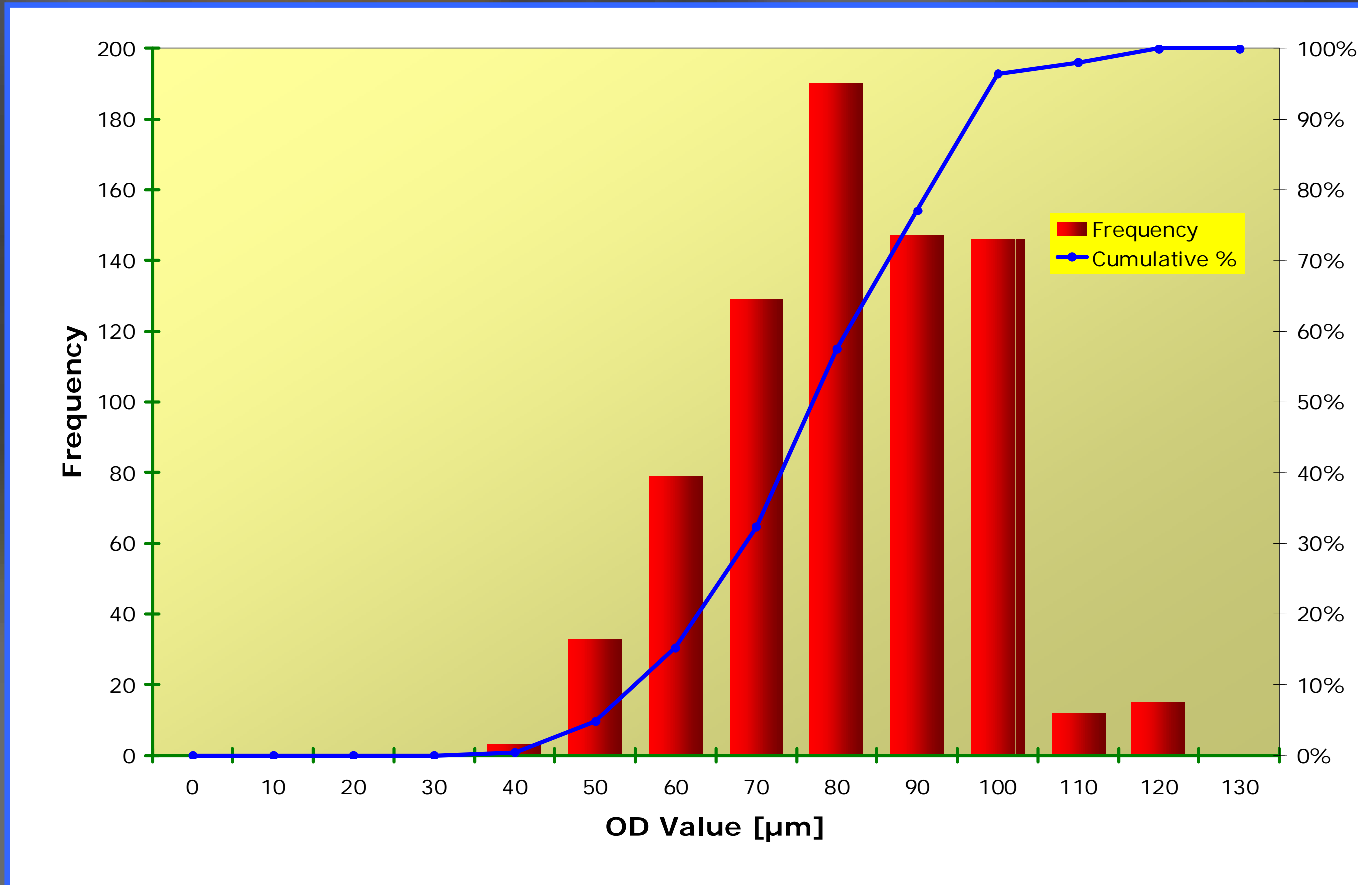
Starting production data

- **Electrical data:**

	STD
Final EWS Yield:	84.4%
ON-Line Retest %:	19.5%
ON-line Gain %:	5.6%

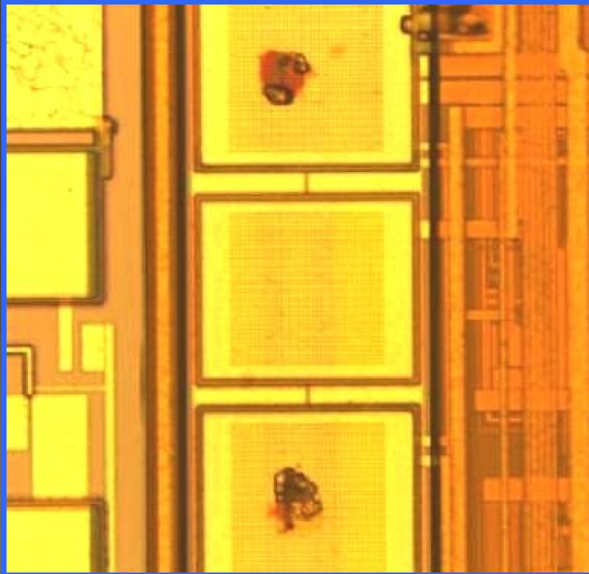
- **Overdrive (OD) distribution**
  - **Average working OD:** 80 µm in DOUBLE TD
  - **Working OD STDEV:** 15.4 µm
  - See next slide for details
- **Pad structure integrity**
  - **High probability of catastrophic dielectric cracks**
  - **High Final Test losses (Shorts)**
  - Need of extra screenings @ Final Test Level

Starting OD distribution

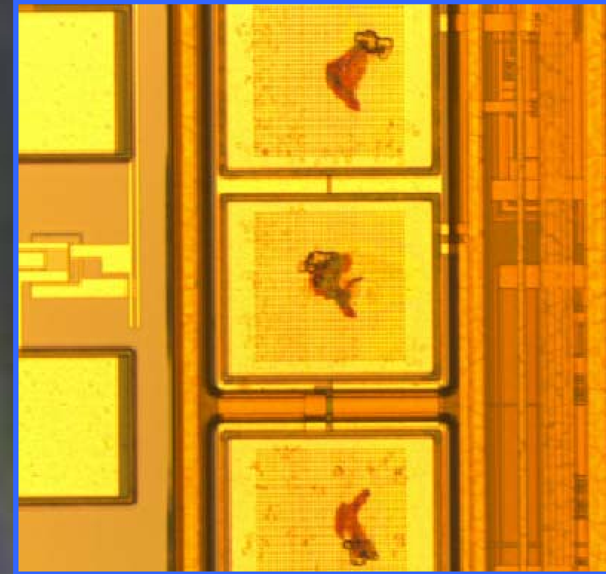


Pad integrity analysis – STD PC (W)

- **Physical analysis** (Delayering + visual inspection) on probed pad revealed in some cases **cracks @ IMD2 level:**



75 um × 6tds



100 um × 4tds

- **EWS Process margins were really limited with STD Probe Card**

PC developments: probing process DOE

Validation tests & analysis

Probe Modelling Validation

Geometries

CCC

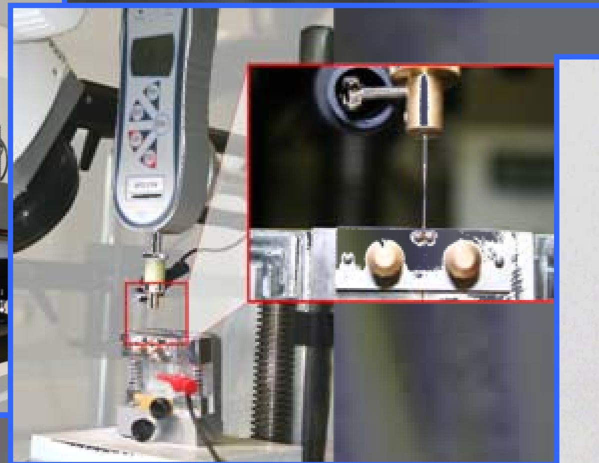
PC Type	Pad Integrity	Current capability	Yield
STD	No Good	Good	No Good
H9-like	Slightly better	Good	NA
Argon W	Good	No Good	NA
Argon BC	Good	Good	Good

Probe Card development: geometries

- **Starting point: standard,** (WRNP 7-8, 2.5 ± 0.5 g/mils, tip dia 25 µm):
  - **Contact** and **dielectrics integrity issues**
- **1st evolution: H9-like** (WRNP 5-6, lower force, tip dia std, tip L > STD):
  - **Still contact issues**, some more margins in terms of dielectrics integrity
- **2nd evolution: Argon W** (WRNP 5-6, new needle geom, force = H9-like, controlled lateral force, tip dia std, tip L > H9-Like):
  - **Better contact**, **more safe margins** BUT **needle burning** even increasing the tip dia (by lapping action)
- **3rd evolution: Argon BC** (BC 7-8 , vertical and lateral force = Argon W, tip dia 30 µm, tip L = Argon W):
  - **Good contact, safe margins, no more burning failures**. Full release to production (see next slides)

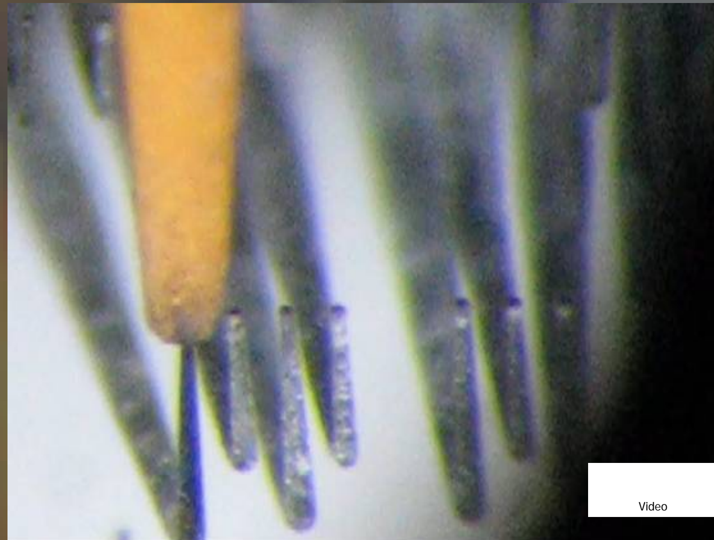
Epoxy CCC: methodology

- **Both W(Re) and Cu(Be)** needles were characterized in Current Carrying Capacity (CCC) with respect wire diameter, tip diameter and taper
- "Keep It Simple" Method: I_{DC} max is the current that causes the tip discoloration after 1 h of DC powering



Epoxy CCC - Findings

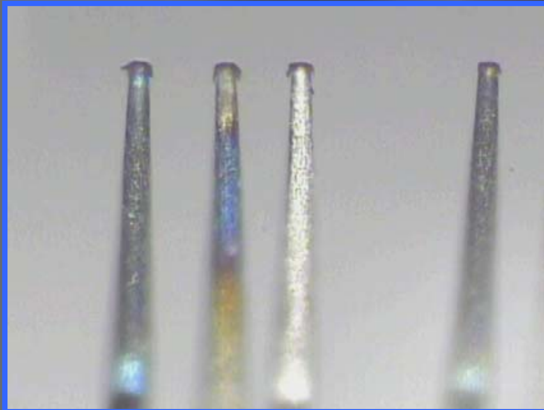
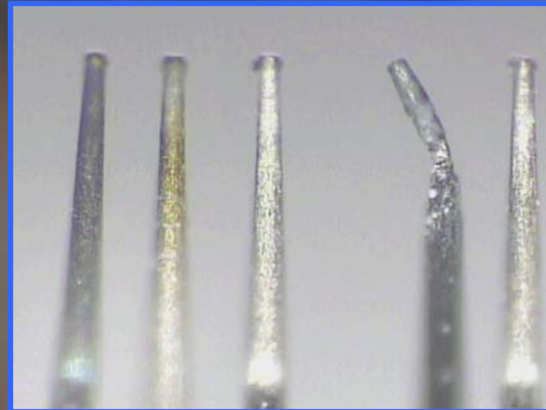
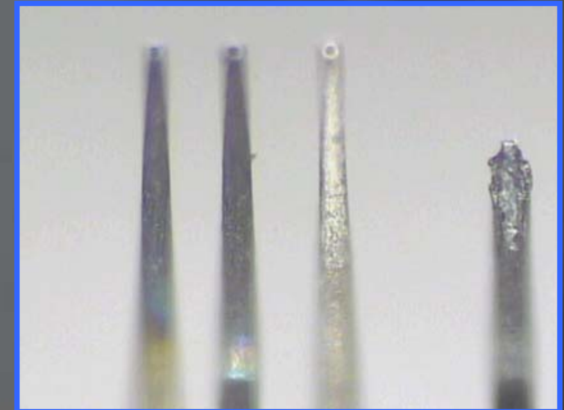
- **No contact force decrease** during needle degradation
- **Needles CCC depends on**:
  - **Needles material**: as expected Cu(Be) carries more current than W(Re)
  - **Tip diameter**: larger tips carry more current
  - **Taper: slimmer tapers carry less current but allow POA probing**



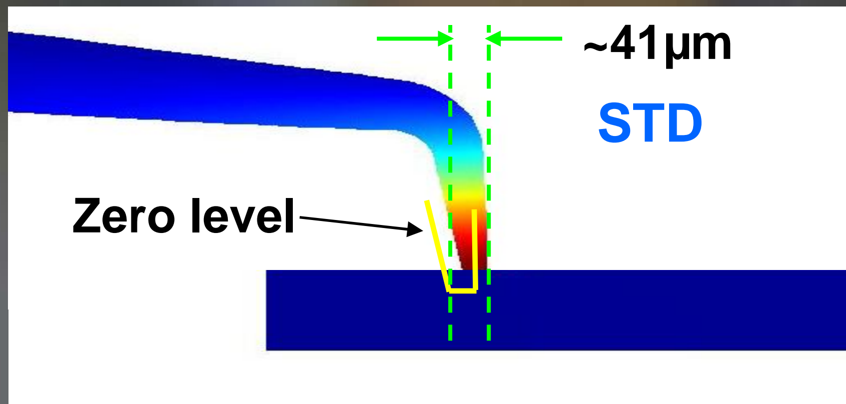
Epoxy CCC - Findings

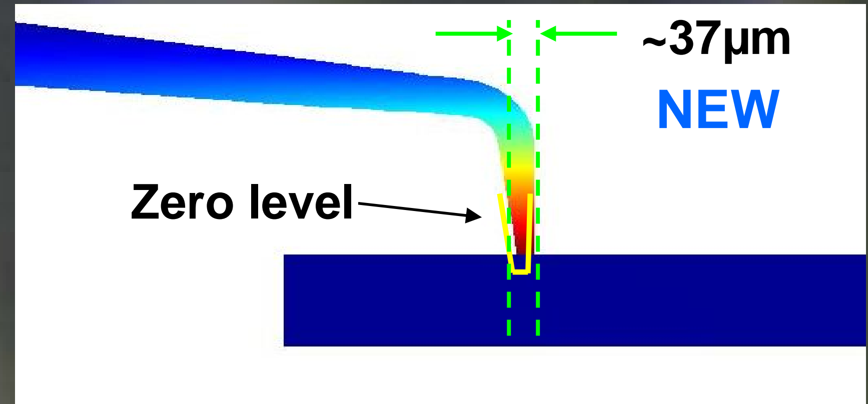
- Typical Reference values for I_{DC} max / Tip area (mA/µm^2):

	Standard	*H9 - like*	*Argon*
W(Re)	1,7 ÷ 4,0	1,4 ÷ 2,5	1,3 ÷ 2,0
Cu(Be)	-	-	1,9 ÷ 3,0

Probe Modeling validation: Std vs. New needles





Displacement in X – direction (overdrive 60µm)

- **Good agreement at simulation level** in both conditions
- **Shorter probe mark length** using new needles
- **See Luca Cecchetto presentation** for additional info (SWTW 08)

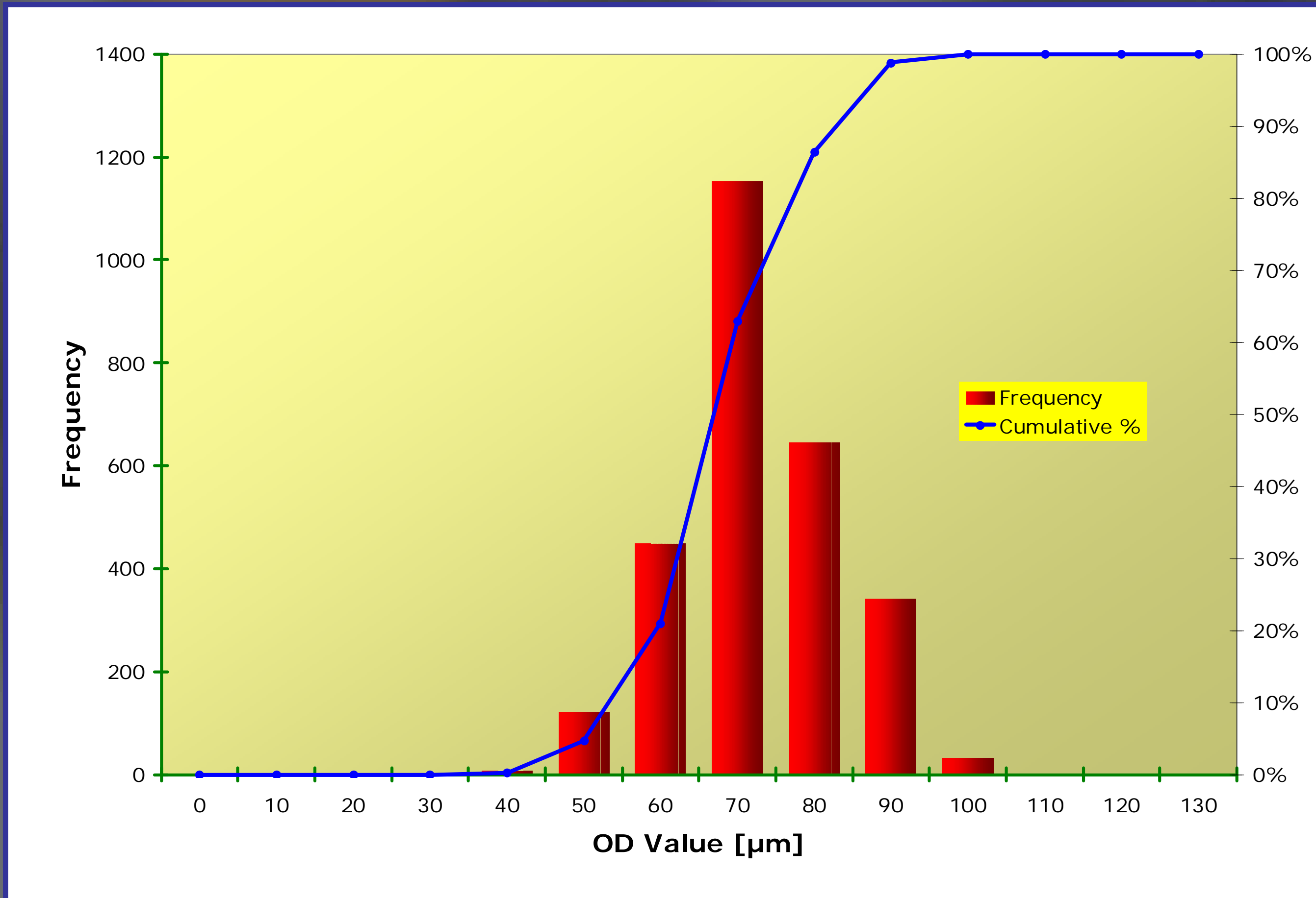
Production results

- Electrical data:

	STD	Argon BC	
Final EWS Yield:	84.4%	91.6%	+7.2%
ON-Line Retest %:	19.5%	10.7%	-8.8%
ON-line Gain %:	5.6%	4,5%	-1.1%

- Overdrive distribution
  - Average working OD: 70 µm in SINGLE TD (it was 80 µm in DOUBLE TD)
  - Working OD STDEV: 10 µm (it was 15.4 µm)
  - See next slide for details
- Pad structure integrity
  - Process window definitely increased

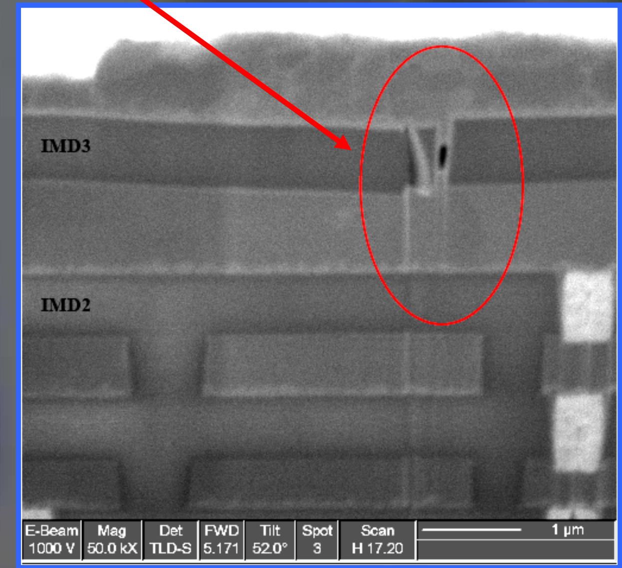
Present OD distribution



Pad integrity analysis

- **Argon W PC 25 µm tip dia –** No soft touch

# TD \ OD (µm)	50	75	100
4	PASS	PASS	PASS
6	PASS	PASS	PASS
8	PASS	FAIL	FAIL



- **Cross sections confirmed** that also in case of 100 µm OD × 8 tds **NO IMD2, catastrophic cracks were observed**

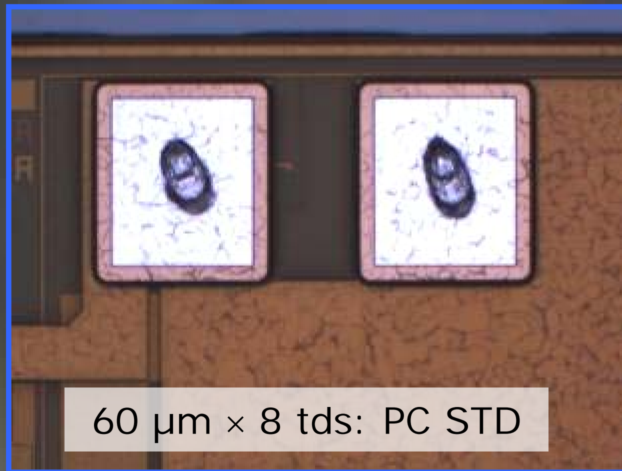
Pad Area Damaged

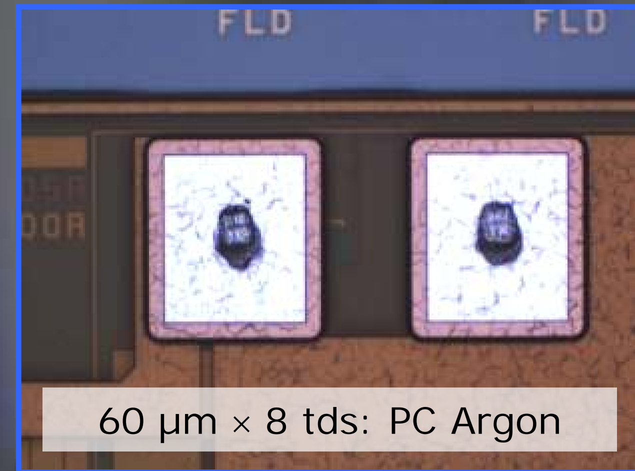
- Following table shows the **data of damaged pad area in different EWS conditions**
- **Argon BC**, even if tip diameter is 30 µm instead of 25 µm, **is behaving better than STD PC due to its controlled scrub action**

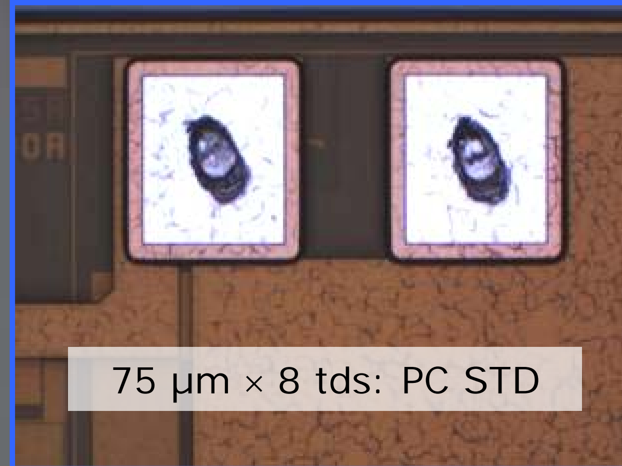
TDS	OD	Scrub Area [µm^2]		% of SQBPO Damaged		DELTA
[#]	[µm]	STD WR	Argon BC	STD WR	Argon PC	
4	**60**	945	660	**14,4%**	**10,1%**	-4,3%
4	**75**	1124	792	**17,1%**	**12,1%**	-5,1%
4	**100**	1295	854	**19,7%**	**13,0%**	-6,7%
6	**60**	989	797	**15,1%**	**12,1%**	-2,9%
6	**75**	1094	834	**16,7%**	**12,7%**	-4,0%
6	**100**	1296	1094	**19,8%**	**16,7%**	-3,1%
8	**60**	967	742	**14,7%**	**11,3%**	-3,4%
8	**75**	1264	927	**19,3%**	**14,1%**	-5,1%
8	**100**	1334	1111	**20,3%**	**16,9%**	-3,4%

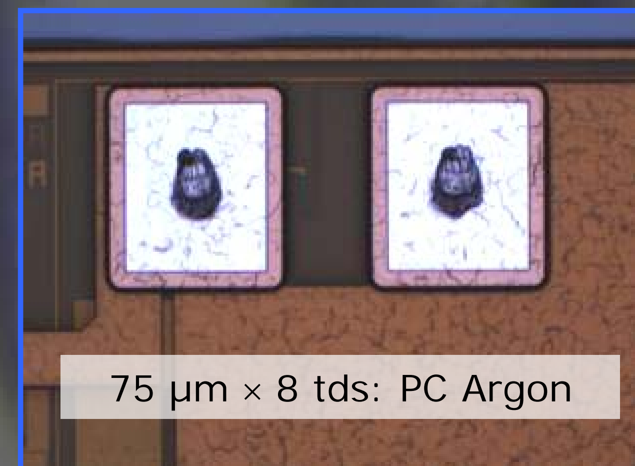
- **Legenda: TDS** = # of touch-downs; **OD** = overdrive; **SQBPO** = Square Bond Pad Opening (= 81 X 81 µm^2 in this case)

Pad Area Damage – Scrub marks Pictures





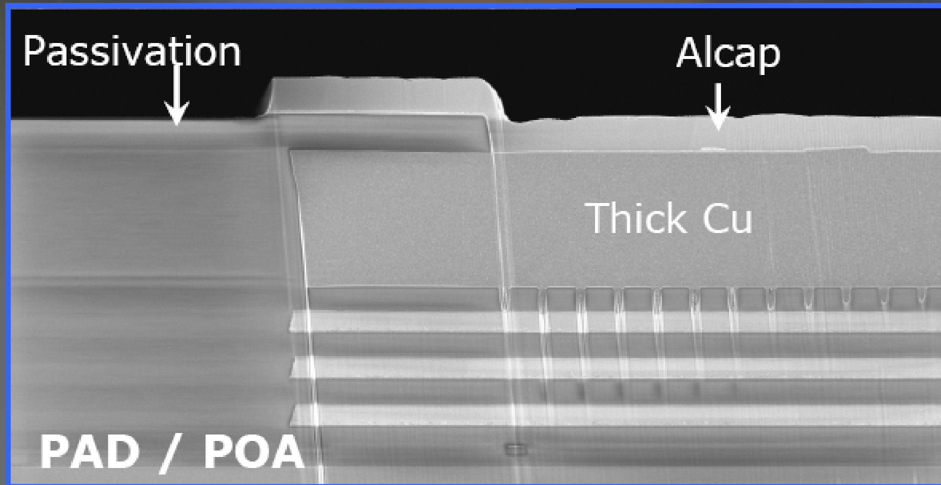




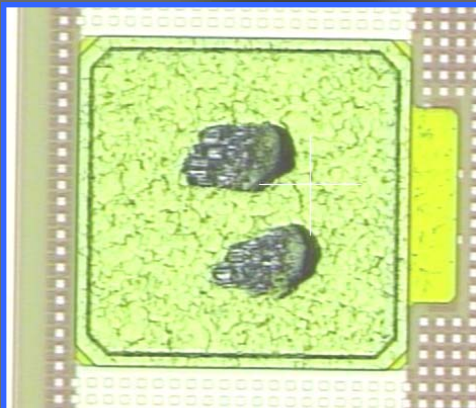
Conclusions

- **Working as an effective Team** with **Technology R&D** and within **a win to win relationship** frame **with the supplier** we succeeded in
  - Developing a **new Epoxy PC technology** called **ARGON**
  - **Releasing a complete new probing process** to production
  - Working with the **right methodology**
- The delivered probing process is **very satisfactory:**
  - **Electrical yield and retest rates significantly improved**
  - **Average OD have been reduced**
  - **OD distribution** is now **under control**
- **New developments**: Argon validation on BCD8 POA devices (Al and Thick Cu options)

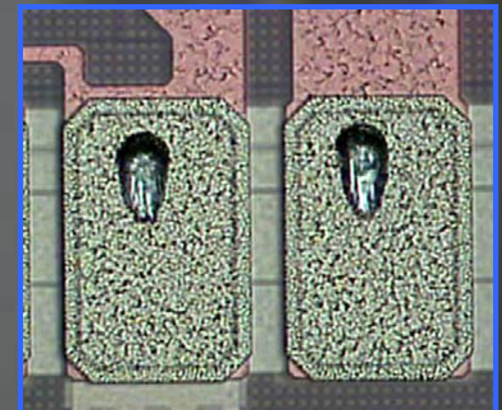
New developments: BCD8 – POA – Thick Cu



- **Argon PC**
  - **OD value**: 60 and 75 µm
  - **# of tds**: 6,8
  - **Test T**: up to +140°C



- **No die Cracks**
- **No Cu exposure**
- **Good Yield** on both single (Tip dia 25 µm) and double pads (Tip dia 35 µm)



Acknowledgements

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