Wedge Bonding Chip on Board (COB) and Direct Chip Attach (DCA) Applications

Lee Levine, Consultant
Process Solutions Consulting, Inc
Distinguished Member of the Technical Staff
Hesse & Knipps, Inc
levilr@ptd.net or Levine@hesse-knipps.us
COB and DCA Requirements

• Flex, COB, laminates, LTCC
  – Many surfaces/materials in one package
  – Different bond heights
  – Discretes
  – Complex PRS, many Reference Systems

• Multiple wire diameters in same package

Only Wire Bonding is Flexible enough to handle all of these requirements
Flex Cable/COB & Passives [Courtesy Lexmark]
COB/Glob-top, Through-hole, and Surface-mount on Back (courtesy Lexmark)
Overview of Wire Bond Interface Reliability

- **High Interface Reliability**
  - Au-Au
  - Al-Al
  - Al-Ni
  - Au-Pd
  - Au-Ag
  - Au-Al
  - Pd, Au, Pt

  - **Wedge Bond**
    - Reliability established by high volume production

- **Low Interface Reliability**
  - Au-Cu
  - Ag-Cu
  - Al-Cu

  - **Al-Al**
    - Reliability established by laboratory experiments of low volume production only. Acceptable for commercial production. Copper wire bonds may crater Si.

  - **Al-Ag**
    - Use only with great caution
Effect on Thin film Au Bondability of Photoresist Contamination on Various Bonding Technologies [Bushmire]

- Wedge Bonding is capable of bonding on dirtier surfaces than ball bonding.
- COB, Flex, Hybrids have dirtier surfaces than chips or leadframes
Improving Bondability of Laminate Packages

Figure (2). Structure of a generic, stiffened-metal bond pad and polymer substrate for wire bonding to MCMs. The ground plane is included for the skin-effect discussion in F. See text for specific structures.
Figure (1). The depth of bond-pad indentation on PI flex boards as a function of ultrasonic energy and bond force. a) is with only 2-μm-thick Au over 18-μm-thick Cu. b) is with a 3-μm-thick Ni layer between the Cu and Au layers [9].
Nickel/Gold Plating for Wire Bonding

- Larger Wire > Thicker Plating > Higher Bonding Parameters
- For Al wedge Al-Ni Intermetallic has best reliability
- For .001-.0015 wire
  - Au wire
    - 3.75μm Ni
    - 0.6μm Au
    - Thinner Au results in bonding problems
  - Al wire
    - 3.75μm Ni
    - 0.1-0.2μm Au
    - Au passivates the Ni (prevents oxidation) but bond is to Ni
- Heavy wire- no Au required
Palladium, ENIG, ENIPIG Plating for Wire Bond

- Both solder and wire bond
- Less expensive than Ni/Au (thinner plating)
- Pure Pd plating softer and easier bonding than 4-6% P containing Pd (Atotech)
- For fine wire suggested film stack
  - 3.75μm Ni
  - 0.1-0.3μm Pd
  - 0.03μm Au
Transducer FEM

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
What is PiQC?

Process Integrated Quality Control

Simply put, PiQC is the truest measure of bond quality available today.
What is PiQC?

The wedge tip oscillation has significant influence on bond quality and is influenced by the conditions of the wire & bond interface (friction feedback).

Monitoring all these signals provides an exhaustive insight into the bond process.

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
PiQC Production Views

- Deformation
- Current
- Radar Chart
- Histogram
- Q-Development (200 values)
- Individual user interface possible

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
PiQC: Optimized Source Bond

<table>
<thead>
<tr>
<th>Wire No.</th>
<th>Frequency [%]</th>
<th>Friction [%]</th>
<th>Ultrasonic [%]</th>
<th>Wedge [%]</th>
<th>Wire [%]</th>
<th>Quality Index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
PiQC: Misplaced Bonds

<table>
<thead>
<tr>
<th>Bond On pad</th>
<th>Frequency [%]</th>
<th>Friction [%]</th>
<th>Ultrasonic [%]</th>
<th>Wedge [%]</th>
<th>Wire [%]</th>
<th>Quality Index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>75%</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99</td>
</tr>
<tr>
<td>50%</td>
<td>58</td>
<td>99</td>
<td>100</td>
<td>51</td>
<td>100</td>
<td>29</td>
</tr>
<tr>
<td>25%</td>
<td>37</td>
<td>23</td>
<td>21</td>
<td>24</td>
<td>49</td>
<td>0</td>
</tr>
</tbody>
</table>

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
## PiQC: Displaced Destination Bonds

<table>
<thead>
<tr>
<th>Bond on Pad</th>
<th>Frequency [%]</th>
<th>Friction [%]</th>
<th>Ultrasonic [%]</th>
<th>Wedge [%]</th>
<th>Wire [%]</th>
<th>Quality Index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>75%</td>
<td>100</td>
<td>89</td>
<td>97</td>
<td>89</td>
<td>99</td>
<td>76</td>
</tr>
<tr>
<td>50%</td>
<td>100</td>
<td>94</td>
<td>99</td>
<td>68</td>
<td>99</td>
<td>63</td>
</tr>
</tbody>
</table>

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
PiQC: Particle on Bond Pad

<table>
<thead>
<tr>
<th>Wire No.</th>
<th>Frequency [%]</th>
<th>Friction [%]</th>
<th>Ultrasonic [%]</th>
<th>Wedge [%]</th>
<th>Wire [%]</th>
<th>Quality Index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>38</td>
<td>14</td>
<td>4</td>
<td>66</td>
<td>0</td>
</tr>
</tbody>
</table>

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
## PiQC: Scratch on Bond Pad

![Image of scratch on bond pad](image)

<table>
<thead>
<tr>
<th>Wire No.</th>
<th>Frequency [%]</th>
<th>Friction [%]</th>
<th>Ultrasonic [%]</th>
<th>Wedge [%]</th>
<th>Wire [%]</th>
<th>Quality Index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>100</td>
<td>59</td>
</tr>
<tr>
<td>2</td>
<td>39</td>
<td>92</td>
<td>72</td>
<td>78</td>
<td>96</td>
<td>19</td>
</tr>
</tbody>
</table>

### Graph: PiQC exclusive Signals

![Graph showing frequency and quality index](graph)

---

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
### PiQC: Short Tail + Big Deformation

<table>
<thead>
<tr>
<th>Wire No.</th>
<th>Frequency [%]</th>
<th>Friction [%]</th>
<th>Ultrasonic [%]</th>
<th>Wedge [%]</th>
<th>Wire [%]</th>
<th>Quality Index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>96</td>
<td>81</td>
<td>76</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>100</td>
<td>91</td>
<td>89</td>
<td>88</td>
<td>67</td>
</tr>
</tbody>
</table>

Why Wedge Bond? © 2011 Hesse & Knipps Inc.
Deep Access Capability to 18 mm
AUTHORS

For additional information please contact:

Lee Levine
Distinguished Member of the Technical Staff
Wedge Bonding Expert
(610) 248-2002
levine@hesse-knipps.us

Joseph S. Bubel
President
Hesse & Knipps, Inc.
(484) 665-0219
bubel@hesse-knipps.us
www.hesse-knipps.com

Register at WireBondDemo.com for wire bonding demonstration videos and updates.