PHOTONICS®

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.

WELDING APPLICATION

Figure 1: WeldMark Sample

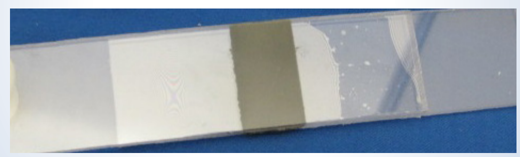

Figure 2: Lap Shear Test Sample

Parameter	YLR-150/1500-QCW-AC	YLR-150/750-QCW-AC
Max. Peak Power	1500 W	750 W
Max. Pulse Duration	10 ms	20 ms
Max. Duty Cycle	10 %	20 %

Table 1: Lap Shear Strength Results

Advantages of Laser Marking

- The chemistry of both components is notaltered, nothing is introduced.
- A visible check on joint quality can beperformed with the unaided eye, a goodwell-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 changedimmediately 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.

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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 mm^2) produced failure in the parent material (Table 1, Right).

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To date, most laser welding of plastics has been performed using direct diode lasers, usually as a continuous beam. It was widely thought that the low power density capability of the direct diode laser was best suited for this process. One of the most remarkable technical aspects of this process is that is clearly possible to produce a very controlled laser weld in polymers using a nanosecond marking laser. In this case we are using a short laser pulse length in the low nanosecond regime and using a very low on-off ratio or duty cycle of only 2.5%. There are a number of polycarbonate and polycarbonate type materials that are suited to this bonding process including Axxis®, Durolon®, Lexan®, Makrofol®, Makrolon® and Xantar®.

BPA free polycarbonate substitutes such as Tritan® copolyesters, widely employed for clear containers and micro-fluidic devices, can also be WeldMarked.

Summary

IPG Photonics has developed a new process combining laser marking and laser bonding of polymers with a single high speed process. This process is best suited to joining clear polycarbonate type materials to themselves without the use of any additive material to either component. The feature size, accuracy, flexibility and controllability of the joining process is unmatched by conventional bonding processes.

Contact any of IPG's application facilities to arrange free sample evaluation & process development. Go to www.ipgphotonics.com for more information on all of IPG's products.