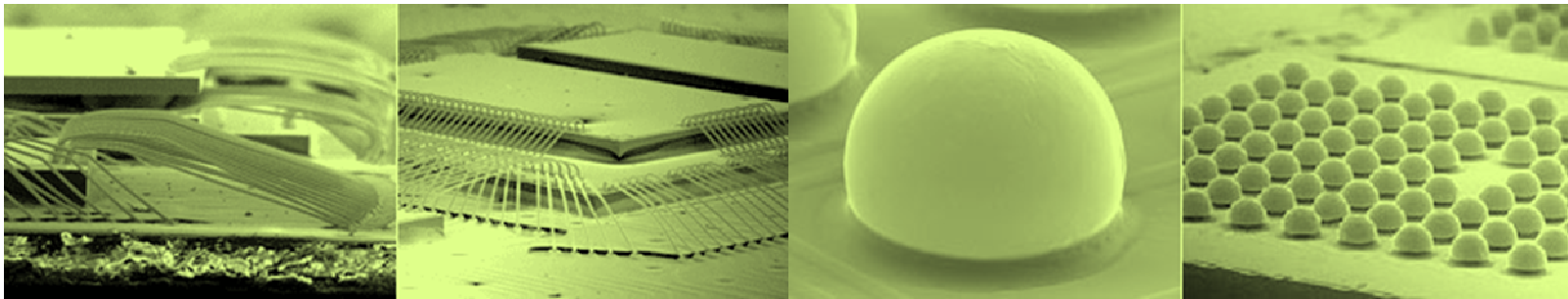


# Impact of **GREEN** materials on test and analysis of IC's



Soesterberg, November 23<sup>rd</sup> 2010

Kees Revenberg MD / Co-founder

# Outline

- Introduction MASER Engineering
- What is GREEN ?
- IC & package manufacturing overview
- Impact on performance
- Impact on testing and analysis
- Examples and results
- Conclusion and summary

# MASER Engineering today

- **Test of electronic components and systems**
  - Strong base in semiconductor IC's test requirements
  - Product and supplier qualification and evaluation
  - Reliability and robustness improvement



ESD/LU test



Full product Q&R test lab



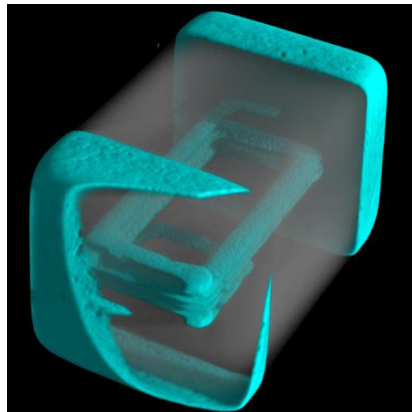
Optical device test



Board Level drop

# MASER Engineering today

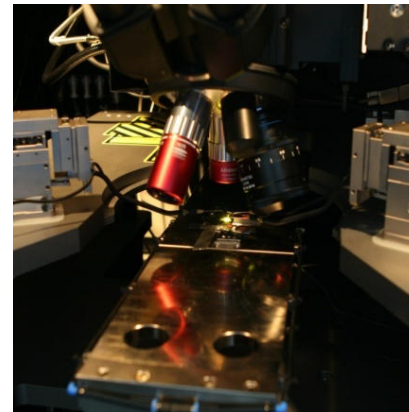
- **Diagnostics of electronic components**
  - Failure Analysis → yield loss & field return analysis
  - Construction Analysis → competitor analysis
  - Nano-material Analysis → patent infringement



XRAY & SAM



28-40nm Circuit Edit



Failure Analysis



STEM analysis

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# What is **GREEN**

- Short catchy name for implementation of sustainability in the companies behavior

- Example: Corporate policy of NXP

“At NXP Semiconductors, we recognize that sustainable development is one of the most compelling challenges of our time. For this reason, we foster ethical principles and respect for the environment, people, and our community while we pursue economic prosperity. Sustainability is a part of the way we conduct business, the way we manage our company, and the way we interact with society at large. We commit ourselves to sustainability because we're more than just a company - we are a group of people working for a better tomorrow.”

- **GREEN** is becoming integral part of policy

# What is a **GREEN** policy

- Culture\*
- Legislation\*
- Ethics\*
- Products

NXP is committed to creating products and packages that are safe to use, and ensures that, with each new generation, the environmental impact of their use and disposal is further reduced.

- Employees

NXP employs a diverse workforce and invests in its people, creating a workplace where employees can reach their full potential in an environment that is healthy, safe, and free of occupational injury and illness.

- Environment

NXP conserves natural resources and reduces the environmental impact of its waste generation and its emissions to the air, water, and land.

- Society

NXP believes education is essential to making the world a better place, and uses educational programs to improve people's lives and prepare the next generation for tomorrow's challenges.

- Transparency\*

- Dialogue\*

\* More information in NXP Sustainability Report 2009

# Impact on GREEN

## International regulations

- REACH

Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals, into force on June 1<sup>st</sup> 2007

- CLP

Regulation on classification, labeling and packaging of substances and mixtures, into force on January 20<sup>th</sup> 2009.



EU chemicals agency → control and support



# Impact on GREEN

## International regulations

- RoHS

EU Directive 2002/95/EC: Restriction of Hazardous Substances,  
into force on July 1<sup>st</sup> 2006

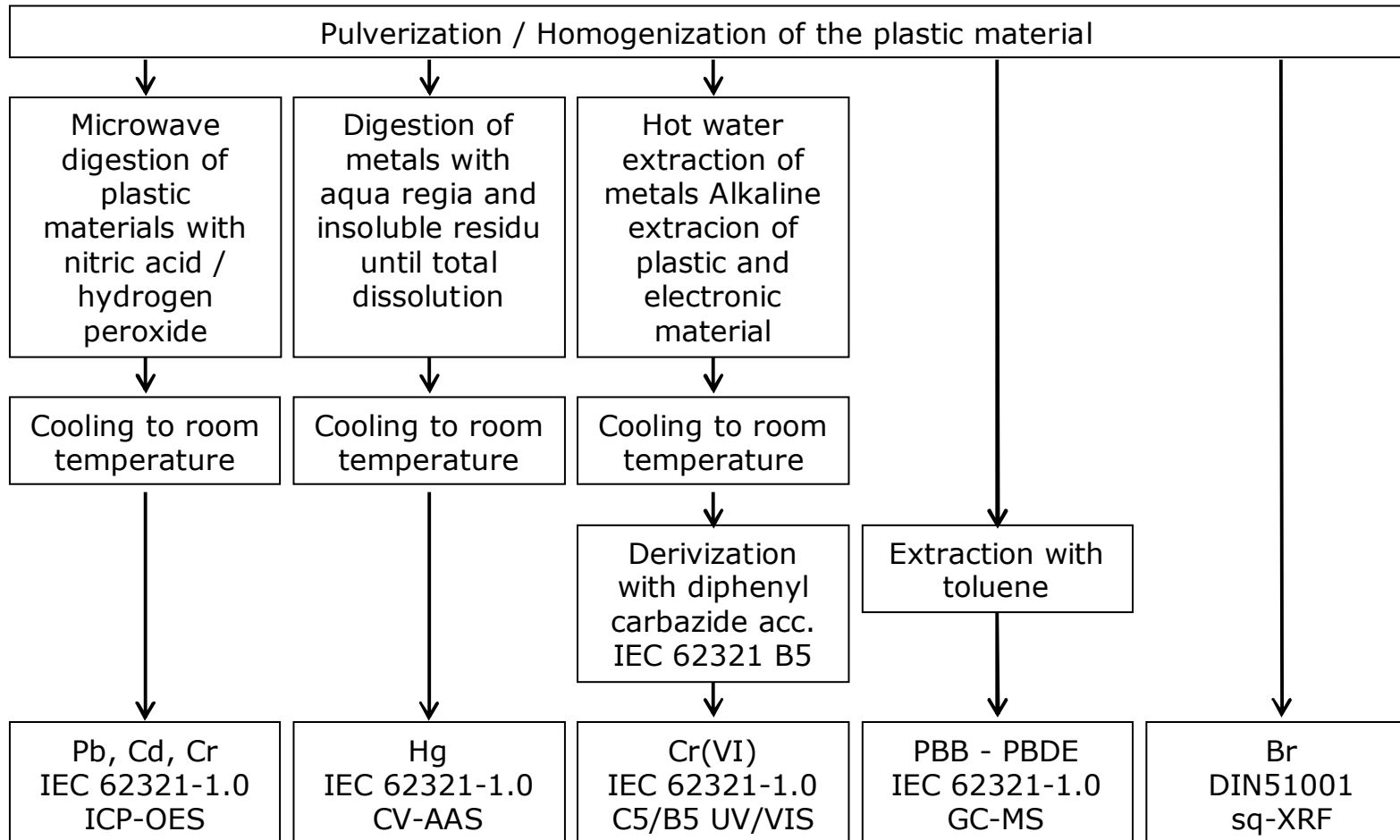
→ Initiated leadfree soldering in electronics

- WEEE

EU Directive 2002/96/EC: Waste Electrical & Electronic Equipment,  
into force on July 1<sup>st</sup> 2006

→ Initiated recycling fee when purchasing

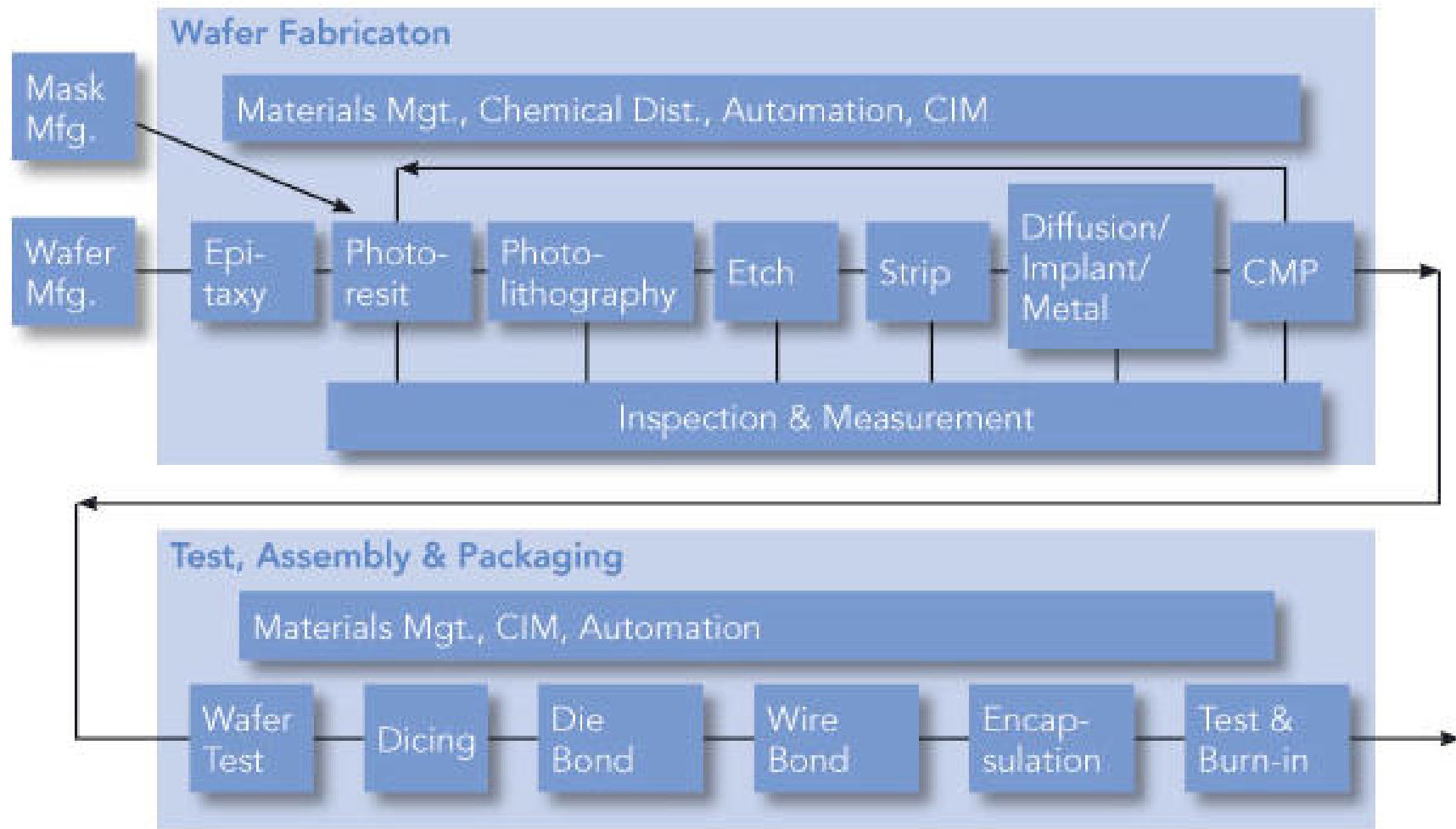
# Impact on GREEN



# Outline

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# IC & package manufacturing



[source: NXP]

# Outline

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# Impact on performance

## Reliability aspects

- Impact of new compounds
- Impact of copper bond wires
- Impact of lead free solder profiles

## Manufacturing process

- Package molding behavior
- Wire bonding parameters of Cu wires
- Lead plating with pure Tin
- Soldering behavior of new alloys

# Outline

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# Impact on test & analysis

## Testmethods

- Process qualification tests
  - Various DOE on all new / modified processes
- Material qualification tests
  - Various DOE on all new materials
- Whisker growth tests, up to 6000 hours
- Changed glassivation temperature properties
  - JEDEC HAST @ +130°C/85%rh → +110°C/85%rh
- Resistance to solderheat
  - Solder profile SAC305 +235°C peak to +250°C
- Copper bond wires
  - New parameters for Wire Pull Strength of Cu wires

# Impact on test & analysis

## HAST parameters become destructive

- Tg GREEN compound significant lower

General properties	Application	Spiral flow	Specific gravity	Glass transition temp.	CTE $\alpha_1$	CTE $\alpha_2$	Flexural strength	Flexural modulus
Unit		cm	-	°C	ppm/°C	ppm/°C	N/mm <sup>2</sup>	N/mm <sup>2</sup>
KMC-180	LQFP, TQFP, QFP, TSOP, TSSOP, SOP	80	1.89	160	13	57	120	13,000
KMC-184		90	1.89	160	13	57	120	13,000
KMC-188		90	1.89	165	13	57	120	13,000
KMC-289		90	1.94	140	11	45	140	19,000
General properties	Application	Spiral flow	Specific gravity	Glass transition temp.	CTE $\alpha_1$	CTE $\alpha_2$	Flexural strength	Flexural modulus
Unit		cm	-	°C	ppm/°C	ppm/°C	N/mm <sup>2</sup>	N/mm <sup>2</sup>
KMC-3800	LQFP, TQFP, QFP, TSOP, TSSOP	90	2.00	130	9	32	150	22,000
KMC-300		160	1.99	130	11	45	150	22,000
KMC-3510		85	1.98	140	9	40	150	21,000
KMC-284	CSP, BGA, MCP	110	2.01	130	9	35	150	25,000
KMC-3580		150	1.98	130	11	45	150	21,000
KMC-6000		100	2.00	145	8	34	140	22,000

# Impact on test & analysis

## HAST

- Tg GREEN compound
- Duration 96 hrs → 264 hrs
- Increased test costs
- Faster board wearout per project
- Adapted by **JEDEC**
- JESD47G.01, April 2010
- 264 hrs @ +110°C/85%rh/biased





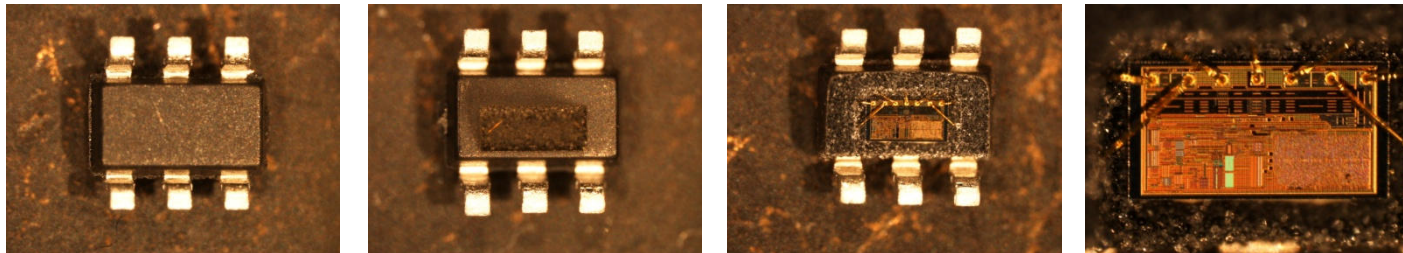
# Impact on test & analysis

## Failure Analysis

- RoHS validation
  - Product analysis and compliance report
- Decap procedure change
  - Cu wires require buffered acid mixture
  - Higher aspect ratio decap introduces laser ablation decap
- More brittle solder interconnects
  - Changed polishing approach
  - Contactless Argon ion beam polishing
- Changed IPC-A-610 inspection requirements
  - New inspector training
- Whisker based fragile package failure modes
  - High sensitive magnetic and thermal microscopy

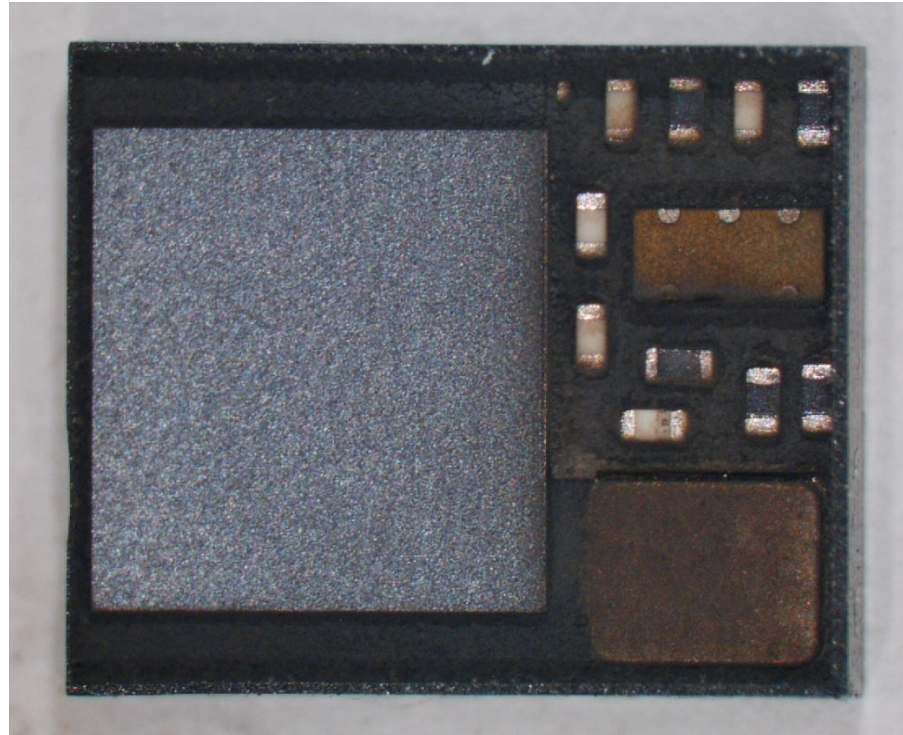
# Impact on test & analysis

- **Laser assisted decapsulation**
  - Controlled Semiconductor Inc. – FATcat
  - Layer-by-layer decapsulation
  - C-SAM and X-Ray image overlay
  - Precision decapsulation, complex shapes
  - High aspect ratio windows



# Impact on test & analysis

- **Laser assisted decapsulation**

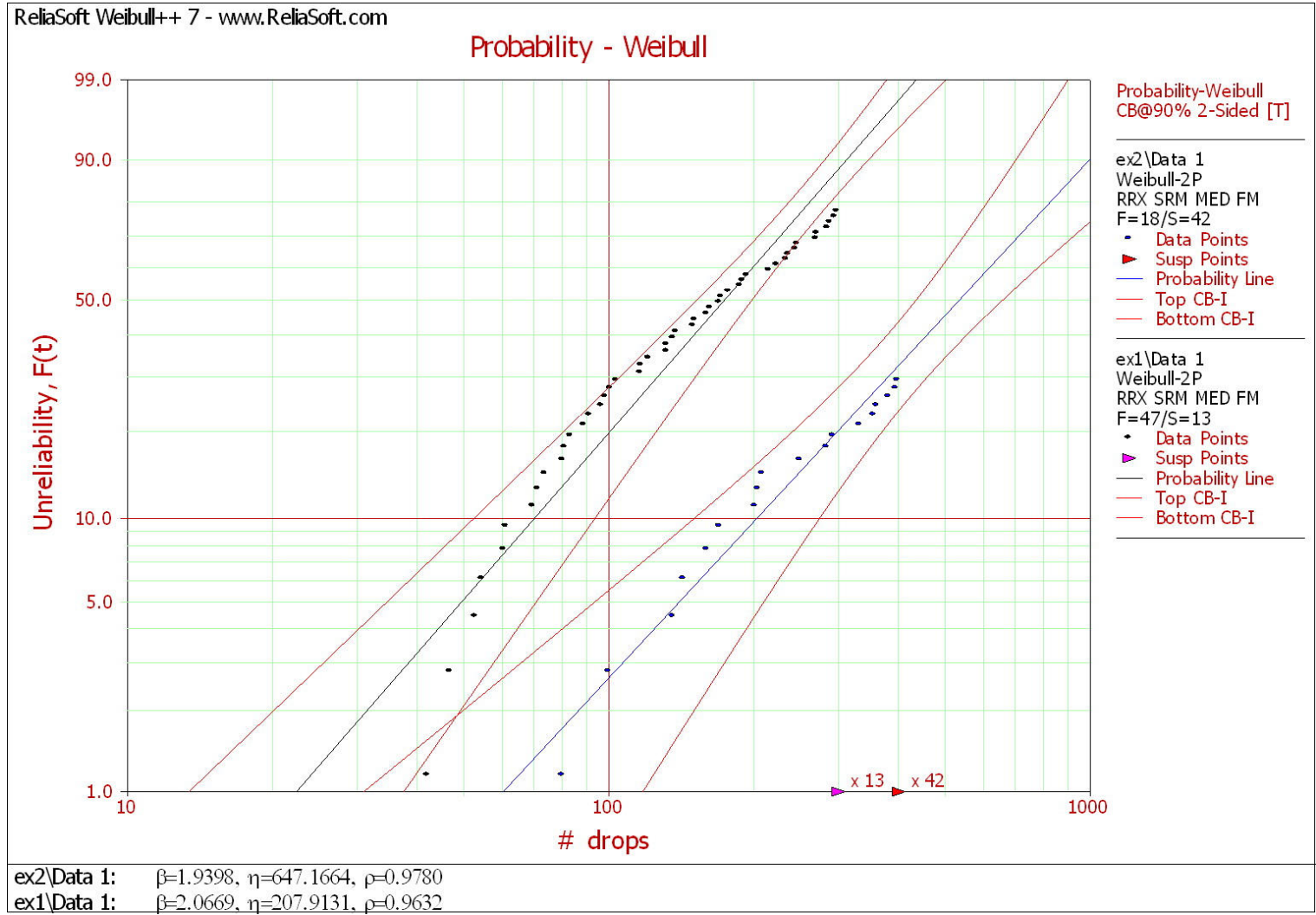


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# Examples and results





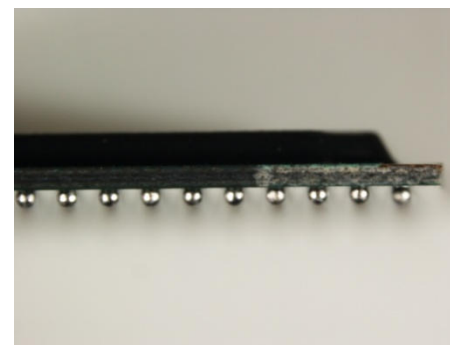
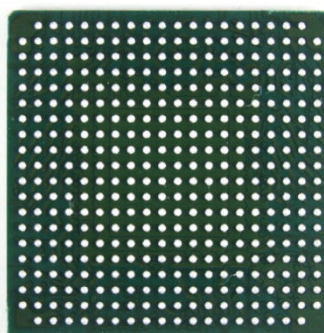
# Examples and results

## RoHS limits

- Cadmium Cd <100 ppm
- Lead Pb < 1000 ppm
- Mercury Hg < 1000 ppm
- Chromium Cr<sup>6</sup> < 1000 ppm
- Sum of PBBs < 1000 ppm
- Sum of PBDEs < 1000 ppm

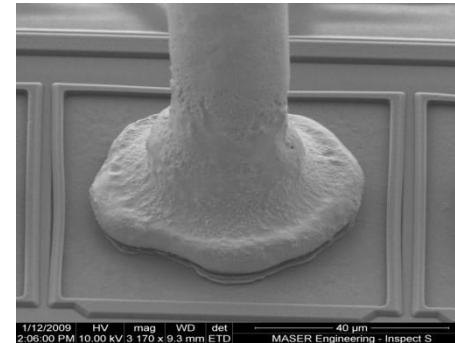
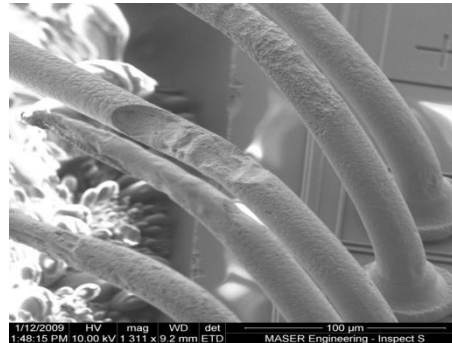
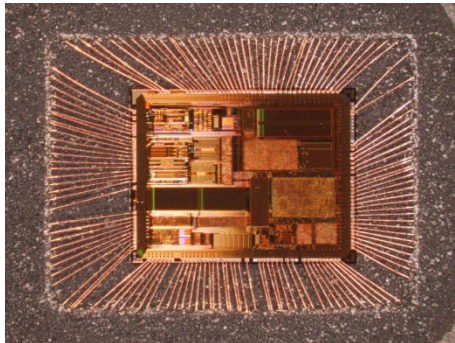
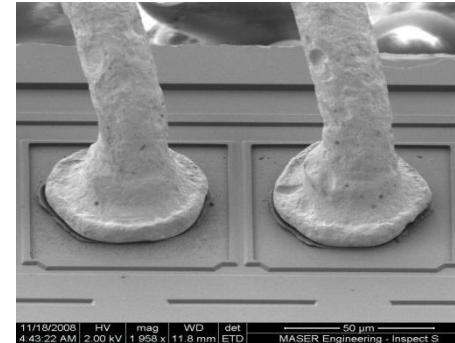
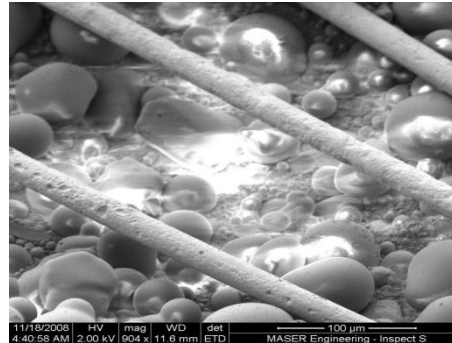
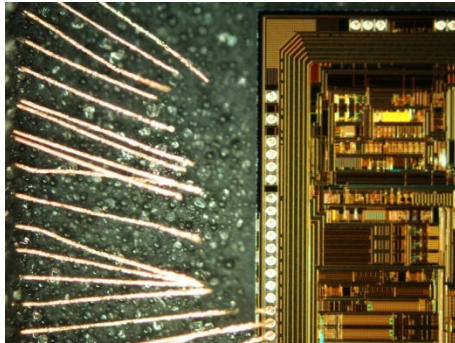
## Example report

- Cd: nd (RL<1 ppm)
- Pb: nd (RL<10 ppm)
- Hg: nd (RL<0,5 ppm)
- Cr<sup>6</sup>: 68 (RL<10 ppm)
- Sum of PBB: nd (RL<50 ppm)
- Sum of PBDE: nd (RL<50 ppm)



# Examples & results

- **Cu wire decapsulation**



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# Conclusion and summary

- Sustainability is an integral strategy
- Pro-active impact investigation
- Replacements well understand now
- Reliability data is still building up
- Impact on performance under control
- New testing and analysis in place
  
- **GREEN** IC's are still **BLACK** and reliable

# Q&A

Questions?

**Thank you for your attention!**

Have a nice lunch!