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Ultraviolet Lasers Tackle Demanding Marking Tasks

UV lasers excel at marking thin foils and many materials that are not compatible with infrared lasers, producing high-contrast marks with fine detail and limited penetration depth.

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Lasers are a well-established marking tool for converters because they offer unique advantages compared with ink-based methods. These include the elimination of consumables, improved mark durability and permanence, and enhanced process versatility. Plus, laser marking is a non-contact technique that is compatible with delicate products, especially those with non-flat surfaces. However, the traditionally used infrared (IR) laser sources can struggle to mark certain material types and thin substrates, such as foils.

In these cases, ultraviolet lasers (UV) offer an alternative. Here, we will learn why and see some of the results it can produce.

UNDERSTANDING LASER MARKING

Most laser marking for converters use IR sources, such as CO_2, fiber or solid-state lasers. Many packaging materials absorb IR light, so exposure to a concentrated laser beam produces intense localised heating. Depending upon the combination of laser and material, this heating produces a visible mark using mechanisms including ablation (material removal), colour change, foaming and oxidation.

Most packaging materials strongly absorb UV light. Rather than simply heating the material, the much higher energy UV photons often produce photochemical interactions such as photodissociation and photoablation.

Photodissociation means the separation of atoms or smaller molecules from a larger molecule. This can initiate chemical changes resulting in a colour change, but without significant material removal. Photoablation is the direct breaking of atomic or molecular bonds. This vaporises the material and causes it to be ejected from the surface. This yields a mark through engraving.

The key takeaway is that UV marking is largely a non-thermal ("cold") process.

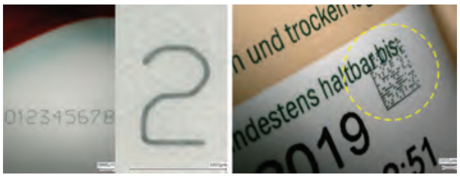

Figure 1: Alphanumeric and barcode marking on different packaging plastics made with the Spectra-Physics Explorer One HP 355-4 (4 W UV laser).

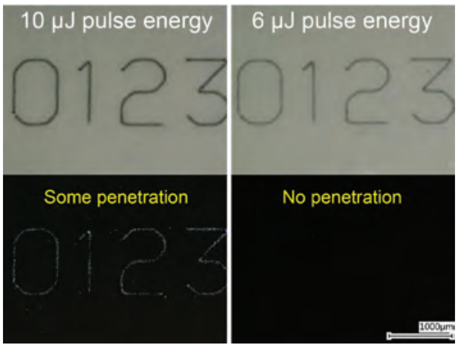

Figure 2: Front and back views of a thin foil marked with the Spectra-Physics Explorer One HP 355-4 UV laser at two different pulse energy settings. Penetration can be precisely controlled by adjusting pulse energy.

Furthermore, the strong UV absorption of most materials means that the laser energy does not penetrate very far into the substrate. Since UV marking has nearly zero effect on surrounding material, it is useful with thin or sensitive materials like films, plastics or coated surfaces.

PRACTICAL CONSIDERATIONS

There are other important practical advantages of UV laser marking. First, UV light can be focused down to a smaller spot size than light having longer wavelengths. This is due to the optical phenomenon of diffraction. So, UV lasers can create finer, more detailed marks. This is especially useful when writing small Data Matrix codes or other complex graphics.

Second, diffraction causes UV laser beams to spread out more gradually than longer wavelength laser beams. This provides a larger depth of focus, allowing the marking system to tolerate greater changes in distance between the focusing optics and the work surface. The result is an improved ability to mark non-flat surfaces.

TYPICAL APPLICATIONS

For the converter, the two most common reasons to use UV marking are to obtain improved mark contrast and legibility on certain materials or to mark thin substrates. Plastics, especially transparent or light-coloured plastics, work well with UV marking because they absorb UV light more strongly than IR light. So, UV lasers can more easily produce a colour change, resulting in a higher contrast mark. Typical compatible materials include PE, PP, PC, PS, PI and PET. UV lasers can also mark glass.

The inherently smaller penetration depth of UV light can be fine-tuned by using a UV laser that offers precise control of output pulse energy. This enables adjustment of mark penetration depth. The images below show marks produced on thin packaging foil with the laser pulse energy set to 10 µJ, and then reduced to 6 µJ. The lower pulse energy avoids perforating the foil while still yielding a legible mark.

CONCLUSION

Laser marking is a highly versatile tool for cost-effective, high throughput marking in many converter applications. UV lasers extend the utility of this process to a broader range of materials, as well as heat-sensitive products.

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