Conductive Inks for RFID Antenna
The low cost high speed route to RFID labels

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• Conductive Ink Alternatives
• Printing Processes
• Commercial Users of Parmod® Inks
• Performance Criteria
• Environmental Considerations
• Summary
Company Overview

- Developer and marketer of Parmod® conductive inks used to print circuits for all kinds of electronics
- Ideally suited for RFID
- Technology protected by eight US patents and international counterparts
- Six years in business; seasoned management team; Headquarters near Princeton, NJ
- ISO 9001:2000 Certified
All conductive inks are *not* created equal. Two types applicable to RFID labels:

**Conventional (PTF) conductive inks**
- Metal particles in (insulating) resin carrier
- Solvent system requires drying
- Residual, non-conductive resin limits achievable conductivity

**Parmod® VLT conductive inks**
- Metal particles in reactive organic carrier
- Thermal cure
- Yields 3-10x higher conductivity than PTF
- Parmod® inks use silver more efficiently – lowers cost!
Conventional Conductive Inks – How They Work

AS PRINTED

Polymer binder

Silver flake

AS CURE

Polymer shrinks – Adventitious contact but non-conductive resin around particles inhibits conductivity
**PARMOD® Inks - How They Work**

**AS PRINTED**
- Reactive Metal Organic
- Silver flake

**AS CURED**
- Metallo-organic welds metal particles together; gets 3x conductivity
## Property Comparison

<table>
<thead>
<tr>
<th>Company</th>
<th>Ink</th>
<th>Print Method</th>
<th>Resistivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>µΩcm</td>
</tr>
<tr>
<td>Parelec</td>
<td>Parmod® Screen Ink</td>
<td>Flat or rotary screen</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Parmod® Gravure Ink</td>
<td>Gravure</td>
<td>9.5</td>
</tr>
<tr>
<td>Dow Corning</td>
<td>Thermoset #1</td>
<td>Screen</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Thermoplastic #1</td>
<td>Screen</td>
<td>56</td>
</tr>
<tr>
<td>DuPont</td>
<td>5028</td>
<td>Screen</td>
<td>17.8 - 30.5</td>
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<tr>
<td>Acheson</td>
<td>Electrodag PF-046</td>
<td>Screen</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Electrodag 725A</td>
<td>Screen</td>
<td>38</td>
</tr>
</tbody>
</table>

Based upon Manufacturer’s Published Data
Parmod® inks suitable for:

- Flat-bed Screen
- Cylindrical Screen
- Roll-to-roll Flatbed
- Rotary Screen
- Flexography
- Gravure

*(All need thermal cure; no other special accommodations)*
Impact of Print Process

- Flat-bed screen
- Rotary screen
- Flexography
- Gravure

RFID cost per tag

- Higher speed printing = lower cost per tag

Print Speed

- 100’s million
- Tens of billions
**Hypothesis:** 2009 Demand = 30 Bil. UHF Tags

<table>
<thead>
<tr>
<th>Image size:</th>
<th>1 x 3 in.</th>
<th>4 x 4 in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna size</td>
<td>8 sq. in.</td>
<td>25 sq. in.</td>
</tr>
<tr>
<td>Sq. in. of web</td>
<td></td>
<td></td>
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</tbody>
</table>

If screen printed:

@ 30 FPM / 20” web

<table>
<thead>
<tr>
<th># of hours of printing</th>
<th>460,000</th>
<th>925,900</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>screen print lines req’d</th>
<th>230</th>
<th>463</th>
</tr>
</thead>
</table>

If gravure printed:

@ 200 FPM / 72” web

<table>
<thead>
<tr>
<th># of hours of printing</th>
<th>19,000</th>
<th>38,600</th>
</tr>
</thead>
</table>

| gravure print presses req’d | 10 | 19 + |
**Commercial Producers**

**Screen**
- Techprint (MA)
- White Electronic Designs (AZ/OH)
- KeytronicEMS (NM)
- RH Technical Industries (UK)
- Shenzhen Hyan Microelectronics (China)
- CCTM/Excel Precision (NY – large format)
- Others

**Rotary Screen**
- One commercial producer

**Gravure**
- Two commercial producers
Commercial RFID Production

Photo courtesy and

Techprint Incorporated and RSI ID Technologies™
Performance Criteria

- Read Distance
- Electrical Conductivity / Resistivity
- Print Quality
  - Edge definition, surface, registration, etc.
- Adhesion
- Environmental Performance
  - Temperature, Humidity, Thermal Shock
Performance of Printed Parmod versus Etched Alien I2-tags

- **Etched I2-Tag reference**
- **Printed Parmod® I2-Tag**
Environmental Considerations

- Fully additive process; no etching wastes
- Parmod® applied thinner than other inks
- Inherent structure improves recyclability
- Fiber Box Association Study due 3Q-2005
Parmod® Inks: The Path to Lower Cost RFID

- High conductivity enables lower cost tags
- Longer Read Distance
- High speed, simplified production
- Parmod® inks <5 microns cured
- Fully compatible with conductive adhesives for high temp / high pressure flip chip attachment or straps
- Additive process; environmentally friendly