Design Considerations In Transitioning To Aluminum Ribbon

Tom Bobal
Senior Metallurgist
Coining, Inc

IMAPS 2016
Pasadena, CA
October 10 – 13, 2016
Topics for Discussion

• Overview
• Physical & Mechanical Properties
• Burnout Current
• Sizes & Tolerances
• Equivalences
• Spooling
• Advantages Of 41 R Spool
• Bonding Tools
• Hardware
• Advantages Of Ribbon In Power Devices
• Cautions
• Conclusions
Why Ribbon?

- Better Electrical Characteristics
- Improved Heat Dissipation
- Fewer Bonds
- Improved Reliability
- Potentially Improved Throughput
Ribbon Defined

- Essentially Flat Wire
- Rectangular Cross Section
- Material is 99.99% Al doped for Corrosion Resistance
- Multiple Manufacturing Methods Available
Physical Properties vs. Annealing

Corrosion Resistant Al Ribbon 40x4 mil Annealed at 530 F

The decrease in break load slows showing that recrystallization occurred with increased annealing time.
Physical Properties vs. Annealing

Corrosion Resistant Al Ribbon 40x4 mil Annnealed at 530 F

Elongation (%) vs. Annealing Time

© 2015 by AMETEK, Inc. All rights reserved.
## Burnout Current

<table>
<thead>
<tr>
<th>Size (mils)</th>
<th>Amps</th>
<th>Size (mils)</th>
<th>Amps</th>
<th>Size (mils)</th>
<th>Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 X 10</td>
<td>76</td>
<td>60 X 8</td>
<td>55</td>
<td>40 X 4</td>
<td>24</td>
</tr>
<tr>
<td>80 X 9</td>
<td>68</td>
<td>60 X 7</td>
<td>46</td>
<td>40 X 3</td>
<td>18</td>
</tr>
<tr>
<td>80 X 8</td>
<td>60</td>
<td>60 X 6</td>
<td>40</td>
<td>40 X 2</td>
<td>11</td>
</tr>
<tr>
<td>80 X 7</td>
<td>50</td>
<td>60 X 5</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 X 6</td>
<td>45</td>
<td>60 X 4</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 X 5</td>
<td>42</td>
<td>60 X 3</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 X 4</td>
<td>35</td>
<td>60 X 2</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 X 3</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Burnout Current Vs Length Of Ribbon

Burnout Current increases dramatically as the length decreases!
# Typical Sizes

<table>
<thead>
<tr>
<th>SIZE (MILS)</th>
<th>TENSILE (GMS)</th>
<th>ELONG. %</th>
<th>QTY/41R</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 X 3</td>
<td>250-350</td>
<td>15-25</td>
<td>125 MTRS</td>
</tr>
<tr>
<td>40 X 4</td>
<td>500-750</td>
<td>20-30</td>
<td>90 MTRS</td>
</tr>
<tr>
<td>50 X 5</td>
<td>1000-1500</td>
<td>20-35</td>
<td>80 MTRS</td>
</tr>
<tr>
<td>40 X 6</td>
<td>700-1100</td>
<td>20-35</td>
<td>70 MTRS</td>
</tr>
<tr>
<td>60 X 6</td>
<td>1300-1700</td>
<td>20-35</td>
<td>70 MTRS</td>
</tr>
<tr>
<td>80 X 6</td>
<td>1800-2200</td>
<td>20-35</td>
<td>70 MTRS</td>
</tr>
<tr>
<td>50 X 8</td>
<td>1500-2000</td>
<td>20-35</td>
<td>55 MTRS</td>
</tr>
<tr>
<td>60 X 8</td>
<td>2000-2500</td>
<td>20-35</td>
<td>55 MTRS</td>
</tr>
<tr>
<td>80 X 8</td>
<td>2300-2800</td>
<td>20-35</td>
<td>55 MTRS</td>
</tr>
<tr>
<td>60 X 10</td>
<td>2200-2600</td>
<td>25-40</td>
<td>38 MTRS</td>
</tr>
<tr>
<td>80 X 10</td>
<td>2700-3400</td>
<td>25-40</td>
<td>38 MTRS</td>
</tr>
</tbody>
</table>

Usual Tolerances: ± 2 mil Width  
± 0.3 mil Thickness
# Ribbon to Wire Conversion

## Equivalent Number of Wires to Ribbon Conversion

<table>
<thead>
<tr>
<th>Ribbon Size (mils)</th>
<th>5</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 x 3</td>
<td>4.58</td>
<td>1.79</td>
<td>1.15</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40 x 4</td>
<td>8.15</td>
<td>3.18</td>
<td>2.04</td>
<td>1.41</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40 x 6</td>
<td>12.22</td>
<td>4.77</td>
<td>3.06</td>
<td>2.12</td>
<td>1.36</td>
<td>-</td>
</tr>
<tr>
<td>60 x 8</td>
<td>24.45</td>
<td>9.55</td>
<td>6.11</td>
<td>4.24</td>
<td>2.72</td>
<td>1.53</td>
</tr>
<tr>
<td>80 x 10</td>
<td>40.74</td>
<td>15.92</td>
<td>10.19</td>
<td>7.07</td>
<td>4.53</td>
<td>2.55</td>
</tr>
</tbody>
</table>
Spooling

Wire Build Up On Spool

Ribbon Build Up On Spool
Potential Issues If Winding Tension Is Not Maintained

- Tangling
- Increased downtime
- Material losses
Benefits Of 41R Spool

- Will Not Underwind Even With Lost Tension
- Compatible With All Heavy Wire Bonders
- Less ft/spool Than Multilayer Spool
Bonding Tool Design

• Cross Hatch Pattern
  – Holds ribbon during feeding & bonding
  – Improves Al diffusion at bond interface

Photos Courtesy of DeWeyl Tool Company
Hardware Considerations For Ribbon Bonding

- Bonding Forces are Higher
- Power Requirements are Higher
- Conversion Kits Available for Existing Equipment
Advantages Of Ribbon Vs Wire For Power Devices

Single Bonds & Low Loop Heights

Photos courtesy of F&K Delvotec
Comparison Of Wire & Ribbon Bonds

HEAVY WIRE BONDS

RIBBON BONDS

Photos courtesy of F&K Delvotec
Leadframe Applications

Note: Single Bond And Change In Elevation With Low Loop Characteristics
Cautions

• Mid-bond Direction Changes Are More Challenging

• Cost Per Unit Length Of Al Ribbon Is Higher Than Wire

• Costs For Equipment Conversion
Conclusions

• **Ribbon Is Viable Alternative To Multiple Heavy Wire Bonds**
  – High Reliability
  – Better Throughput
  – Low Profiles
Thank You

For More Information Contact:
Coining Inc.
15 Mercedes Drive
Montvale, NJ 07645
P: +1-201-791-4020

http://www.ametek-ecp.com/coining