rofin
LASER MARKING

Laser Marking on Plastic Materials

With the advances in plastic formulations yielding higher mark contrasts, the laser is here to stay in this world of just-in-time manufacturing

Laser marked characters and bar codes;an example of engraving with color change

Laser marked characters and bar codes; an example of color change (bleaching)

Recent technological innovations in the laser industry and the formulation of plastic have led to advances that allow a marriage of the two technologies. It is important for plastics formulators and product designers to investigate the benefits that can be gained by this new union.

Applications involving the use of lasers to mark plastics and coated materials have increased significantly in the last several years. This is due in large part to several characteristics of laser marking:

- Permanent, durable, high-resolution marks
- Excellent flexibility for accommodating part and mark changes via software
- Noncontact marking; no tool wear
- Clean, environmentally benign process; requires no paints, inks, acids, solvents, or labels
- High production rates, especially for small lot sizes
- Capability for marking recessed, hard-to-reach areas of parts
- Easy integration into automated production lines
- Simple size reduction of high-quality graphics
- Low operating cost

Plastic material selection

Product designers will often choose a plastic material primarily based on the electrical and mechanical properties required. These properties include absorption, carbonization, molecular weight, thermoplastic additives (blends, impact modifiers), pigments, fillers, reinforcements, flame retardants, mold releasers, and stabilizers. The suitability for laser marking is seldom considered when choosing a plastic resin.

This oversight is not a concern when certain types of plastics in certain colors are used. However, there is no general rule covering which type of plastic is markable vs. nonmarkable. At the request of large-scale resin consumers, plastic resin suppliers, in conjunction with laser-marker manufacturers, have begun to characterize their various plastic types according to color, brightness level

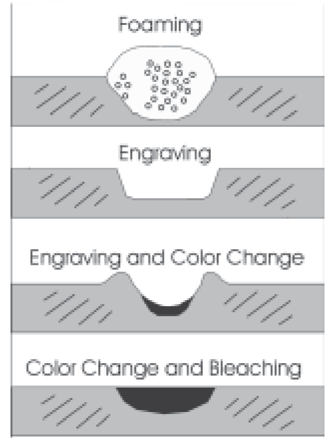

Fig. 1 Example of four types of laser marking on plastics

(marked vs. unmarked), and contrast level. These suppliers have also defined several visual features such as mark consistency and contour sharpness, along with mark color.

This additional information can help the product designer recognize what type of laser mark is possible for a given grade of material.

Effects of laser marking

Laser marking of plastics is accomplished through color changes and/or surface restructuring. We can distinguish between four mark types: foaming, engraving, engraving with color change, and color change only (bleaching). (See Figure 1).

Foaming. At low laser intensities, a destruction of molecular structures causes a color change and surface restructuring. This effect is similar to what can be achieved when bending nylon many times–at the bend you will observe a lighter color.

Engraving. Localized increase in temperatures above the melting point of the material causes melting. Once the material is resolidified, a modified surface structure occurs in the form of an etch. This effect is typically achieved with CO_2 wavelengths in most thermoplastics.

Engraving with color change. At relatively high laser intensities,, a local evaporation of surface material causes a trench with ridges. As a result of carbonization, a color change occurs.

Color change (bleaching with smooth surface): At laser radiations of sufficiently short wavelength, a dissociation of molecules results in a color change. This is the most desired effect. Mark contrast can be enhanced using a limited amount of additives (for example, bone meal added to polyacetal resulting in a light foaming structure).

Another factor affecting mark contrast is the regrind content used in molded plastics. Nominal regrind content may not have any adverse effects on the electrical or mechanical properties, but it could significantly affect the markability. Virgin material is the best if mark aesthetics are vital.

Laser type and laser parameter optimization (pulse rate + spacing + intensity) significantly contribute to level of contrast and/or type of mark that can be achieved.

Laser marking system selection

Of all the laser wavelengths, only six traditional laser types are available for industrial laser marking. Ranging from UV to far-infrared, these include excimer, frequency-doubled Nd:YAG, helium-neon, Nd:YAG, and CO_2 laser systems.

Table 1 charts the material reaction associated with each of these wavelengths. At UV and visible wavelengths, photochemical reactions cause a color change mark or etch. In the infrared region, the dominant mechanism for marking is a thermochemical reaction causing the full spectrum of mark effects. Consideration of what type of laser (UV, visible, or infrared) and method of marking (mask vs. stroke) are to be used is tantamount to successful laser marking of plastics.

An excimer laser marker that utilizes masks is ideal for small mark areas where high throughput yet low variability of mark is required. Typically, one of two effects is achieved: photochemical ablation or photochemical reaction (bleaching).

Table 1. Material reaction vs. laser wavelength

Laser	Wavelength	Type	Mechanisms
Excimer	196 nm	Mask	Photochemical ablation (high-precision)
	248 nm 308 nm 352 nm		Photochemical reaction (bleaching of colors)
Nd:YAG (frequency doubled)	532 nm	Stroke	Photochemical reaction (bleaching of colors)
Nd:YAG	1064 nm	Stroke	Thermochemical reaction (color change, foaming, engraving, sublimation)
CO_2	10600 nm	Mask Stroke	Thermochemical reaction (melting, vaporizing, engraving)

The far-infrared CO_2 TEA mask marker is ideal when high throughput and moderate variability in text are required, such as marking phenolic circuit-breaker housings (glass content aids in the mark). The TEA laser also works well with plastics utilizing mica-based additives, such as AFFLAIR Lustre Pigments, to yield higher contrast.

The near-infrared Nd: YAG stroke marker addresses the widest variety of plastics. This system offers rapid text change and freely programmable graphics, along with a large mark zone (10 in. diameter) for the most demanding applications. Most recent advancements in beam delivery result in laser-marking systems that use multiple deflection heads to double mark throughput. This advancement also allows for multiple side marking while the part is stationary.

Regardless of the laser system chosen, the incorporation of an exhaust system with an active charcoal filter to minimize fumes and particulate generation during marking is highly recommended.

Summary

Laser marking plastics is gaining wide-spread acceptance as the alternative to existing printing and stamping technologies. With the advances in plastic formulations yielding higher mark contrasts, the laser is here to stay in this world of just-in-time manufacturing.

Although there is no set rule covering which type of plastic is markable, resin suppliers are beginning to characterize and tabulate the markability of their most popular grades. To achieve optimum aesthetic marks, it is still necessary to work closely with your plastic formulator to produce the desired grade that meets all your material requirements.

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