Application Note #14

Welding Clear-to-clear Polymers with Thulium Fiber Lasers

Introduction

Erbium and Thulium fiber lasers emitting in the spectral range of 1.4 - 2 µm have been used in a variety of medical and airborne applications for many years. It has been known for some time that many polymers have increased absorption at these wavelengths but only recently established that this level of absorption is suitable for welding a range of translucent and transparent polymers as well as creating welds that are optically clear to the naked eye.

Experimental Work

Initial ranging trials were performed to identify the power, spot size and exposure time at which controlled melting occurs in various thicknesses of commonly used polymer resins. A spot size and an average power were chosen such that no melting occurred during the time needed to measure the absorption of each type and each thickness of clear polymer. These static exposure trials at wavelengths of 1540 & 1940 nm allowed the percentage absorption to be calculated (Table 1, Right).

When exposure time was increased with the Thulium laser it was clear that melting occurred to a depth in the bulk of the material. With relative motion between the laser beam and the part, controlled melting occurred to a depth in the material that depended on beam power and speed. This basic relationship is symptomatic of almost any welding process. When two layers of clear polymer were lightly held together, it was possible by adjusting the speed to produce a lap weld between these two layers. Figure 1 (Right) shows an optically clear weld through multiple layers of polypropylene.

WELDING APPLICATION

Polymer	Thickness (mm)	Wavelength (nm)	Absorption at Rt (%)
PMMA (acrylic) Transcolors	3.2	1540	10-13
PMMA (acrylic) Transcolors	3.2	1940	50-55
Polycarbonate Makrolon®	3	1540	10-12
Polycarbonate Makrolon®	3	1940	44-50
Polypropylene	1.2	1540	10
Polypropylene	1.2	1940	31

Table 1: Absorption of Clear Polymers at 1540 & 1940 nm

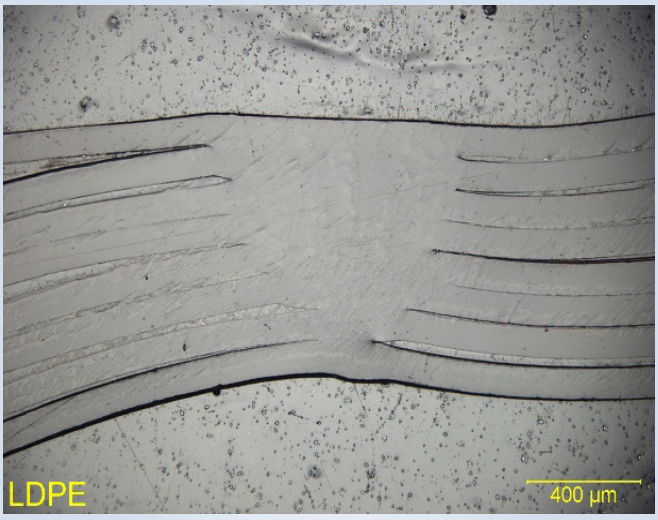

Figure 1: Weld Through Multiple Layers of Polypropylene

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The tightly controlled rate of heat input from the thulium fiber laser beam allows the heat input to the joint to also be tightly controlled. Further trials have produced optically clear joints in both the butt and lap weld configuration and the technique is applicable for many other joint configurations such as fillet, spike and spot welds and also flange, edge, flair, corner and T joints. Trials have also shown that multiple weld passes may be used to improve weld depth or quality and multiple layers of thin polymer films can also be joined in single or multiple pass techniques. Although there are many benefits to this welding technique the most important may be that no material modifications or additional infrared absorbing layers are necessary to improve the absorption of the laser beam in the polymer.

Summary

These results demonstrate a new welding technique for welding clear polymers and confirm the rapid progress that is being made in fiber laser technology.

IPG looks forward to helping our customers with their laser applications and future plans. A laser solution should evaluate all aspects of the project including feasibility, productivity, polymer characteristics and part fixturing before a laser type and optical configuration is selected. IPG supports well equipped and professionally staffed applications laboratories to fully explore and develop fiber laser solutions. Contact IPG's applications facilities to arrange free sample evaluation or process development. Go to www.ipgphotonics.com for more information on all of IPG's products.

Polymer	Lap Weld Depth (mm)	Weld Speed (mm/min)	Power (W)
Polypropylene	>3.6	300	25
Co-polyester	>2	420	25
Polycarbonate	>3.6	600	25
Polycarbonate	>6	300	25

Table 2: Preliminary Weld Speed Data

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