THERMAL SYSTEMS

The Voiding Phenomenon

University of Technology, Brnó, Czech Republic

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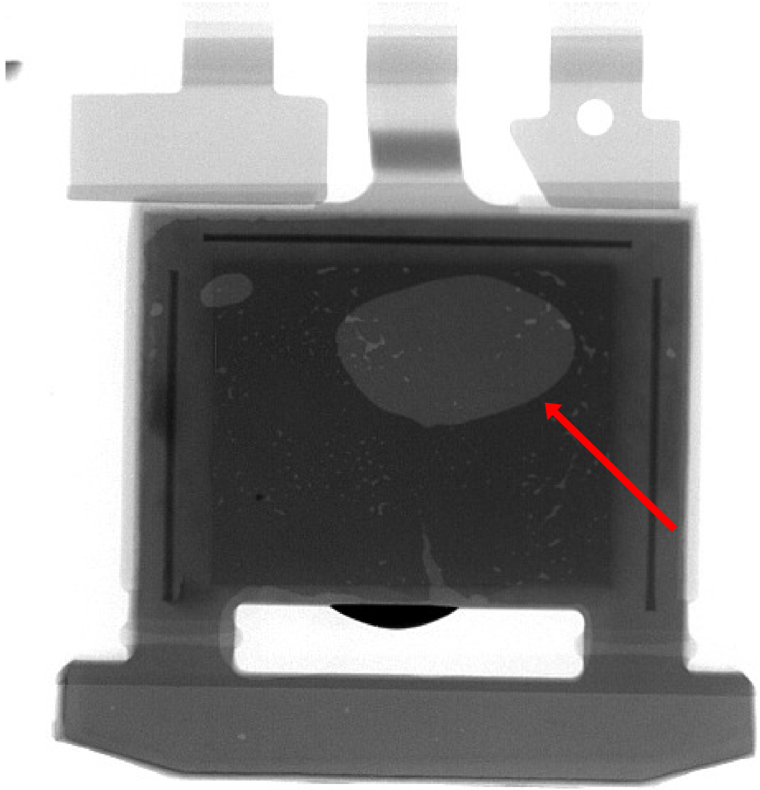
Dr. Hans Bell

Standards

- **IPC-A-610 D**
  Acceptability of Electronic Assemblies
  - Only for Area Array components (BGA)
    Section 8.2.12.4: Voids
    Acceptance criterion class 1-3:
    ≤ 25 % of contact surface (X-ray)



- **IPC-7095B**
  Design and Assembly Process Implementation for BGA (March 2008)
  - Classification, quantification of voids

Standards

IPC 7095B Design and Assembly Process Implementation for BGA (March 2008)

- **Macrovoids:**
  Most widely occuring voids in solder joints, to be found rather isolated in solder volume.
  They do not generally affect the solder joint reliability.
- **Planar Microvoids:**
  Small voids, mostly located at the solder-to-PCB land interfac
  They can affect long term solder joint reliability.
- **Shrinkage voids:**
  Mostly occur on lead-free solders.
  They do not generally impair the solder joint reliability.
- **Microvia voids:**
  Voids over open microvias in pads.
  Depending on their size, they can impact solder joint reliabilit
- **IMC microvoids:**
  Very small voids occuring within the Intermetallic Compound,
  genererally after heat agings (Kirkendall-Voids).
  They can affect solder joint reliability.

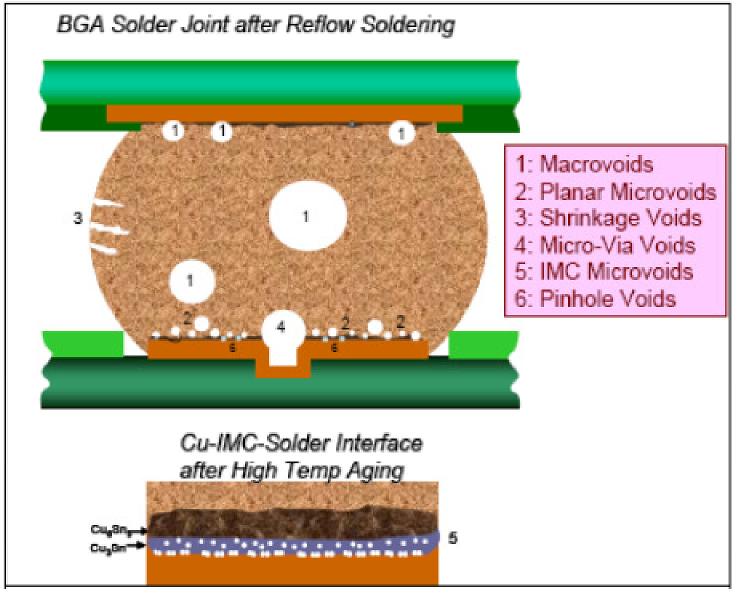


Figure 7-44 Typical size and location of various types of voids in a BGA solder joint

- **Pinhole voids:**
  Very small voids near the metallization. They are caused by pinholes in the copper lands of the PCB.
  Chemicals within these pinholes volatilize during the reflow soldering process.
  With sufficient quantity, they can affect solder joint reliability.

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IEC 61191-6 PRINTED BOARD ASSEMBLIES

- Part 6: Evaluation criteria for voids in soldered joints of BGA and LGA and measurement method

Table A.3 – Voids evaluation criteria for soldered joints of BGA

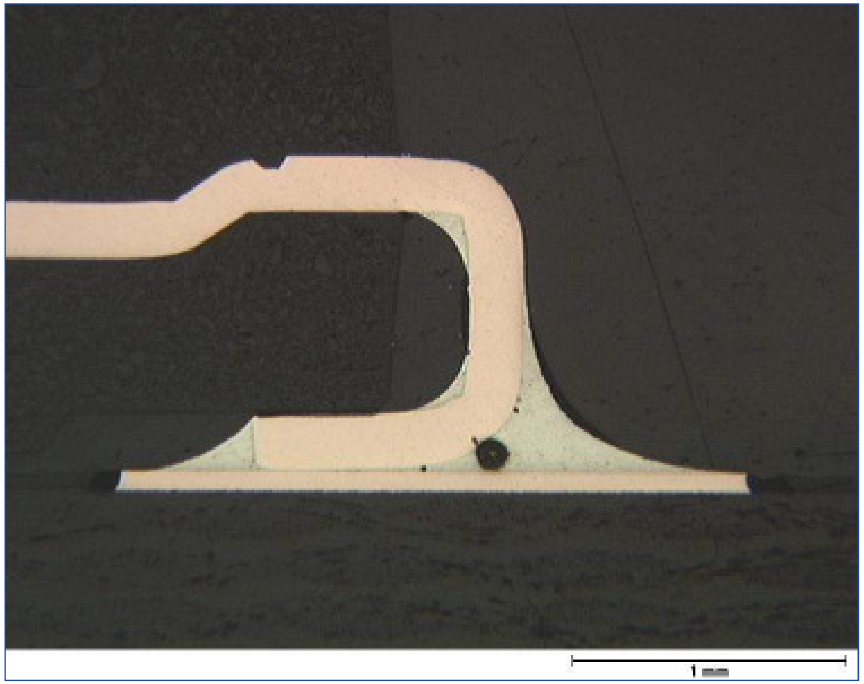
Process goal for decreased void percentage occupancy		Marginal	Preferred	Target
Void evaluation criteria (void occupancy)	Sn-Ag-Cu alloy	<20 %	<10 %	<5 %
	Sn-Zn-(Bi) alloy	<30 %	<25 %	<20 %
The evaluation criteria are not specified for those assemblies, that have a sufficient design margin of reliability.				

Table A.4 – Voids evaluation criteria for soldered joints of LGA

Process goal for decreased void percentage occupancy	Marginal	Preferred	Target
Void evaluation criteria (for all lead-free solder) (void occupancy)	<35 %	<20 %	<5 %
The evaluation criteria are not specified for those assemblies, that have a sufficient design margin of reliability.			

Reliability

■ 1 million US$ Reliability Test Programm, IPC Sep. 2005



PLCC 68, SnAgCu solder paste

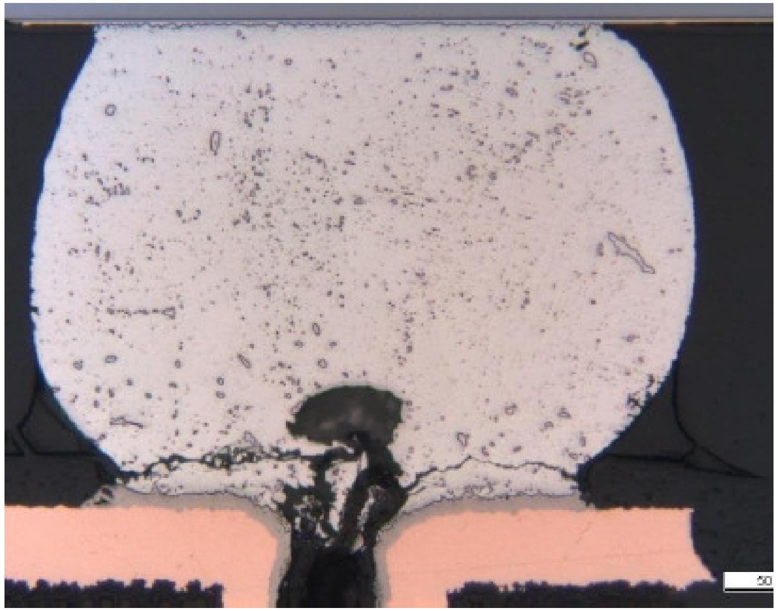
IPC investigation of three SnAgCu alloys
Solders: 96,5/3,0/0,5
95,5/3,8/0,7
95,5/4,0/0,5

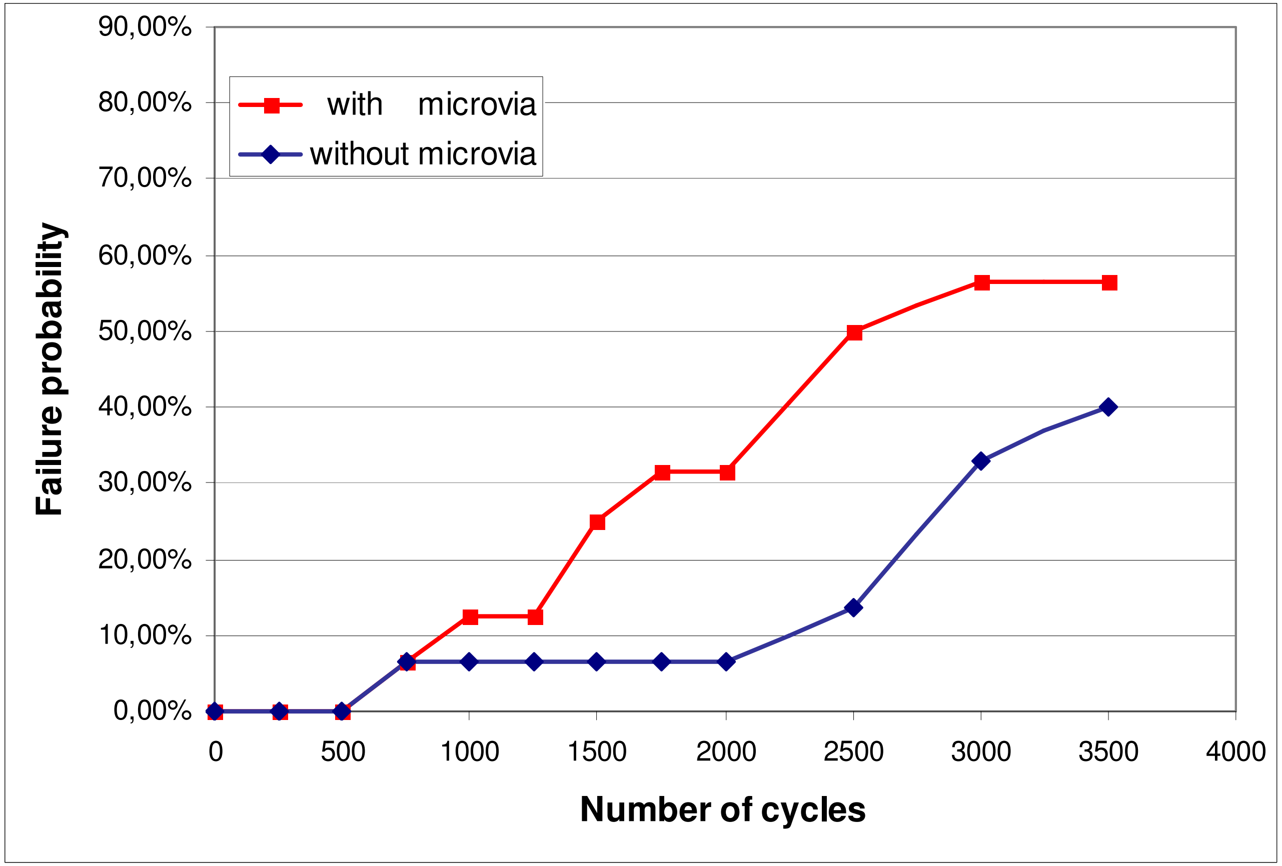
Results:

- No significant difference between the wetting behaviors of the three solders
- More voids in SnAgCu as in SnPb
- Voids have no significant influence on the reliability

Reliability

- **Microvia Voids**
  - LGA80, TCT -40/+125 °C →
  - BGA SAC,
    500 cycles –40/+125 °C ↓

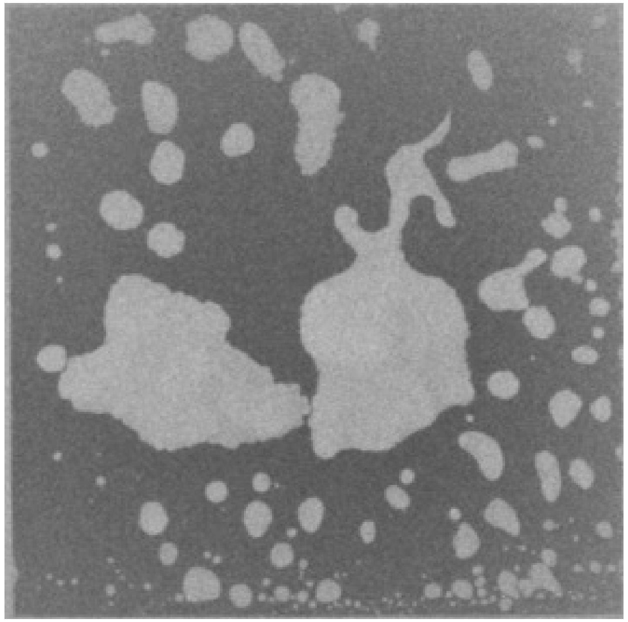


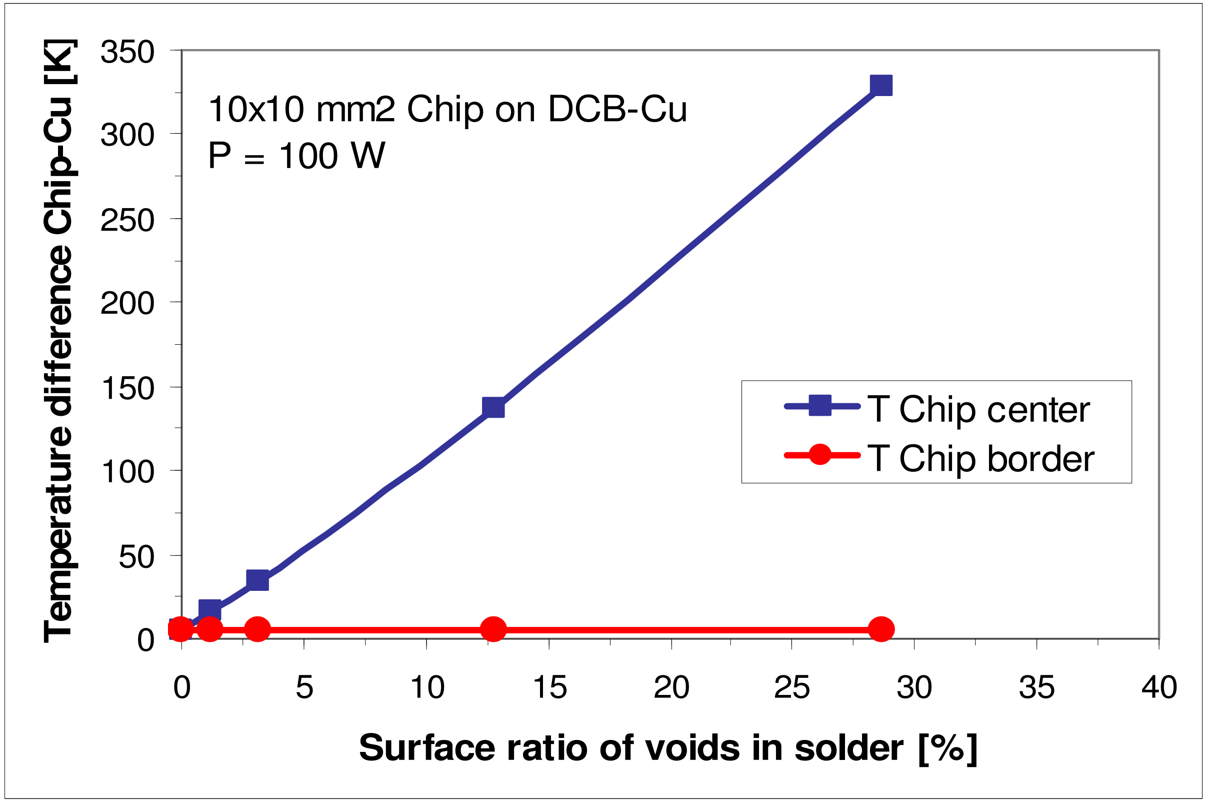


Sources: Dr. Poech, AiF Projekt „Volumeneffekte“ 132ZN / DVS 7.02 IP, Aug. 2006
Abschlussbericht DLR-Förderprojekt „Innovative, kostengünstige Packageplatform für Halbleitergehäuse mit hoher Pinzahl“, 2006

■ **Influence of voids on power electronics solder joints**

- ■ Void in solder layer between chip and DCB substrate, P = 100 W

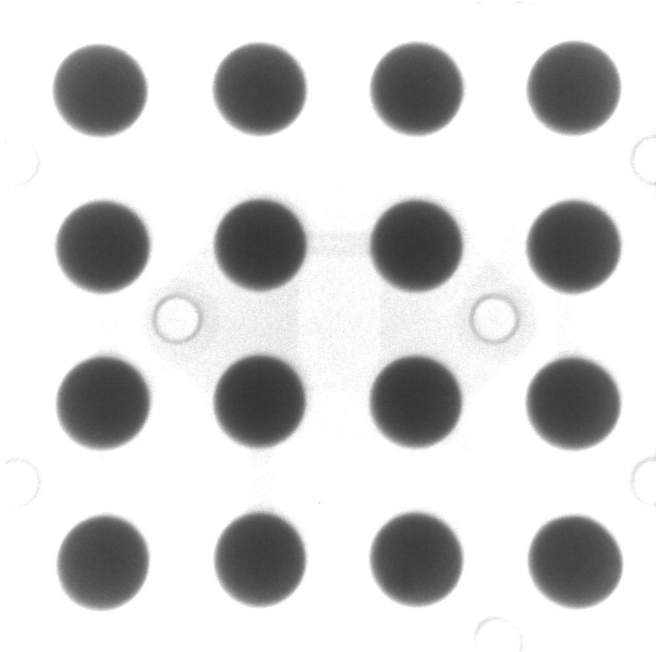




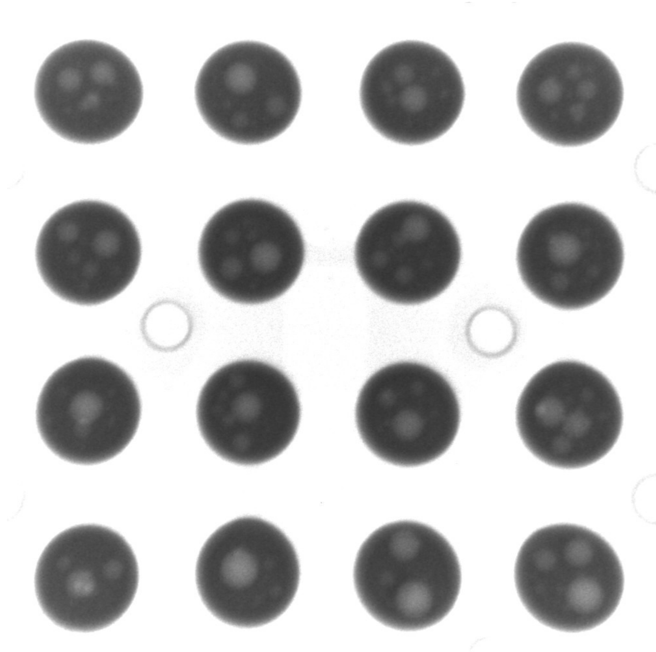
Source: M. Poech, FhG ISIT 2009

Influences on voids formation

- **Influence of solder paste**
  - Ball solder joints, X-Ray, stencil 150 µm, aperture 380 µm



Solder joint realized only **with Flux**

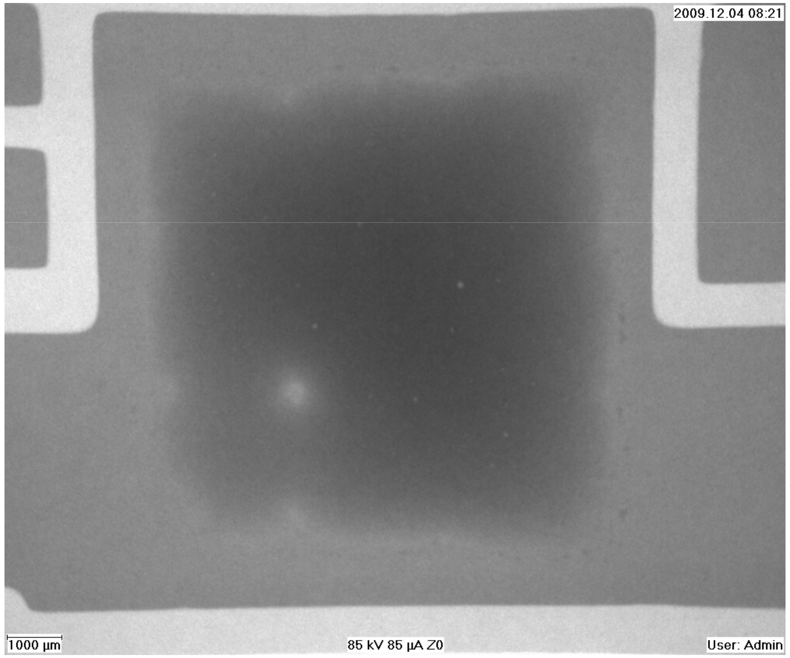


Solder joint realized **with solder paste**

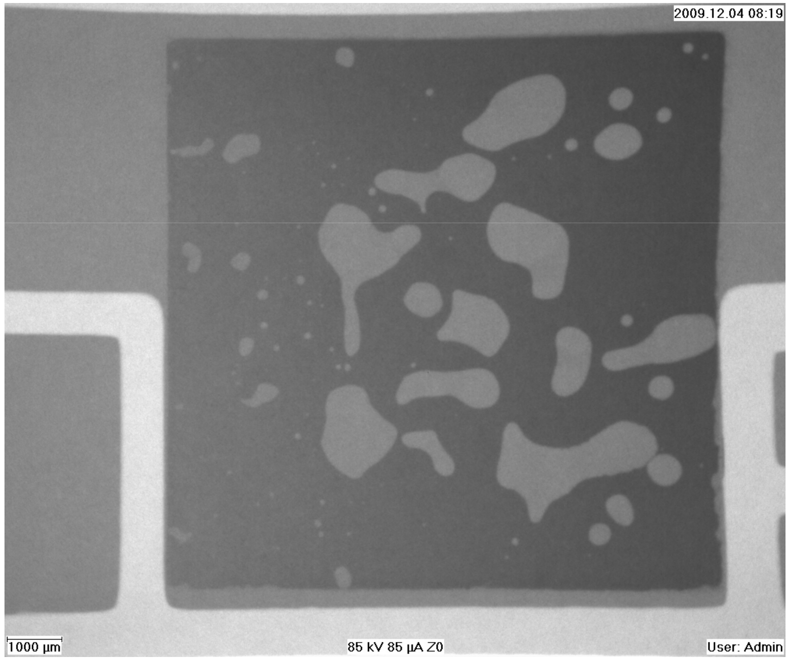
Source: J. Trodler, Heraeus 2009

Influences on voids formation

- **Initial state: Influence of component placement**
  - Chip solder joints, 1 cm², condensation soldering without vacuum



Solder joint **without component**

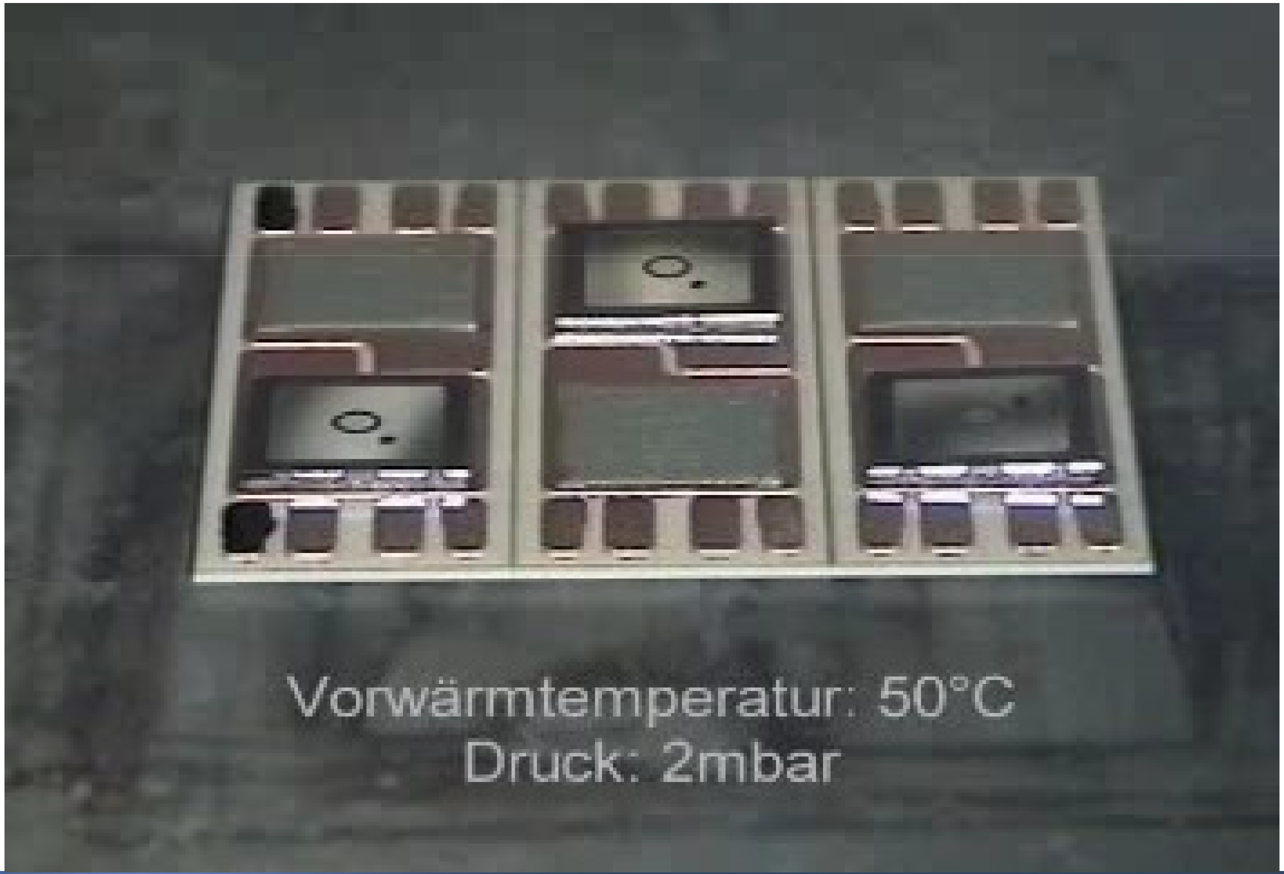


Solder joint **with component**

Source: K.-H. Schaller, Siemens 2009

Influences on voids formation

- **Formation of voids**
  - Influence of solder paste SnAgCu



Influences on voids formation

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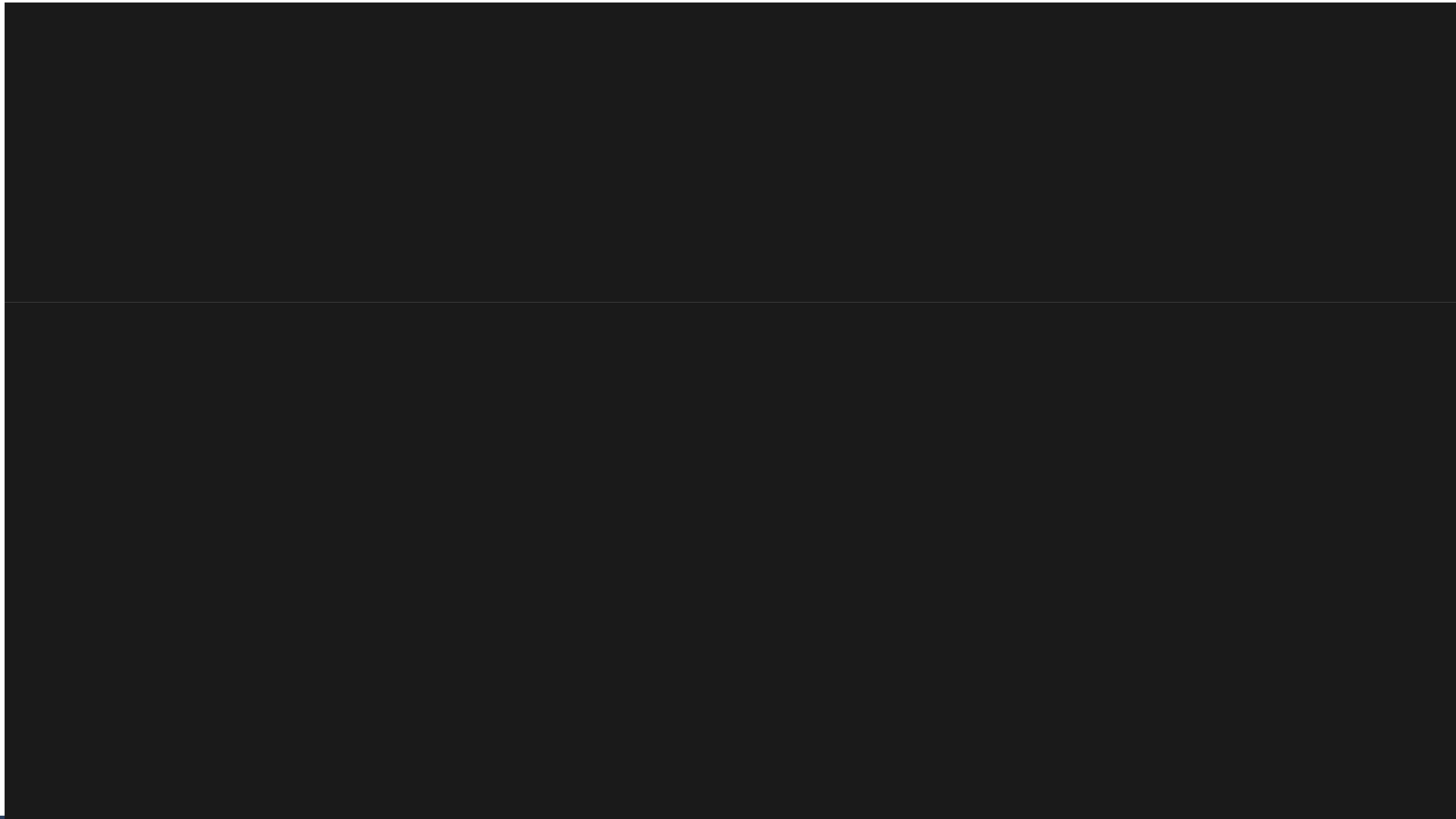
- Animation Voiding



Influences on voids formation

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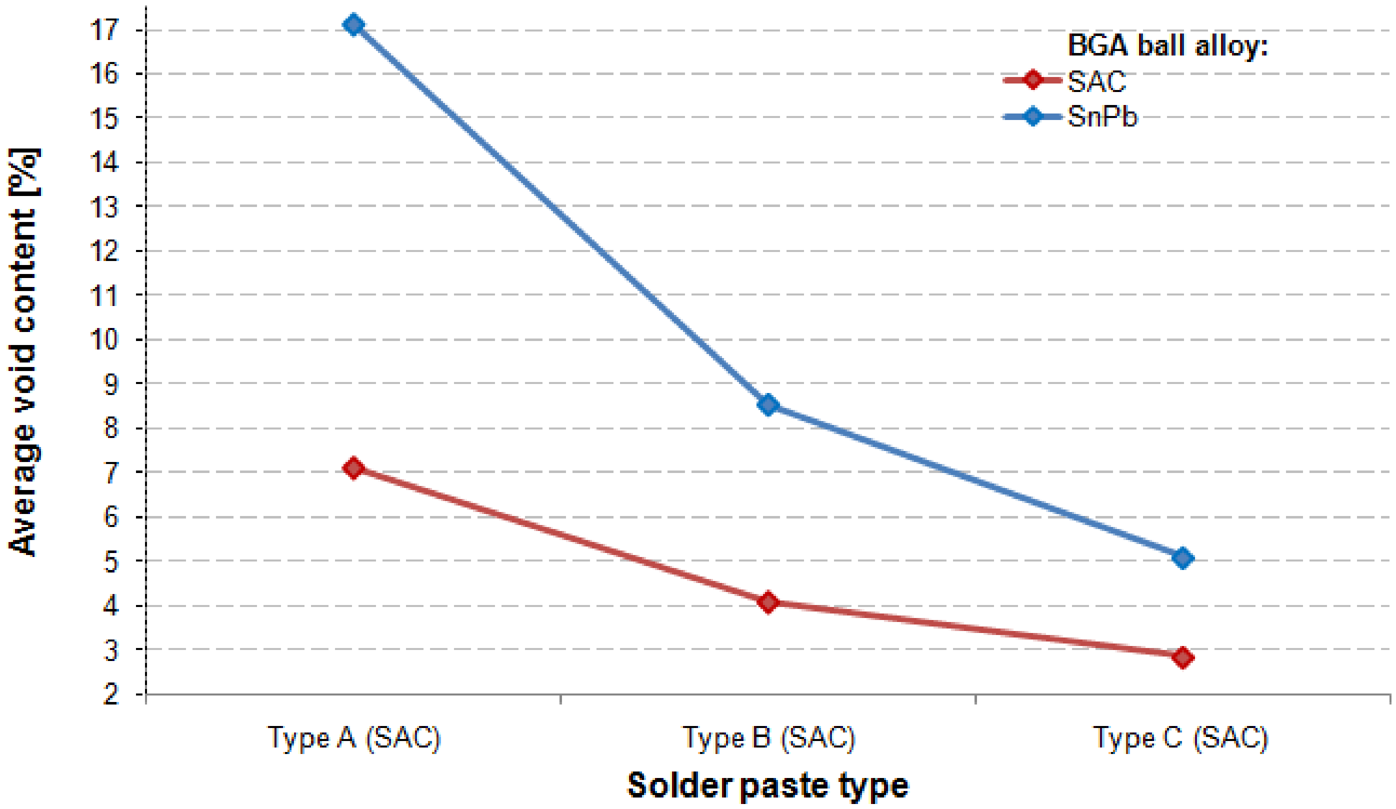
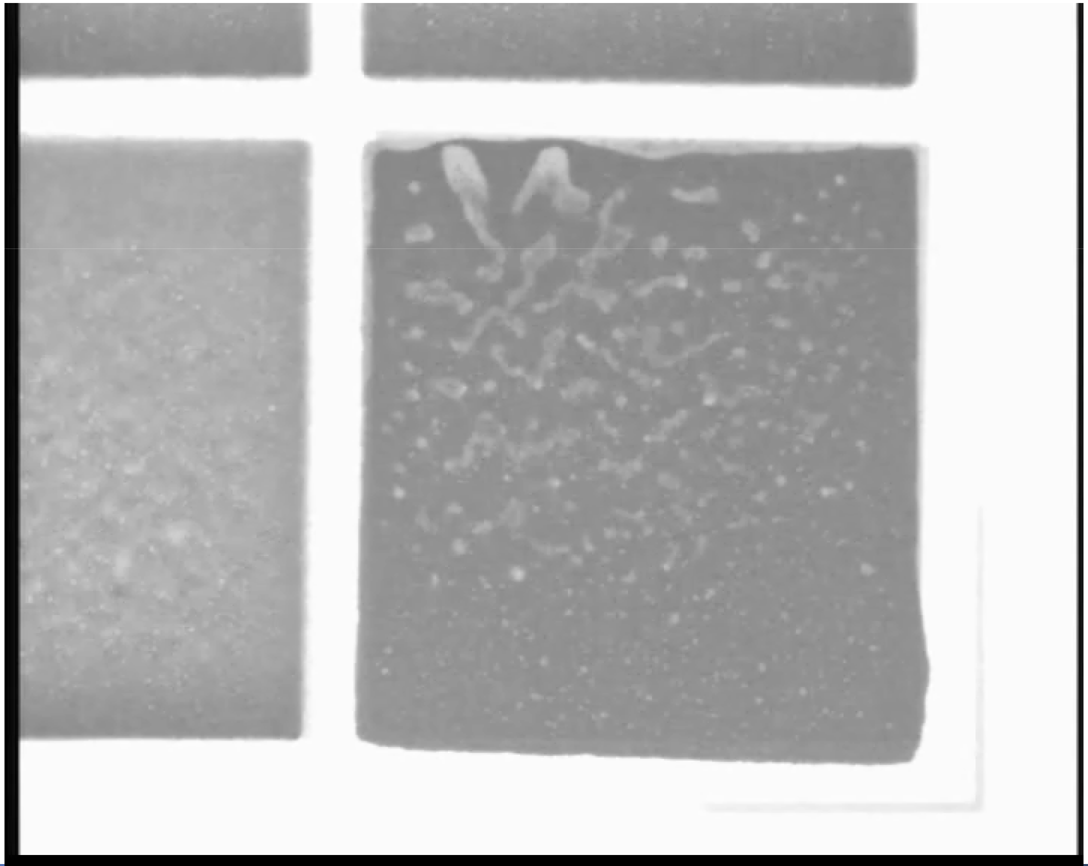
- **Influence of alloy**
  - SAC solder paste, BGA: SnPb balls vs. SAC balls



Source: H. Wohlrabe, TU Dresden, 2010

Influences on voids formation

- **Formation of voids**
  - Insitu X-ray examinations, FhG ISIT, Dr. M. Poech, 2009



Influences on voids formation

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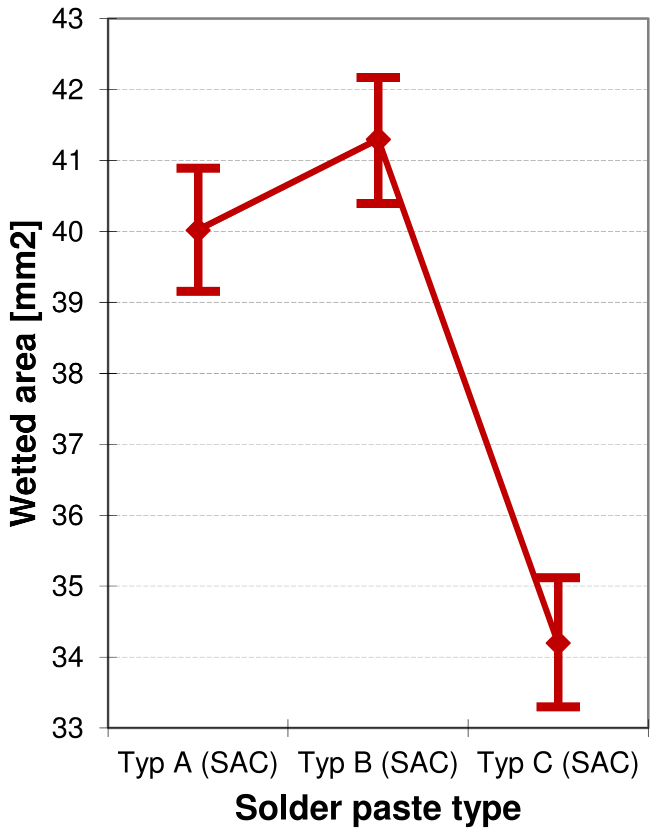
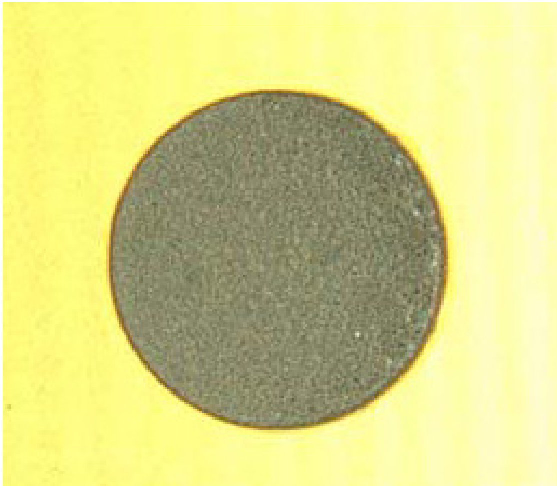
Influence of solder paste and wetting

- Solder spreading



Paste deposit

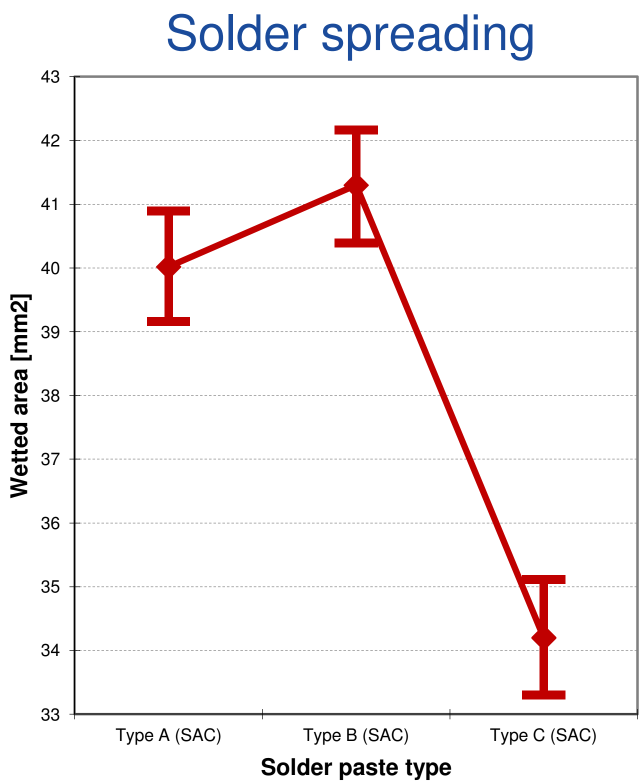


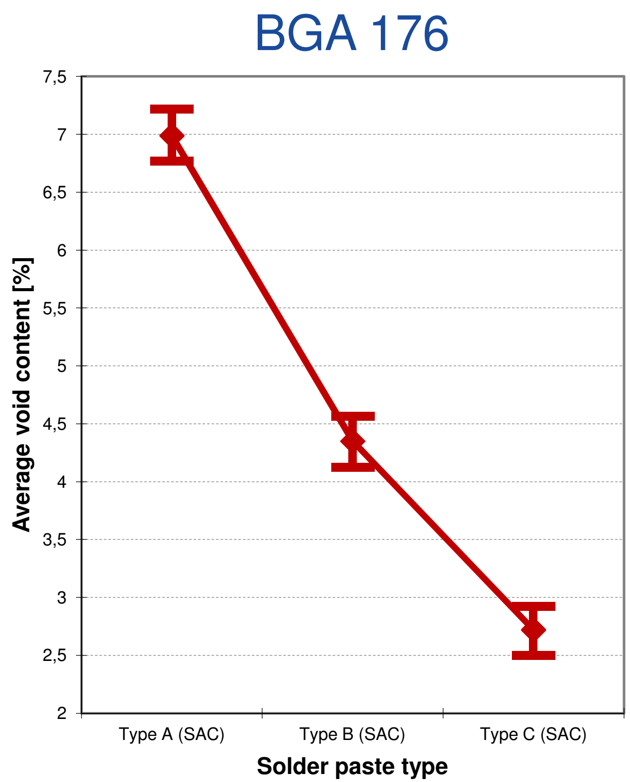
Wetted area

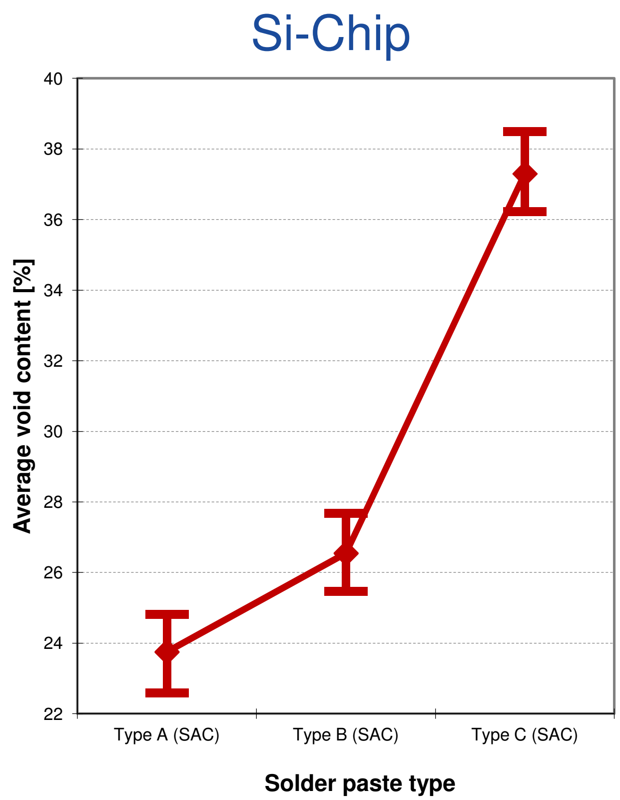
Source: H. Wohlrabe, TU Dresden, 2010

Influences on voids formation

- **Influence of solder paste and wetting**
  - Contrary effects, BGA vs. Si-Chip solder joints







Source: H. Wohlrabe, TU Dresden, 2010

Influences on voids formation

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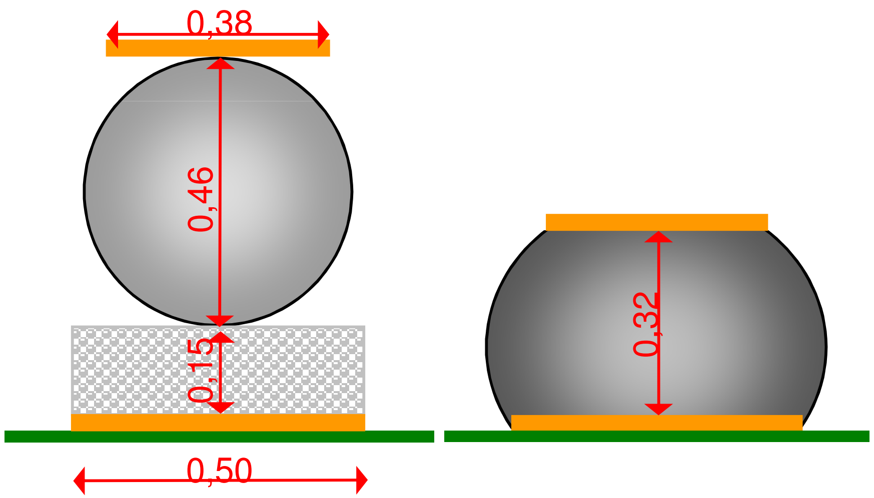
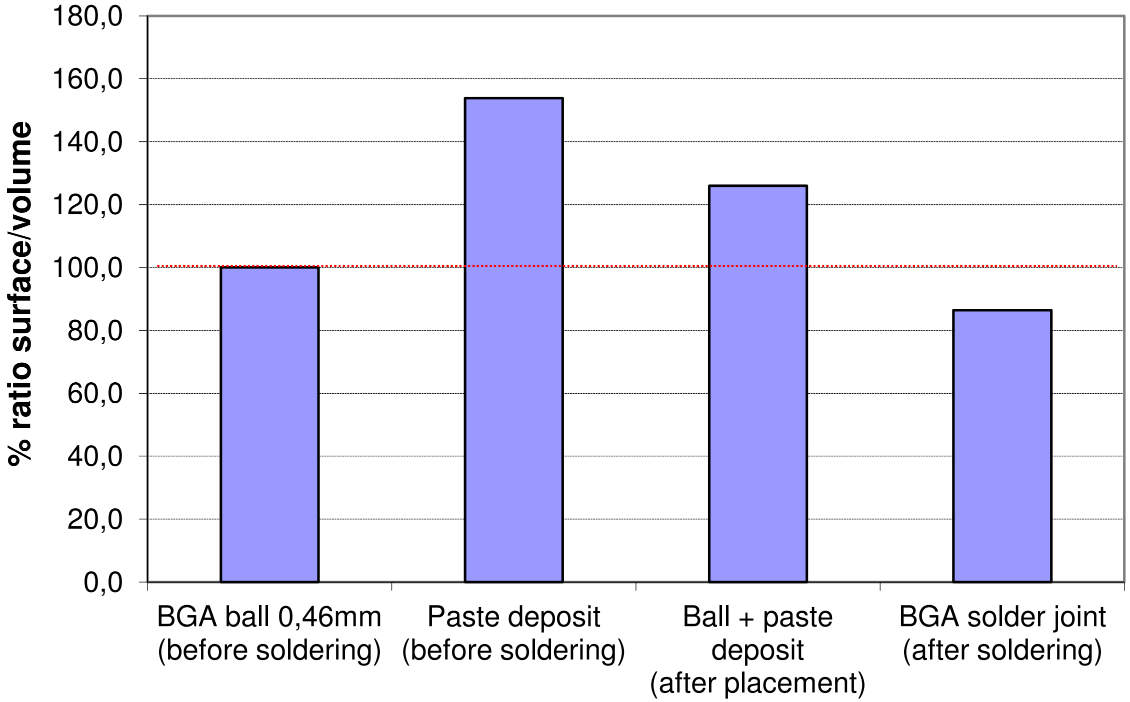
Influence of geometry

- BGA solder joint, geometric conditions
  Total solder volume: 0,065 mm³

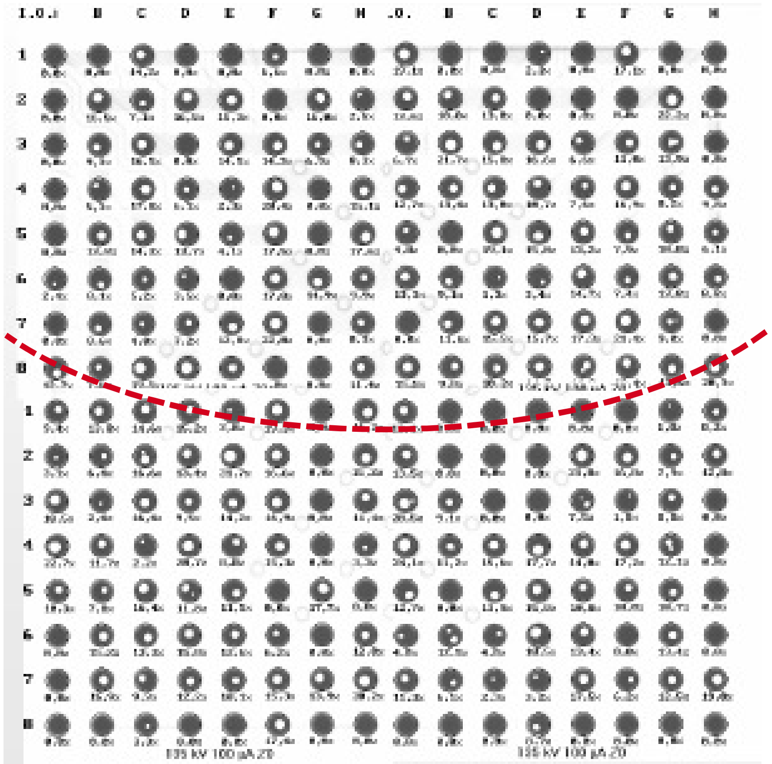


Before placement After soldering

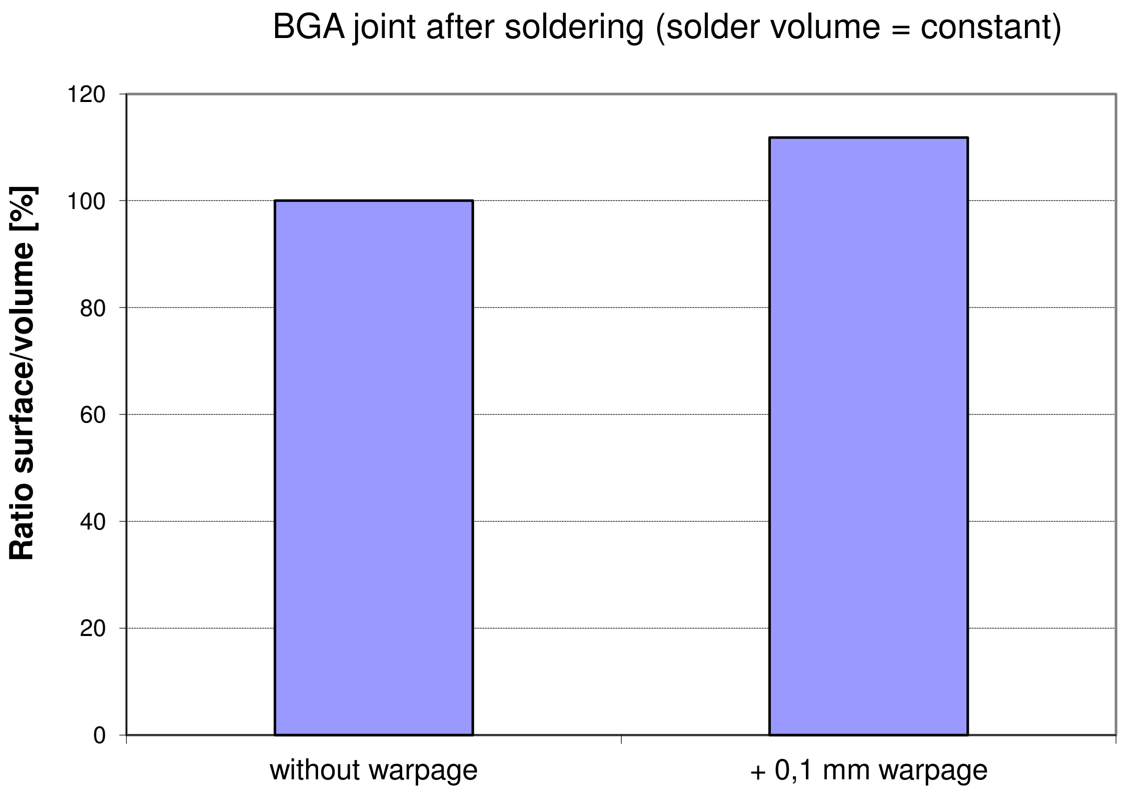


Influences on voids formation

- **Influence of twisting/warpage**
  - BGA solder joints



X-Ray: H. Wohlrabe, TU Dresden, 2010



Influences on voids formation

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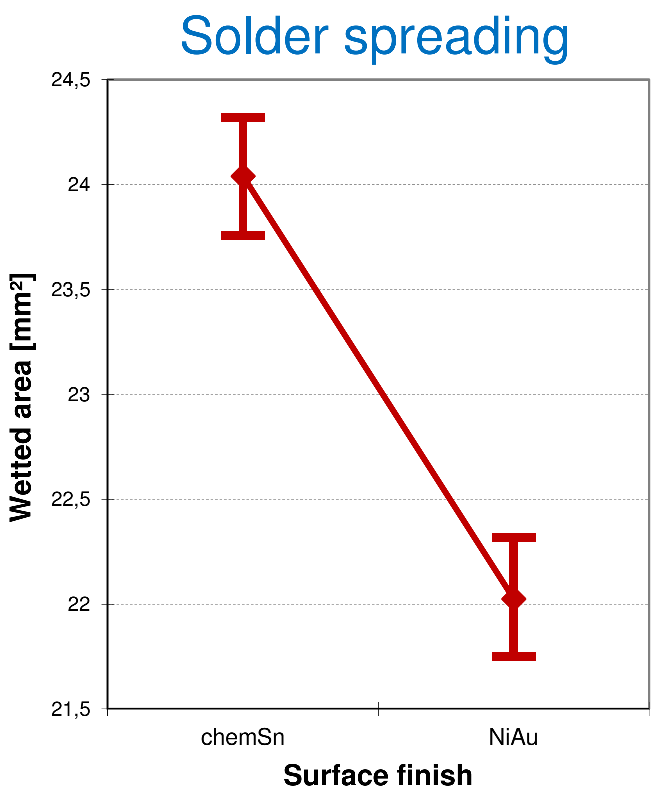
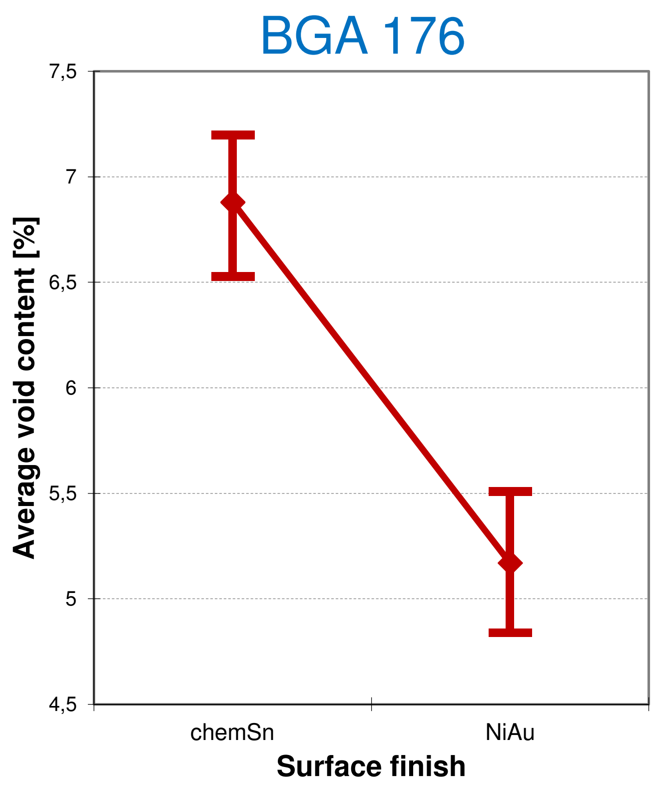
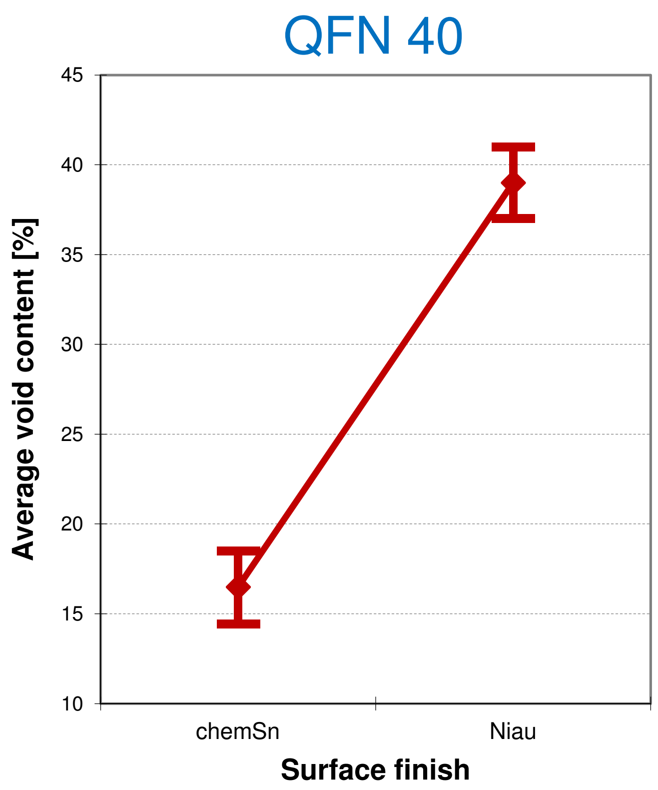
Influence of PCB finish

- Contrary effects, BGA vs. QFN soldering joints



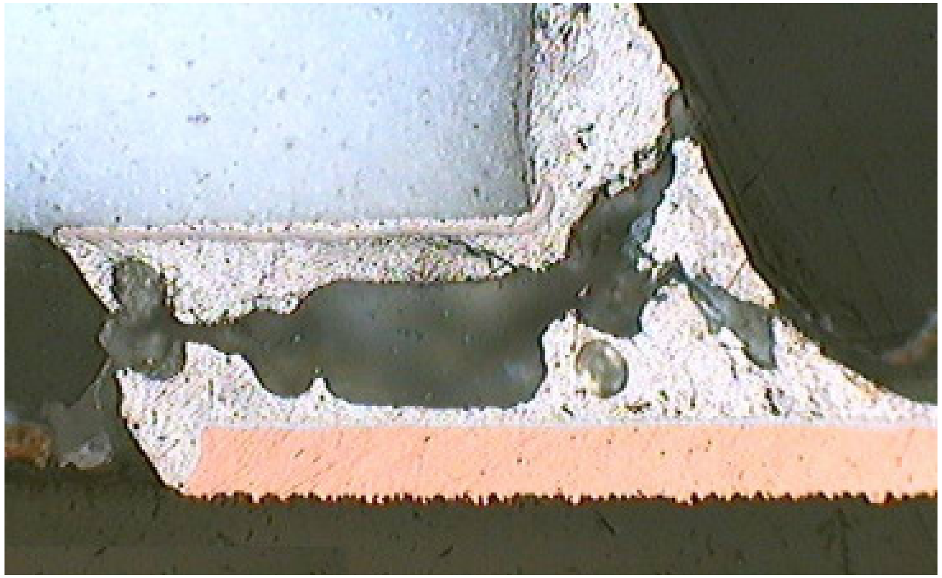




Source: H. Wohlrabe, TU Dresden, 2010

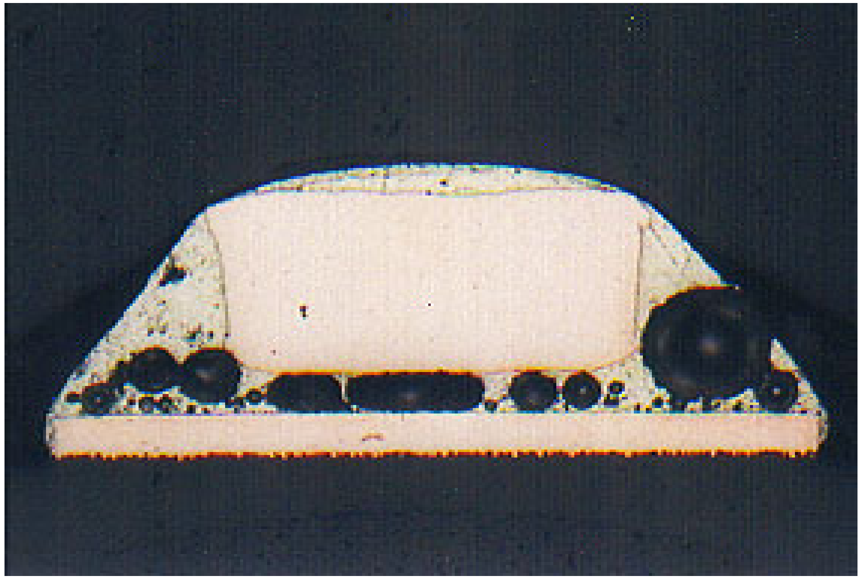
Influences on voids formation

- **Influence of metallization**
  - Quality defects of the solderable surface



Defect of components
PCB: HAL SnCuNi, comp.: Sn/Ni/AgPd
After TW +10 ℃ / +65 ℃ approx. 700 cycles

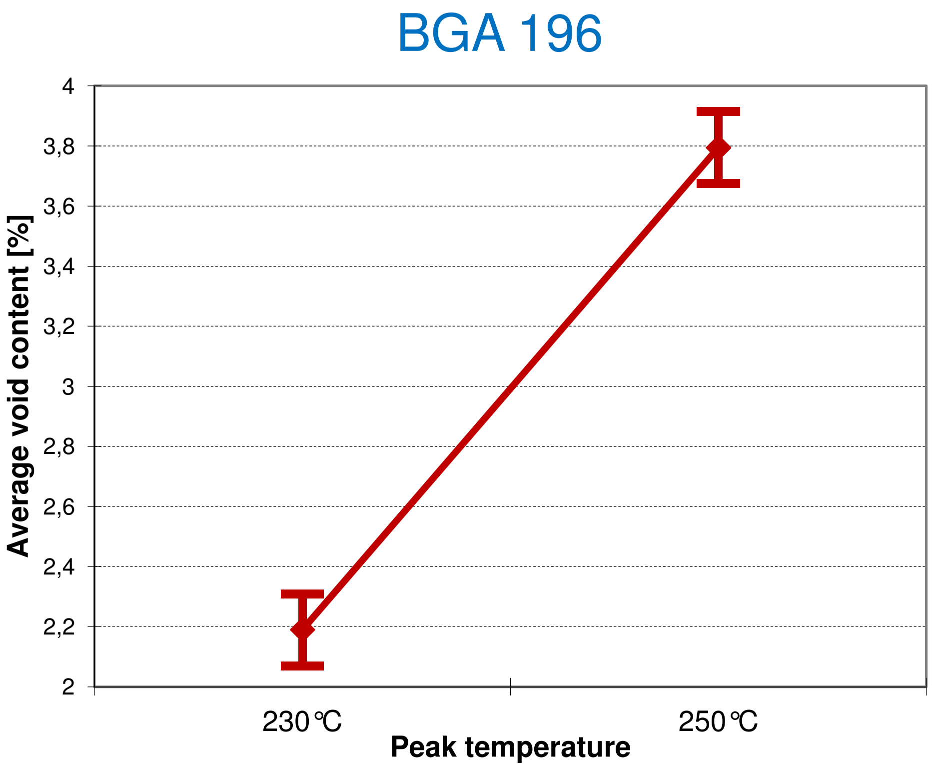
Source: U. Frank, Hydrometer

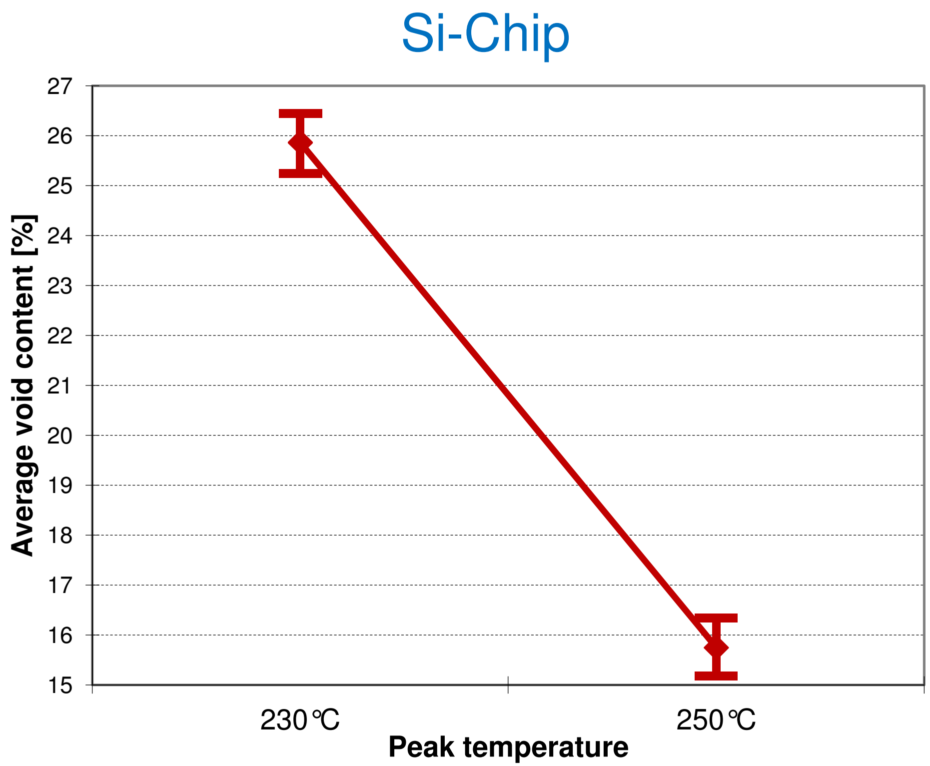


Defect of PCB
Palladium PCB surface
SO-Lead / SnPb
SnPb solder paste

Influences on voids formation

- **Influence of peak temperature**
  - Contrary effects, BGA vs. Si-Chip soldering joints

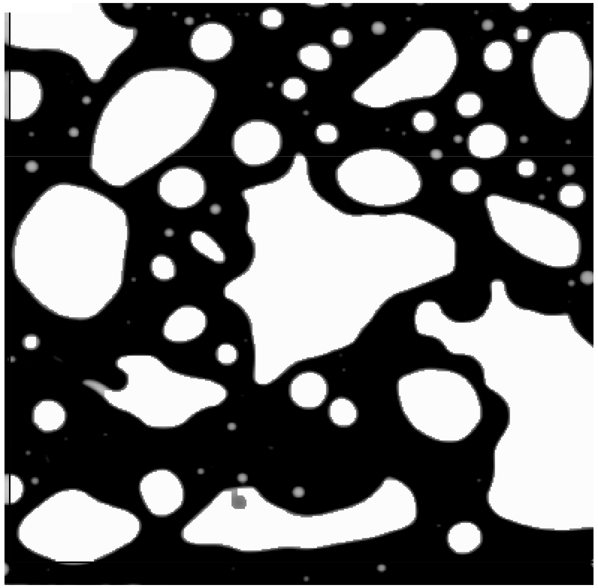




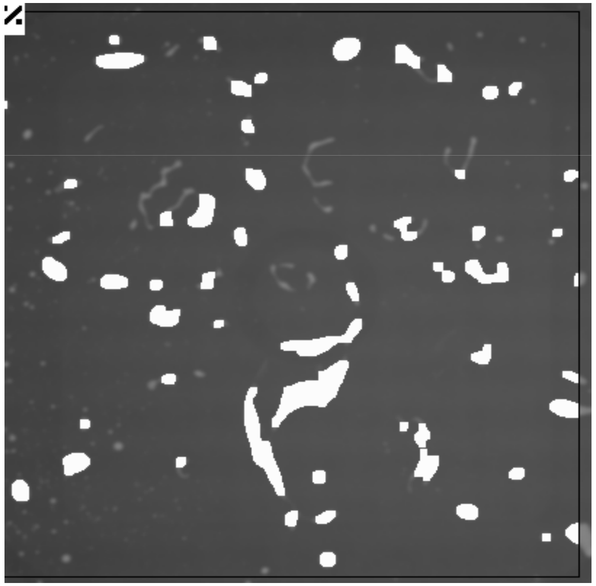
Source: H. Wohlrabe, TU Dresden, 2010

Influences on voids formation

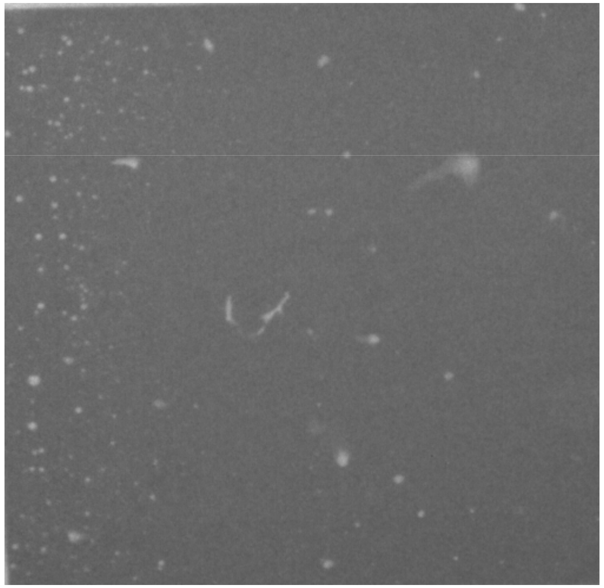
- **Influence of soldering method**
  - Si-Chip, paste: SnAgCu
  - Power electronics accepted < 2 % Voids



Convection N_2



Vacuum Condensation
Paste thickness: 125 µm

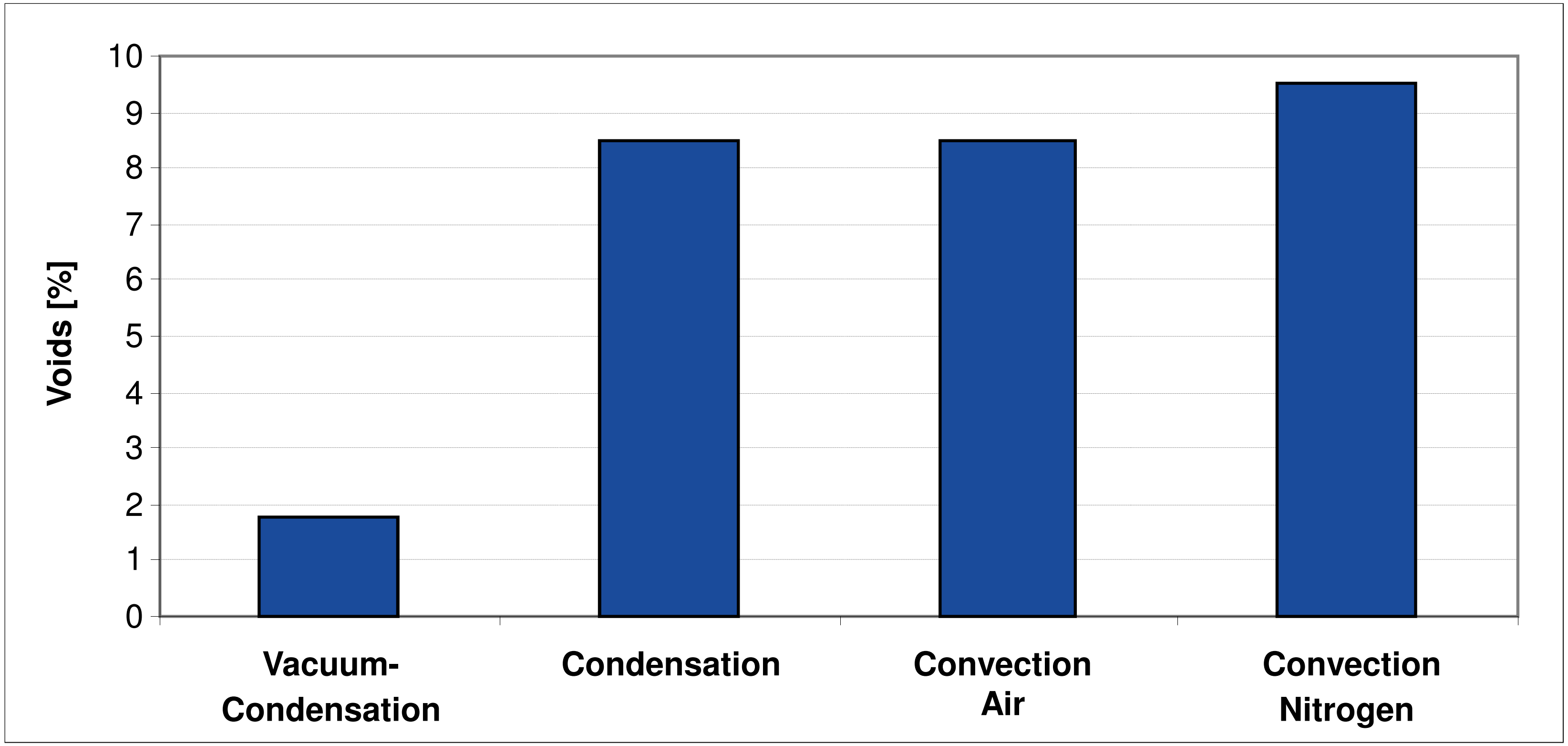


Vacuum Condensation
Paste thickness: 180 µm

Source: Dr. H. Wohlrabe, TU Dresden, 2009

Voids

- **Influence of reflow soldering method**
  - BGA-SAC ball, solder paste: SnAgCu



Source: H. Wohlrabe, T. Herzog, M. Detert, S. Meyer, Abschlussbericht Voiding Projekt, 2007

Thank you!

- … natural voiding

http://blog.doctissimo.fr/php/blog/mimi_la_souris/images/fromage_souris.jpg