Embedded Components in PCB

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Imbera Electronics
Agenda

- Imbera Electronics Introduction
- Evolution in Electronics Production Technologies
- Imbera Integrated Module Board Technology Solution
- Applications
- Summary
Imbera Electronics - Overview

- Imbera Electronics provides novel and innovative manufacturing solutions for advanced consumer electronics
  - Imbera’s core process enables further product level miniaturization and improved performance with attractive production cost levels

- Imbera solution embeds standard components inside a PCB structure
  - Currently Imbera is building a supply base for high volume manufacturing utilizing it’s 3rd generation technology

- Imbera development team has a long history in component embedding technology development
  - First embedded modules manufactured in late 90’s in Helsinki University of Technology
  - Technology concept industrialization launched in 2001 / 2002
    - Company established in spring 2002 by Elcoteq Network and Aspocomp Group
  - Proto and small volume manufacturing in 2005 / 2006
  - High volume supply base development in 2008 / 2009

- New funding collected in 2007 for technology commercialization
  - Strong and long term investors; leading European investors with strong development commitment
Evolution in Electronics Production Technologies
The new technology evolution must provide:

- Significant technological benefits and strong road map to further improve the technology competitiveness
- Solid and robust manufacturing process with excellent quality and yield levels
- A path for the Customer to easily adopt the technology with existing applications
- Credible value chain to support the high volume manufacturing
  - Open technology platform with multiple manufacturing service providers
- Lower total cost of ownership when the technology reaches maturity

Electronics production technologies

TECHNOLOGY INNOVATIONS

- Trough hole technologies
- Surface mount technologies
- Bare die and 3D technologies
- Embedded components
Integrated Module Board Technology Solution
Imbera Integrated Module Board Production Process for Discrete Component Embedding

Active and Passive Component Attachment

Core Board Stack-up

Core Pressing and Via Formation

PCB processing; Plating, Patterning
Electrical Features

- Electrical Modelling: S-parameter Measurements (IMB vs. COB)
  - The measurements from 50 MHz to 20 GHz
  - Signal passing through two IMB interconnections and an on-chip aluminium conductor

Attenuation

IMB interconnection - attenuation less than 0.7dB

Wire bond interconnection

Wire bond interconnection - attenuation less than 0.7dB

Model of the IMB interconnection

\[
R = \frac{Z_0}{Q} \\
L = \frac{Z_0}{2\pi f_0} \\
C = \frac{1}{2\pi f_0 Z_0} \\
L = \frac{Z_0}{2\pi f_0} \approx 24 \text{ pH}
\]
Integrated EMI shield

- Cross-section and top view schematics of the integrated EMI shield
  - Routing
  - Embedded IC
  - Ground layer
  - Drilled through holes

- Measurements on a demo-board showed excellent isolation from both capacitively and inductively coupled noise on a wide frequency range.
  - Shield efficiency was measured with response probe, which was EMI shielded and excited with a nearby noise-source.
  - The signal-level received inside the shield is shown in the figure below.
• IMB technology offers novel solutions to manage thermal issues
  • Thermal copper structures (vias, planes...) can be manufactured to reach from the IC to edges of the package

Direct thermal contact between die and copper ensures effective heat conduction from the critical areas.

Cross-section of thermal contact from back side of the IC to the heat conducting copper structures

Cross-section of thermal via and copper plane structure of BGA type module. Thermal vias on rear side of the IC.
SIB, motherboard level products PCB structure: 1+2+1
- 65/65 L/S design
- Material: standard FR4

Embedded component:
- Silicon component, Cu bump
- Thickness: 150 µm
- Pitch: 150 µm

Reliability Test

<table>
<thead>
<tr>
<th>Test Standard (Jedec)</th>
<th>Preconditioning</th>
<th>Package Level Conditions</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-STD-020</td>
<td>Reflow Moisture Sensitive</td>
<td>level 3 60°C/60% RH 40h + reflow 3 times</td>
<td>Pass</td>
</tr>
<tr>
<td>JESD22-A104</td>
<td>Thermal Cycling</td>
<td>Condition: M (-40 °C - +150°C) Soak mode: 3 (10 min) Cycles per hour: 2 Cycle count: 1000 cycles</td>
<td>Pass</td>
</tr>
<tr>
<td>JESD22-A103</td>
<td>High Temperature Storage</td>
<td>Condition A: 125°C, 500 h</td>
<td>Pass</td>
</tr>
<tr>
<td>JESD22-A119</td>
<td>Low Temperature Storage</td>
<td>Condition A: -40°C ± 3 °C, 168 h</td>
<td>Pass</td>
</tr>
</tbody>
</table>

SIP, Single IC, package level products PCB structure: 1+2+1
- Material: High Tg FR4
- Embedded component:
  - Silicon component, Cu bump
  - Thickness: 150 µm
  - Pitch: 250 µm

Preconditioning Reliability Test Test Standard (Jedec) Package Level Conditions Pass/Fail
Reflow Moisture Sensitive J-STD-020 level 3 60°C/60% RH 40h + reflow 3 times Pass
Thermal Cycling JESD22-A104 Condition: M (-40 °C - +150°C) Soak mode: 3 (10 min) Cycles per hour: 2 Cycle count: 1000 cycles Pass
High Temperature Storage JESD22-A103 Condition A: 125°C, 500 h Pass
Low Temperature Storage JESD22-A119 Condition A: -40°C ± 3 °C, 168 h Pass
Applications
Imbera Product Families

• System – In – Board motherboard applications
  • Embedded discrete passives; capacitors & resistors
  • Embedded actives; standard ASICs, low I/O WLCSPs

• Module applications
  • Single IC packages
    • Si or GaAs die
  • SiP packages
    • Multiple ICs
  • Hybrid modules
    • Embedded active and passive components

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### Summary of applications

<table>
<thead>
<tr>
<th>Features</th>
<th>System in Board (SIB)</th>
<th>System In Package (SIP)</th>
<th>Single IC Package</th>
</tr>
</thead>
</table>
|          | • Cost driven process; component placement with chip shooter  
            • Motherboard PCB process | • Accuracy driven process; component placement with FC bonder  
            • Substrate PCB process | • Accuracy driven process; component placement with FC bonder  
            • Substrate PCB process |
| Embedded components | • Low to medium I/O count Si, GaAs  
            • Discrete passives and IPDs; capacitors, resistors, inductors | • Low to medium high I/O count Si, GaAs  
            • IPDs | • Low to medium high I/O count Si, GaAs  
            • IPDs |
| Benefits | • Miniaturization  
            • Free utilization of surface area  
            • Lower profile | • Miniaturization  
            • Free utilization of surface area  
            • Excellent electrical and thermal performance  
            • Embedded EMI shield | • Full array solder lands on the back side  
            • Embedded EMI shield  
            • Excellent electrical and thermal performance |
| Applications | • Embedded discrete passives, digital ICs | • High frequency, high heat producing analog devices, digital component | • POP, IQFN, iBGA, high frequency, high heat producing analog devices, digital component |

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**iBGA**

**SIB with two embedded ICs**
• Two layer interposer with capacitors and/or inductors on top

• Two to four layer interposer with heat conductor structure and capacitors and/or inductors on top

• Four layer interposer with embedded shield and capacitors and/or inductors on top

• 8 layer interposed with 3 embedded ICs in 3D arrangement, embedded shield for both layers
Summary
• Short and robust manufacturing process
  • For passive and active components
  • Standard materials and equipments used in the process enable good scalability to high volumes
  • Fulfils all today’s environmental requirements
  • Enables high yield levels in embedding

• Novel structure designs
  • 3D ground for EMI shielding
  • 3D component assembly

• Excellent electrical performance – ideal for high frequency applications
  • No gold wire bond interconnection

• Excellent thermal performance – ideal for high power applications
  • Thermal vias on front and back side of the component to improve heat conductivity

• Proven reliability in telecom and handheld area