Carbon Black Selection for Successful Through Transmission Laser Welding

All Carbon Black is Not Created Equal!
Advantages of TTLW

- Non Contact
- No Adhesives
- No Liquid Absorber
- Hermetic Seal
- Sub Surface
- Instant Cure
- Dissimilar Materials
- Precise
- Minimal Heat Affected Area
- No Flash
Welding Concepts

DIODE Laser

PTFE / PET

ABS

Optical Rail

Weld

Laser Beam

Transparent Material

Absorbing Material

Image courtesy LEISTER
Discoveries

Carbon Black

Surface Texture

Push-Pull Direction
**Carbon Black -- Absorbent or Transmissive**

- Defined by the Compounding Process
- Particle -- Size, Aggregation & Distribution
- Weight Percent Affects Weld Quality & Speed
- **0.15%** and lower (literature states 1-2%)
## Fundamental Carbon Black Properties

<table>
<thead>
<tr>
<th>Process</th>
<th>Particle size (nm)</th>
<th>Particle aggre.</th>
<th>Particle distrib.</th>
<th>Specific surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace black</td>
<td>10-80</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td>Gas black</td>
<td>10-30</td>
<td>Low</td>
<td>Narrow</td>
<td>High</td>
</tr>
<tr>
<td>Lamp black</td>
<td>60-200</td>
<td>Substantial</td>
<td>Broad</td>
<td>Low</td>
</tr>
<tr>
<td>Thermal black</td>
<td>100-500</td>
<td>Very low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

## Influence of Carbon Properties on Applications Performance

- **Smaller Particle Size (Higher Surface Area)**
  - Increases Blackness
  - Increases Tint
  - Increases UV Protection
  - Increases Electrical Conductivity
  - Increases Vehicle Demand and Viscosity
  - Reduces Dispersibility

- **Higher Structure (Increasing Oil Absorption)**
  - Reduces Blackness and Tint
  - Improves Dispersibility
  - Increases Vehicle Demand and Viscosity
  - Increases Electrical Conductivity
Thermomechanical Mismatch
Laser Bonding ABS – PTFE/PET

| PET Backing | PTFE Membrane | WELD | ABS | Rigid Structure |

Varying degrees of PTFE On Membrane Backing after Welding

Varying degrees of adhesion After welding

PTFE Cohesive Failure

PET Adhesion Failure (IDEAL)

ABS Adhesion Failure
### Stress Relaxation - Tg

- **PET Non-Woven Backing**
- **PTFE Porous Membrane**
- **ABS Rigid Structure**

<table>
<thead>
<tr>
<th></th>
<th>ABS</th>
<th>PET</th>
<th>PTFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_g$ - Glass Transition Temperature</td>
<td>80-125°C</td>
<td>65-82°C</td>
<td>N/A</td>
</tr>
<tr>
<td>$T_m$ - Melting Temperature</td>
<td>N/A Amorphous</td>
<td>200-260°C</td>
<td>320-340°C</td>
</tr>
<tr>
<td>Processing Temperature</td>
<td>235-265°C</td>
<td>250-290°C</td>
<td></td>
</tr>
<tr>
<td>$a$ - Coef. of Thermal Expansion</td>
<td>74-100x10^{-6} m/(m°C)</td>
<td>60-90x10^{-6} m/(m°C)</td>
<td>86-135x10^{-6} m/(m°C)</td>
</tr>
</tbody>
</table>
Texture – Staking & Surface Finish

<table>
<thead>
<tr>
<th>SPI FINISH</th>
<th>GUIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - 1</td>
<td>GRADE #3 DIAMOND BUFF</td>
</tr>
<tr>
<td>A - 2</td>
<td>GRADE #6 DIAMOND BUFF</td>
</tr>
<tr>
<td>A - 3</td>
<td>GRADE #15 DIAMOND BUFF</td>
</tr>
<tr>
<td>B - 1</td>
<td>600 GRIT PAPER</td>
</tr>
<tr>
<td>B - 2</td>
<td>400 GRIP PAPER</td>
</tr>
<tr>
<td>B - 3</td>
<td>320 GRIP PAPER</td>
</tr>
<tr>
<td>C - 1</td>
<td>600 STONE</td>
</tr>
<tr>
<td>C - 2</td>
<td>400 STONE</td>
</tr>
<tr>
<td>C - 3</td>
<td>320 STONE</td>
</tr>
<tr>
<td>D - 1</td>
<td>DRY BLAST GLASS BEAD #11</td>
</tr>
<tr>
<td>D - 2</td>
<td>DRY BLAST #240 OXIDE</td>
</tr>
<tr>
<td>D - 3</td>
<td>DRY BLAST #24 OXIDE</td>
</tr>
</tbody>
</table>
TILT “Pull versus “Push”

Pull  Push

substrate
Carbon Black

Surface Texture

Push-Pull Direction
End of Presentation

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Question & Answer

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