Development and Evaluation of Equipment Enhancements for Transient Liquid Phase Bonding (TLPB) and Sintering

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Outline

- Introduction to TLPB
- Motivation
- Introduction to bonding equipment
- Equipment and process evaluation
  - Silver sintering
  - Transient Liquid Phase Bonding (TLPB)
Introduction to TLPB

- Process stages of Transient Liquid Phase Bonding:

1. Stage: Interlayer preparation

2. Stage: Interlayer melting and dissolution

3. Stage: Isothermal solidification

4. Stage: Homogenization
Motivation

- Requirements on bonding equipment:
  - pressure uniformity
  - temperature uniformity
  - accuracy of position
  - flexible heat and pressure profile
  - inert and reducing atmosphere
  - complex topography
  - processing of multiple substrates

- new approach combining vacuum reflow soldering system with press unit
Introduction to bonding equipment

**Basic idea:** Isostatic press using an elastomer membrane
Evaluation of bonding equipment

- Pressure distribution study

Sample distance [mm]: 0.5..4

Sample heights [mm]: 0.5, 1, 1.5, 2, 2.5, 3

Sample size [mm²]: 5 x 30

Working area: Ø 160 mm

Boundary region around the samples
Evaluation of bonding equipment

- Dependence on sample height and applied pressure

  - very slight influence on sample distance and height
  - operation within a wide design diversity possible
Evaluation of bonding equipment

- Processing of complex topographies

- Dummy power module
- 0.3 MPa

- FR4 demo board
- 0.5 MPa

- No need of tooling
- Simultaneous bonding of a batch of assemblies
Evaluation of bonding equipment

- membrane material: FKM vs. VMQ based elastomers

Continuous operation at 300°C

Aging after 8 days at 300°C

- FKM material
- VMQ material

- hardness [shore A]
- weight loss [%]
- thickness change [%]
- hardness change [%]

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Evaluation of bonding equipment

- maintaining of the alignment accuracy

alignment after FC-bonder

alignment after process run in bonding oven
Evaluation of bonding equipment

- lateral displacement after permanent bonding well below 3 μm
- samples transfer manageable
- use of temporal adhesives possible

Cross-section and x-ray image of an encapsulated silicon package for MEMS applications.
Process evaluation - TLPB

- Transient Liquid Phase Bonding for power devices (Sn-Cu)

- void free joint
- interlayer thickness and applied pressure critical
- process time to be adopted
Process evaluation - TLPB

- Uniform TLPB joint across entire device

- oxide reduction over large area

- bending of device neutralised
Process evaluation – Ag sintering

- Low pressure silver sintering

- 3 types of pastes tested: for pressures > 10 MPa, 5 – 10 MPa, and for pressureless sintering

- Pressureless paste showed highest sintering degree at 0.45 MPa
Process evaluation – Ag sintering

- Low pressure silver sintering

  - bonding duration for pressureless paste lowered significantly
  - porosity is similar to conventional pressureless process
Future work

- chip to wafer packaging
- fully automatic handling
- integration with dieplacer
- upscaling
- Cu sintering
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