NDT Investigations on CCGA Solderings
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SGS INSTITUT FRESENIUS GmbH
SGS Facts & Figures

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
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**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.
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Initial Situation

- XILINX Virtex 5 (1752 connectors)
  
  Source: XILINX

- Microsemi RTG 4 (1657 Anschlüsse)

  Source: Microsemi
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**Initial Situation**

- **IBM 90Pb/10Sn Columns, 20 mils ø**
- **6-Sigma 80Pb/20Sn Columns, 20 mils ø**

Source: Microsemi

Source: XILINX
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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.
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- 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
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**Scanning Electron Microscopic Evaluation**

**SEM:**
Better resolution / depth of field but again only limited number of soldering rows can be inspected.
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- **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.
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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.
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- 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
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- **Scanning Acoustic Microscopy (CSAM)**

  ![Diagram of X-ray and Acoustic detection](image)

  **X-ray techniques:**
  - Volumetric failures (→ pores)
  **Ultrasonic techniques:**
  - Flat failures (→ cracks, delamination)

  ![Columns](image)
## No sufficiently suitable NDT Method for CCGA Solder Joints Testing

<table>
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<tr>
<th>Method-Parameter</th>
<th>Optical Methods</th>
<th>X-ray Methods</th>
<th>Ultrasonic Methods</th>
<th>Materialography</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Microscopy</td>
<td>SEM</td>
<td>Radioscopy</td>
<td>3D-CT</td>
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<tr>
<td>DT / NDT</td>
<td>NDT / DT</td>
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<td>NDT</td>
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<tr>
<td>2D / 3D</td>
<td>2D / (3D)</td>
<td>2D</td>
<td>2D</td>
<td>3D</td>
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<td>Medium</td>
<td>air</td>
<td>vacuum</td>
<td>air</td>
<td>air</td>
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<td>max. spatial resolution</td>
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<td>&lt;0,01 µm</td>
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<td>Sample size [mm]</td>
<td>n. relevant</td>
<td>~300 mm</td>
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<td>Electrical operation</td>
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<td>(yes)</td>
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<tr>
<td>Flight Hardware</td>
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<td>(yes)</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>Failure Category</td>
<td>Volumetric (pores)</td>
<td>--</td>
<td>--</td>
<td>+</td>
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<tr>
<td></td>
<td>Plane (cracks / delam.)</td>
<td>+</td>
<td>++</td>
<td>-</td>
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<tr>
<td>Investigation area</td>
<td>&lt;3 rows</td>
<td>&lt;2 rows</td>
<td>100%</td>
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</table>
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DPBLR 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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