Application Note #07
Laser Marking and Welding of Polycarbonate with Short Pulse, Low Nanosecond Fiber Lasers

Introduction

Laser marking of polycarbonate has been widespread for a number of years; many parts from varied industries are marked with nanosecond fiber lasers. The mechanism that produces a laser mark in polycarbonate is quite different from that produced by lasers in most other material types. Under certain conditions, infrared laser beams are not immediately absorbed at the surface of clear or lightly colored polycarbonate and polycarbonate type materials but are absorbed in the upper layers of the material. This controlled absorption produces small nodules or bubbles within the material, sometimes to a depth of as much as 0.2-0.3 mm. Close examination of these densely packed bubbles shows them to be sub-micron. As heat input from the laser is increased by decreasing mark speed or increasing laser power these particles agglomerate and typically form on the surface of the part. A good visible laser mark on polycarbonate is usually composed of a combination of surface and sub-surface marks.

Laser Welding of Polymers

Laser welding of polymers also has many applications in industry. The usual overlap joint configuration relies on an infra-red laser beam being transmitted through the upper part of the joint which is then absorbed by the lower component. This lower component is often black or dark colored, containing a broad band absorber, usually carbon. More recently dyes such as Lumogen™ products may be incorporated into the absorbing component. For welding clear to clear polymers the Clearweld™ technique is sometimes used although this requires either incorporation of the dye into the polymer or the addition of an absorbing layer of the dye into the area to be joined.

Advantages of Laser Marking

- The chemistry of both components is not altered, nothing is introduced.
- A visible check on joint quality can be performed with the unaided eye, a good well-wetted weld appears black.
- Any shape of joint can be produced and incorporated into the design of a component in novel ways (Figure 1, Above).
- The area of the joint can be changed immediately in the same way that a laser mark is made, through advanced software.
- The same fiber laser, incorporated into a desktop laser marking system is used for delineating the joint area and subsequently performing the welding process, all that is required is a virtually instantaneous change of laser and process parameters.
- The laser bonding process melts an exceedingly small volume of material producing a small bond line thickness. The result is minimal contraction on solidification, minimal heat input into the components and minimal distortion.

Table 1: Lap Shear Strength Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>YLR-150/1500-QCW-AC</th>
<th>YLR-150/750-QCW-AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Peak Power</td>
<td>1500 W</td>
<td>750 W</td>
</tr>
<tr>
<td>Max. Pulse Duration</td>
<td>10 ms</td>
<td>20 ms</td>
</tr>
<tr>
<td>Max. Duty Cycle</td>
<td>10 %</td>
<td>20 %</td>
</tr>
</tbody>
</table>

Figure 1: WeldMark Sample
Figure 2: Lap Shear Test Sample
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Laser WeldMarking

Both techniques add a significant cost to either the components to be bonded or joining process cost. IPG’s innovation uses a laser marking technique to darken an area on or near the polymer surface which then acts as an absorber for laser energy and permits bonding of another transmissive polycarbonate component to the surface of the laser marked component.

Similar to other laser techniques, certain precautions must be taken to ensure good wetting and bonding. First and foremost, part fit-up and clamping must be excellent; due to the thin bond line, gap tolerance is limited. Although we see benefits from the creation of a darkened bond area (Figure 1, Opposite) this may be perceived as a cosmetic disadvantage for certain applications.

Certain colored polycarbonate materials can also be bonded using this technique depending on the dye and fillers that are used in the material. The laser bonded area may also appear darker than the non-bonded area and may or may not be a disadvantage.

Experimental Results

To evaluate the joint strength, lap shear samples were prepared equivalent to ASTM D3163 (Figure 2, Right). It was found that a bonded area 25 mm x 20 mm (500 mm²) produced failure in the parent material (Table 1, Right).

Contact any of IPG’s application facilities to arrange free sample evaluation & process development.

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