

NDT Investigations on CCGA Solderings

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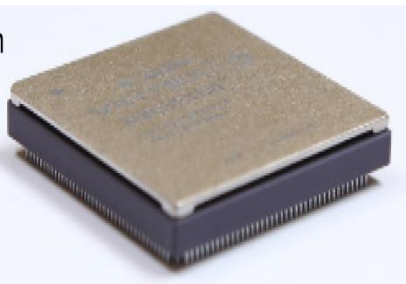
WHEN YOU NEED TO BE SURE





SGS - SOCIÉTÉ GÉNÉRALE DE SURVEILLANCE

- Founded in Rouen (France) in 1878
- First registration as Société Générale de Surveillance in Geneva 1919
- More than 97'000 employees worldwide
- Global network of 2'600 offices and laboratories
- Since 1920 in Germany with actual 3'300 employees
- 40 subsidiaries in Germany
- German headquarter is Hamburg
- Total revenues in 2018: CHF 6.70 billion



Source: XILINX

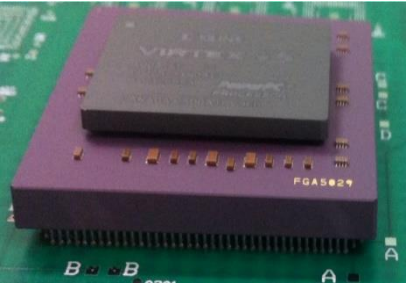


Source: Microsemi

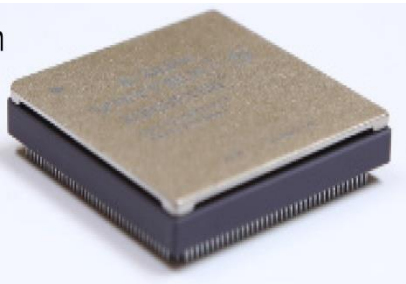
■ Initial Situation

- With each new space mission, higher demands are placed on the functionalities of EEE components and assemblies. This development will continue in the future.
- The increasing requirements require the use of modern electronics such as freely programmable logic components (FPGA) with typically a high number of I/O connections.
- This is accompanied by increasing miniaturization and complexity in assembly and interconnection technology.
 - XILINX Virtex 5: 1752 connections
 - Microsemi RTG4: 1657 connections
- Although hardware and its technology have been constantly further developed in this context, the test technology is lagging behind.

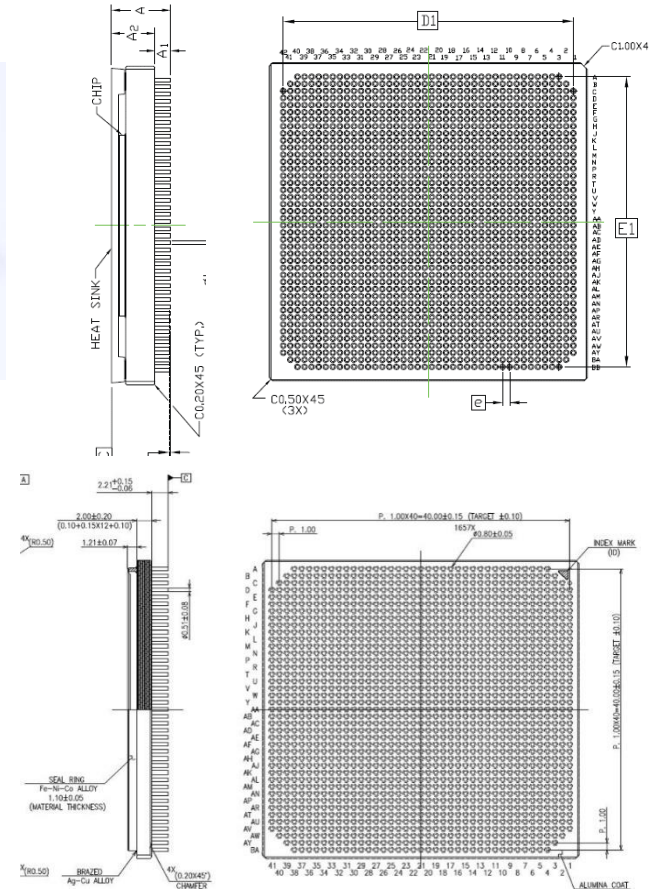
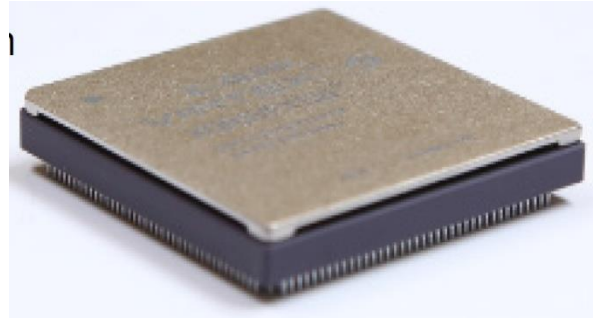
Initial Situation



XILINX Virtex 5
(1752 connectors)



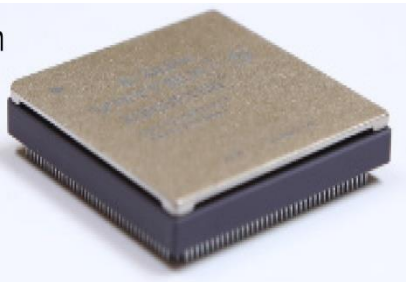
Microsemi RTG 4
(1657 Anschlüsse)



Source: XILINX

Source: Microsemi

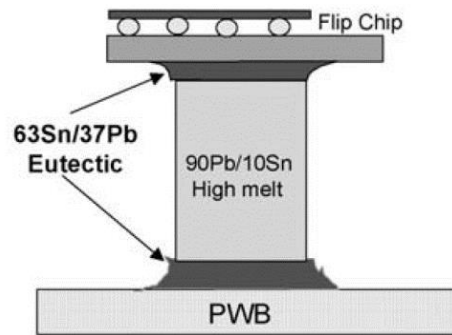
Initial Situation



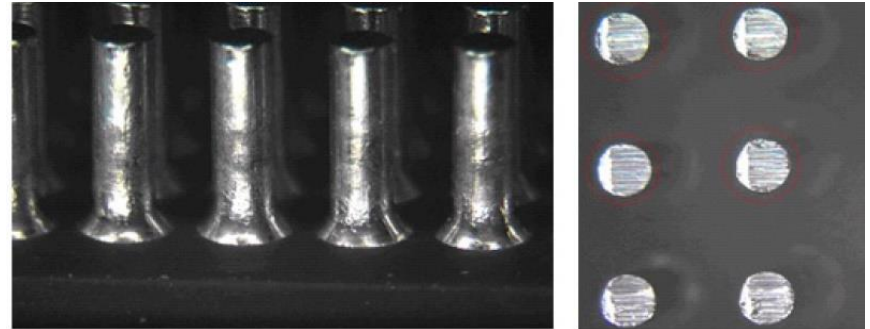
Source: XILINX



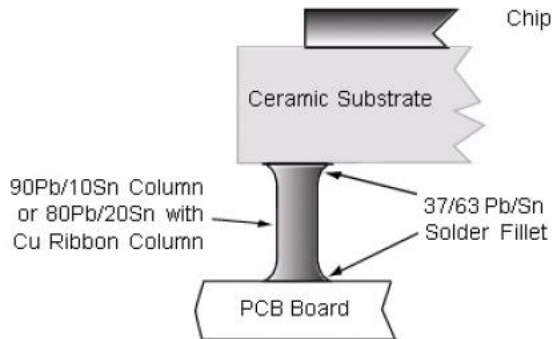
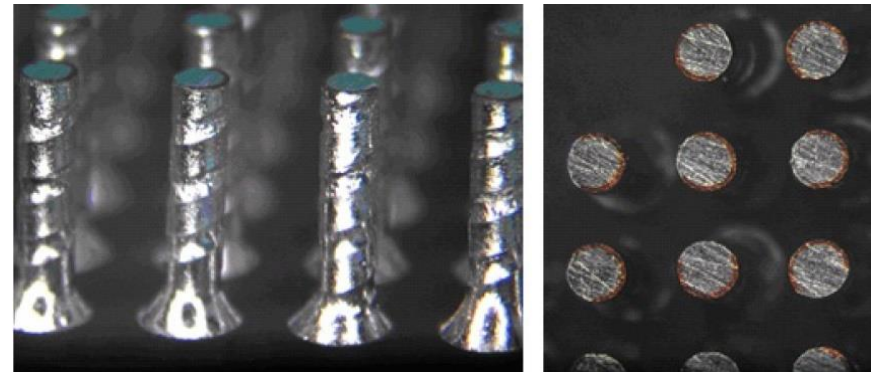
Source: Microsemi



IBM 90Pb/10Sn Columns, 20 mils Ø

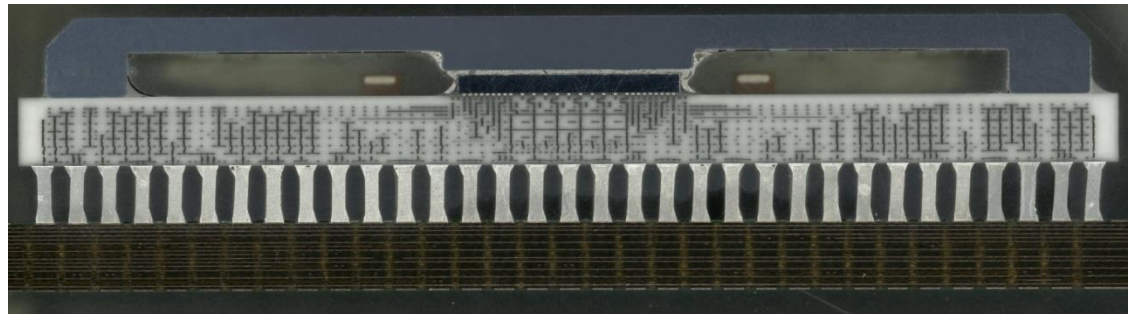
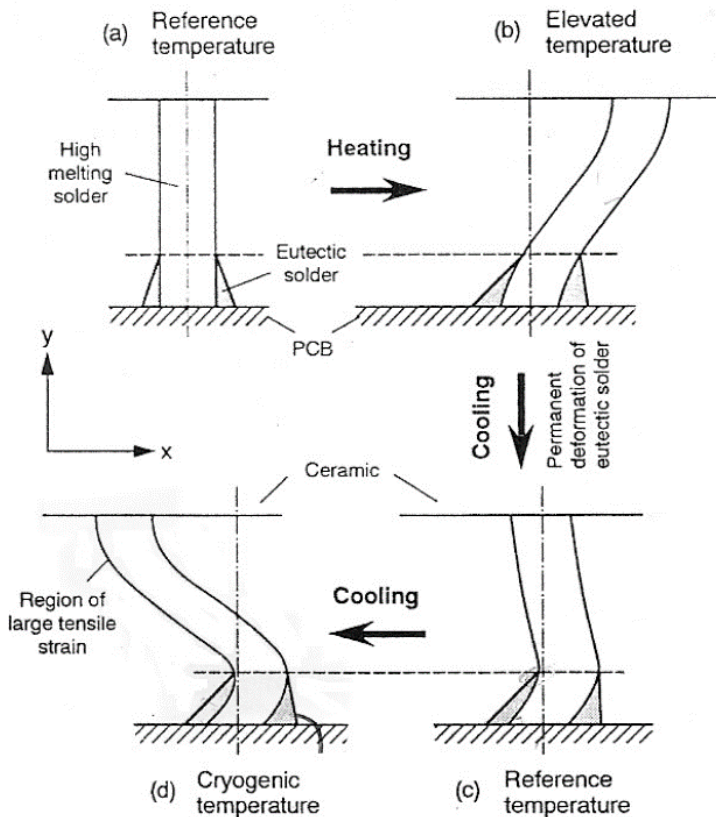


6-Sigma 80Pb/20Sn Columns, 20 mils Ø



Quelle: Microsemi

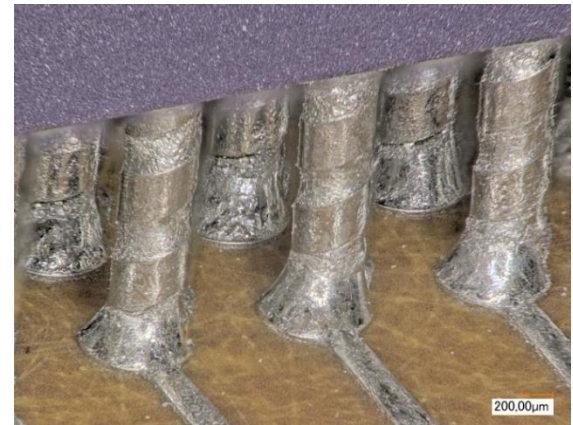
■ The challenges: Temperature and Vibration Loads



Solder Cracks:

After environmental simulation (thermal shock / shaker tests), cracks in the solder joints can be detected by metallographic microsections.

Light Microscopic Characterization using Digital Microscopy



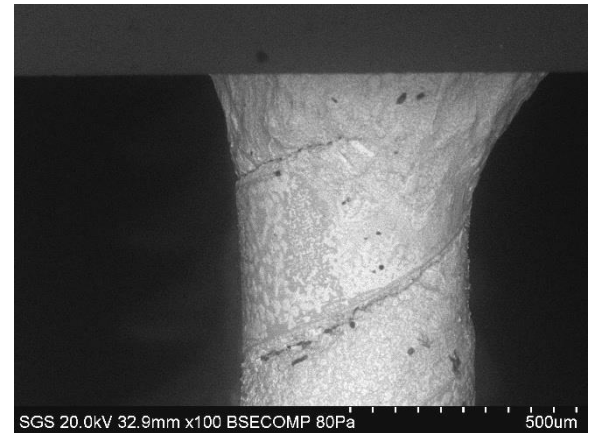
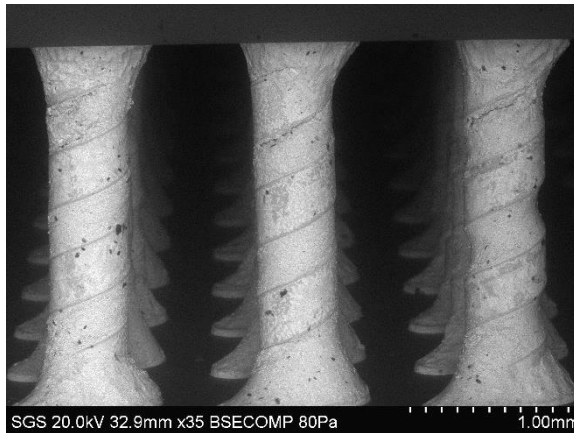
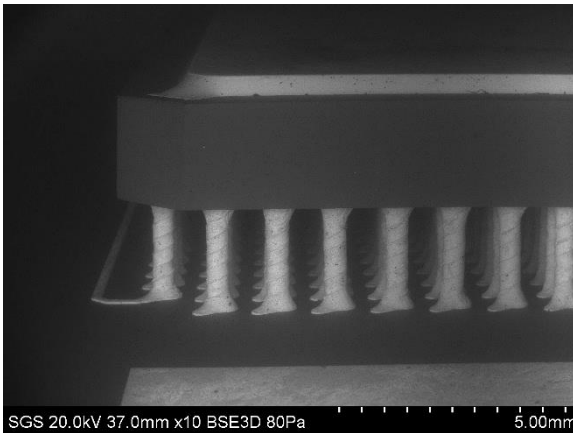
Light Microscopy:

Only the first 2-3 soldering rows can be inspected.

→ **Not all solder joints can be evaluated**

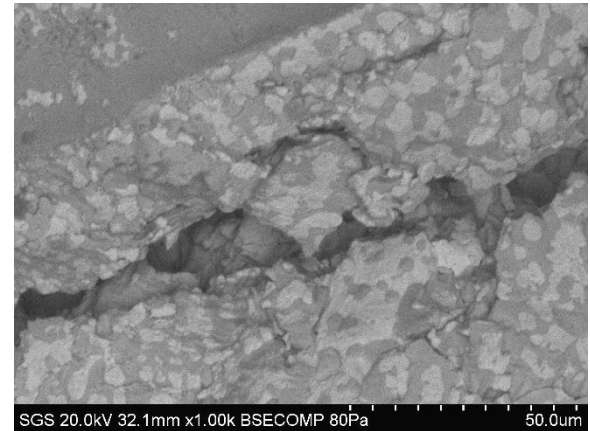
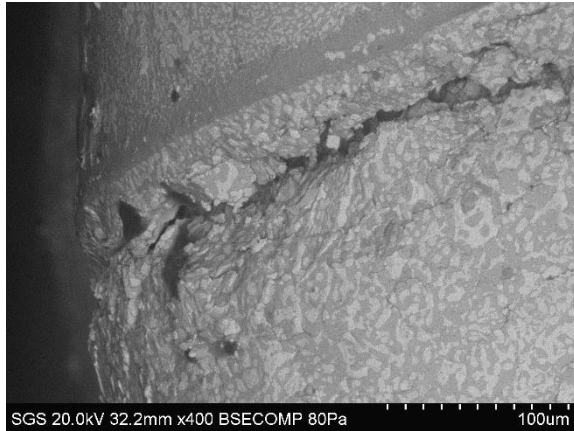


■ Scanning Electron Microscopic Evaluation

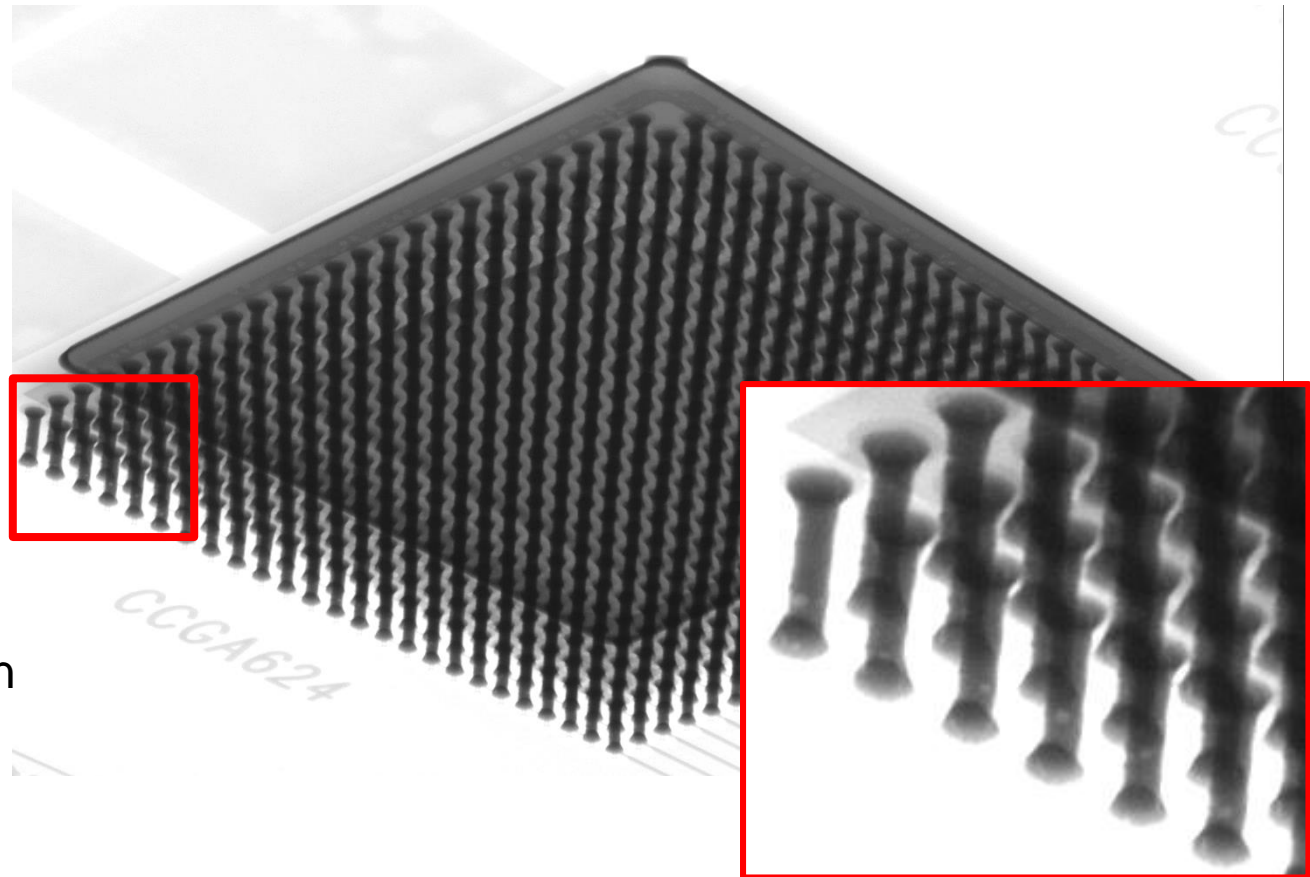


SEM:

Better resolution / depth of field but again only limited number of soldering rows can be inspected.



■ X-ray Inspection: Digital Radioscopy (Microfocus X-ray Source)

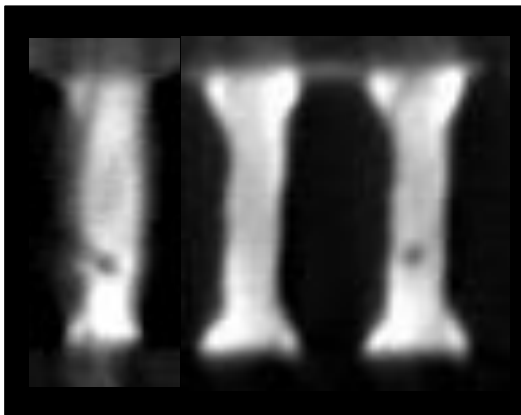


Radioscopy:

All solder joints can be inspected.

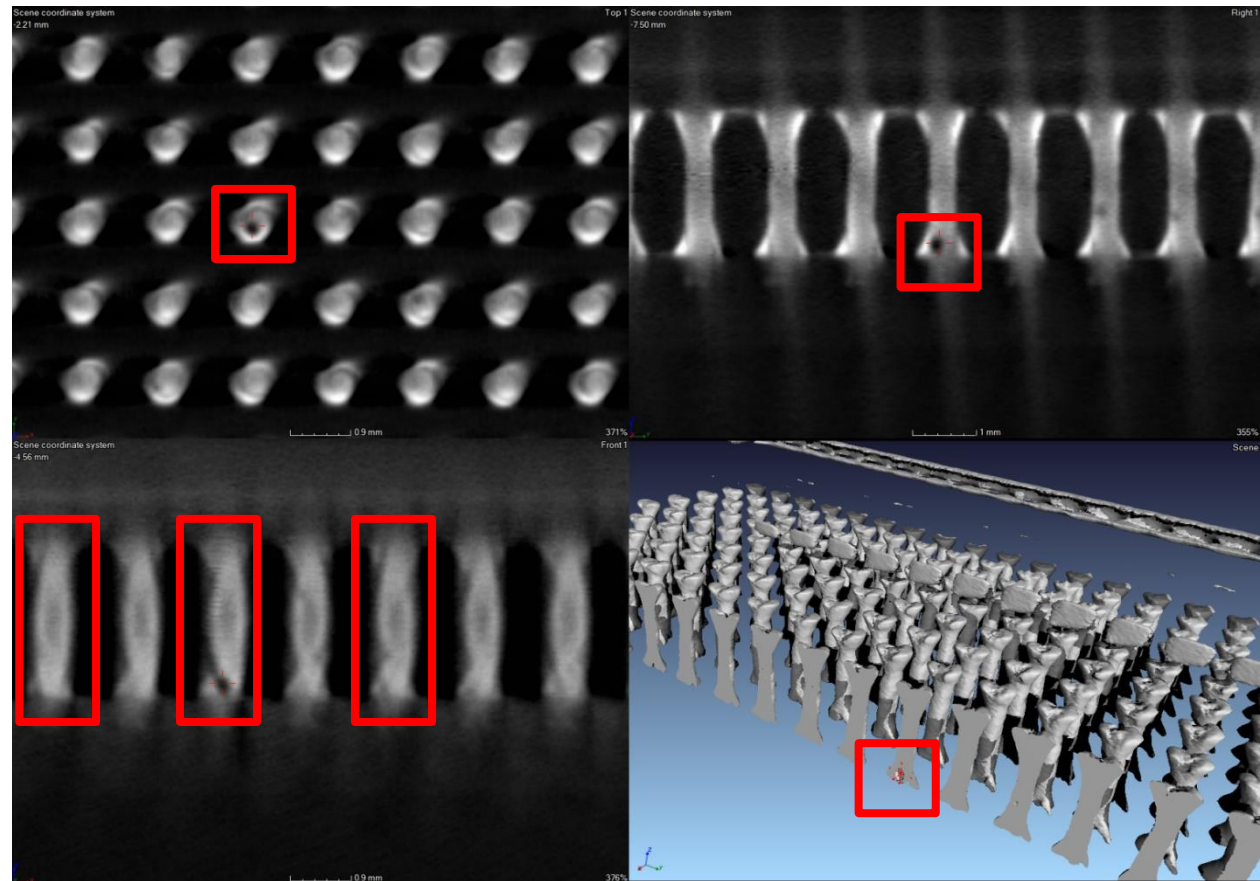
Volumetric failures can be easily detected, cracks are not visible.

3D Computerized Tomography

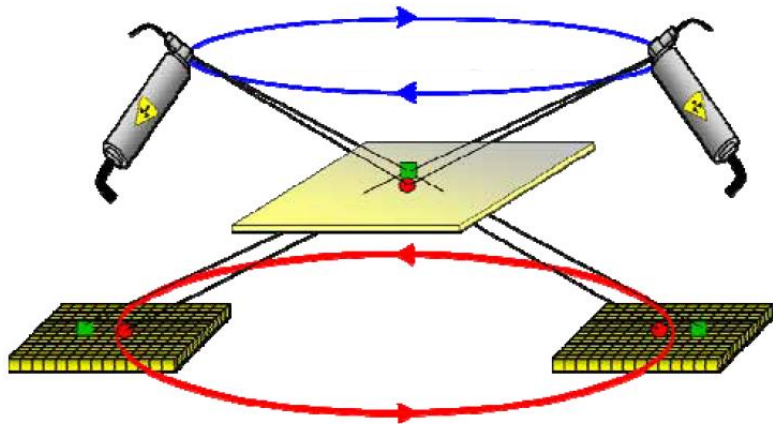


3D Tomography:

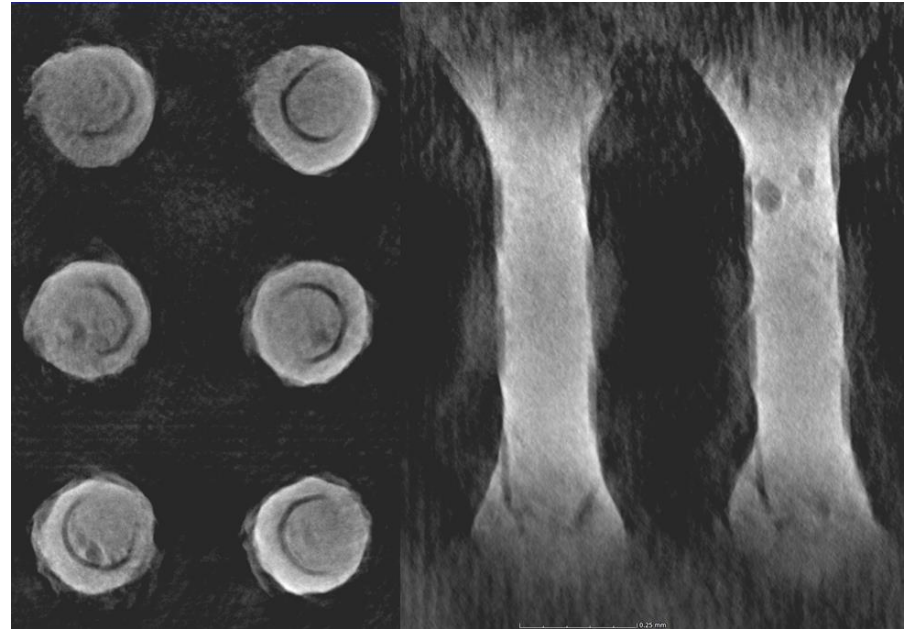
The complete sample must be in the X-ray beam. For large printed circuit boards the spatial resolution is therefore reduced.



■ Laminography



X-ray source and detector revolve around the flat specimen: Flat specimens (printed circuit boards) can be examined in this way with higher resolution.

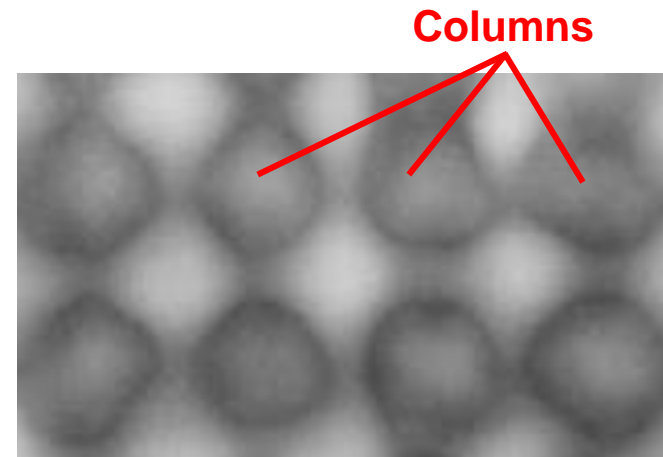
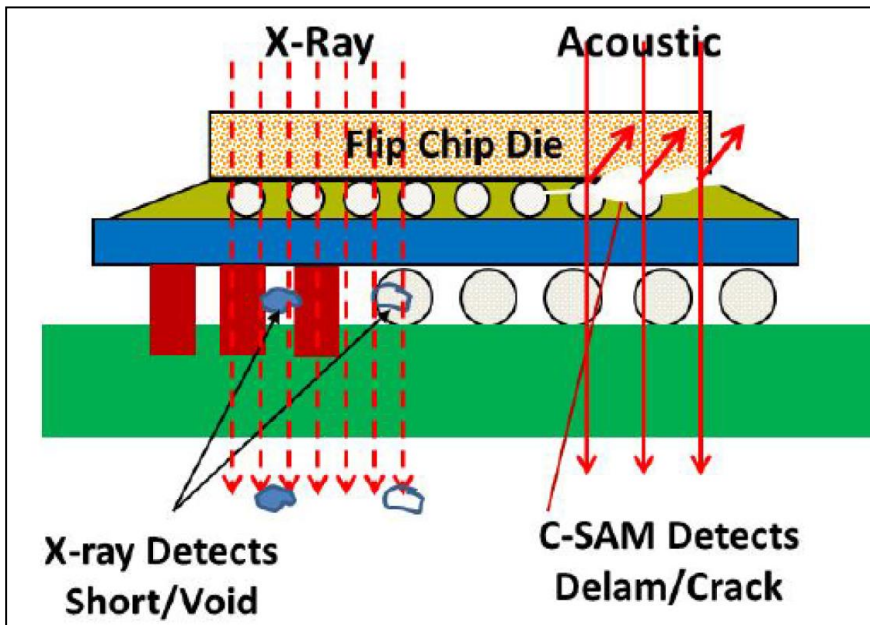


Laminography:

Voxel size: 1,7 μm

Significant residual blur and artifacts due to reconstruction algorithm

■ Scanning Acoustic Microscopy (CSAM)



X-ray techniques:

Volumetric failures (→ pores)

Ultrasonic techniques:

Flat failures (→ cracks, delamination)

■ No sufficiently suitable NDT Method for CCGA Solder Joints Testing

Method-Parameter	Methods									
	Optical Methods		X-ray Methods				Ultrasonic Methods		Materialography	
	Microscopy	SEM	Radioscopy		3D-CT	Laminography	SAM Pulse-Echo	SAM Transmission	Microsection	FPI and Break Open
			μ-Focus	nanofocus	μ-Focus	nanofocus				
DT / NDT	NDT / DT	NDT / DT	NDT	NDT	NDT	NDT	NDT	NDT	DT	DT
2D / 3D	2D / (3D)	2D	2D	2D	3D	3D	2D / (3D)	2D / (3D)	2D	2D / 3D
Medium	air	vacuum	air	air	air	air	liquid	liquid	air	air, penetrant
max. spatial resolution	1 μm	<0,01 μm	>5 μm	>1 μm	>5 μm	>2 μm	<10 μm	?	SEM: <0,01 μm	1 μm
Sample size [mm]	n. relevant	~300 mm	400 mm x 400 mm	400 mm x 400 mm	<10 mm: 5 μm <50 mm: 25 μm <200 mm: 100 μm	400 mm x 400 mm	400 mm x 400 mm	400 mm x 400 mm	Æ 50 mm / ~100 mm	n. relevant
Electrical operation	yes	(yes)	yes	yes	yes	yes	no	no	(yes)	no
Flight Hardware	yes	(yes)	yes	yes	yes	yes	(yes)	(yes)	no	no
Failure Category										
Volumetric (pores)	--	--	+	+	++	++	(x)	(x)	++	--
Plane (cracks / delam.)	+	++	-	0	0	+	++	++	++	+
Investigation area	<3 rows	<2 rows	100%	100%	100%	100%	>70%	>80%	100%	100%



DLR Project „NDT Investigations on CCGA Solderings “

WP1: Selection of components

Selection of critical components, substrates, soldering processes and associated materials, the use of which will take place at short notice in national / international missions.



WP2: Validation and Modification of NDT

Examination of already existing NDT methods for applicability. Testing of comparable commercial CCGA components or qualification samples. Modification, optimization or extension of the technological methods to the individual needs of NDT testing of CCGA solder joints. Validation of NDT results by metallographic micrographs.

WP3: Testing of manufactured samples

Daisy chain components:
Virtex 5, RTG 4 and Actel 624

Soldering process:
Space-qualified low-CTE PCBs
“Pad in VIA“-technology
2 variants (with / without error) x
4 PCBs each x 3 Daisy Chains

Failure Induction & Analysis:
Environmental simulation,
NDT testing and validation via
metallographic cross sections

WP4: Development of Standard Draft

Creation of an product safety standard draft

WP5: Optional – Flight Hardware Investigations

Adaptation of the test methods to the requirements of flight hardware tests



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