2μm LASER MATERIALS PROCESSING

PRECISE FEATURES, MINIMAL LOCALIZED HEATING

Lasers have become an increasingly crucial part of industrial materials processing applications. They provide a large quantity of highly-controllable optical energy that is ideal for processes including cutting, drilling, engraving, etching, and sintering for a wide range of materials. Laser materials processing plays a constantly expanding role in all aspects of manufacturing, from new product development to high volume production.

Lasers with output wavelengths of 1-1.5μm have been used in materials processing applications for years, but recently there has also been significant development in 2μm lasers. Compared to their 1-1.5μm counterparts, 2μms can be just as efficient, stable, and easy to use, while offering significant advantages for certain materials such as plastics.

Plastic Processing

2μm lasers are ideal for materials processing applications, including the processing of plastics, because of their unique absorption properties. For many plastics, wavelengths from 0.8-1μm have too little absorption, while 10μm have too much. 2μm lasers provide the optimal absorption characteristics for finely-controlled processing.

Specific plastic materials processing applications utilizing 2μm lasers include welding, marking, and cutting for materials for which other lasers are not as effective. Many plastics are transparent and have very high transmission in the visible spectral range. In addition, many plastics also have high transmission and very little absorption around 1μm, which is detrimental for welding, marking, or cutting at 1μm as the radiation would pass through the material instead of being absorbed.

Before the introduction of 2μm lasers, plastic processing with shorter wavelengths was often only possible by introducing additives inside the plastic that increase the absorption of laser light. This complicates the fabrication process and is many times prohibited depending on the final application, such as medical. On the other hand, plastics have strong absorption around 10μm, which leads to effective surface heating but not localized heating required for processing. Fortunately, many of these same materials have more ideal amounts of wavelength absorption around 2μm. This allows 2μm radiation to penetrate through the plastic material at an optimal distance, with the ability to be finely attenuated, resulting in localized heating of the material as demonstrated in ***Figure 1***.

Figure 1

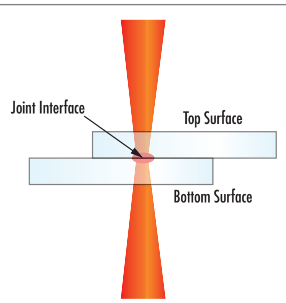

Figure 1: Laser welding of plastics

When lasers pass through a transmitting medium, more energy is absorbed at the material interfaces than inside the volume of the medium. In laser welding, there are four surface interfaces where absorption will increase: the top surface where the laser beam initially enters, the joint interface between the two materials, and the lower bottom surface. The majority of absorption in transparent plastic welding occurs at the joint interface because it is comprised of two separate surfaces (see ***Figure 2*** for joint type examples).

Figure 2

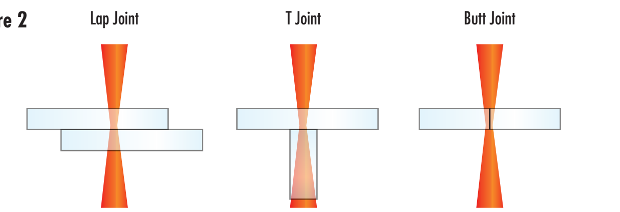

Figure 2: 3 different joint types: lap joint (left), T joint (middle), and butt joint (right)

Laser Design

The first 2μm lasers were very large, expensive, liquid-nitrogen cooled devices. Today, there are 2μm diode lasers 30mm long and fiber lasers that are even smaller. Advances in technology are driving down costs and decreasing the size, while simultaneously improving performance. In some cases, researchers are developing components out of optical fibers, which can dramatically decrease the cost.

2μm lasers are steadily replacing other light sources due to their low cost, ease of use, and range of energy delivery methods such as pulsed and continuous wave beams. Many question whether a pulsed or continuous wave (CW) laser should be used for their materials processing application. ***Figure 3*** shows the differences between using a 2μm CW laser and a 2μm pulsed laser for plastic welding.

Figure 3

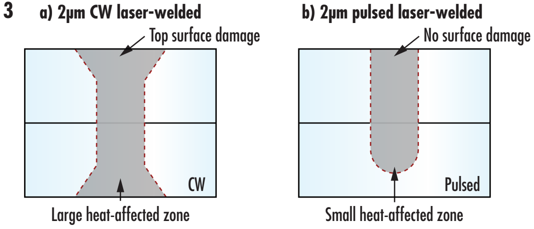

Figure 3: Pulsed lasers should be used for highly precise plastic welding due to the smaller amount of surface damage

Conclusion

In conclusion, laser technology utilizing the 2μm spectral range is useful in materials processing applications due to the moderate and sufficient absorption in plastics, small thermal injury zone, consistency, practical output powers, and readily available optical materials and coatings for transmissive and reflective optics. 2μm lasers will continue to increase in popularity and potentially become the leading technology for the processing of plastics in the years to come.

References

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