Marking of Food and Beverage Products in High Throughput Production Lines

The food and beverage industry traditionally uses conventional ink printing to label products with expiration dates and origin information. However, ink cartridges require frequent and costly replacement, and ink can even be harmful to health. Laser marking of packaging materials is becoming increasingly widespread thanks to its lower operating costs and high flexibility. Due to their relatively low acquisition costs, infrared (IR) lasers (including carbon dioxide lasers) have been used to mark packaging.

In many cases, however, these IR lasers cannot achieve the desired marking quality, and ultraviolet (UV) pulsed lasers produce superior results and therefore are the better choice. For instance, some plastic materials exhibit photochemical color change only for UV wavelengths, while with IR lasers marking contrast is poor (Figure 1a). Furthermore, the shallow penetration depth of UV laser light enables marking of thin foils without perforation (Figure 1b). Finally, UV beams are less divergent than IR beams, resulting in a longer Rayleigh range, much larger tolerance to variations in surface topography, and higher process yields (Figures 1c and 1d).

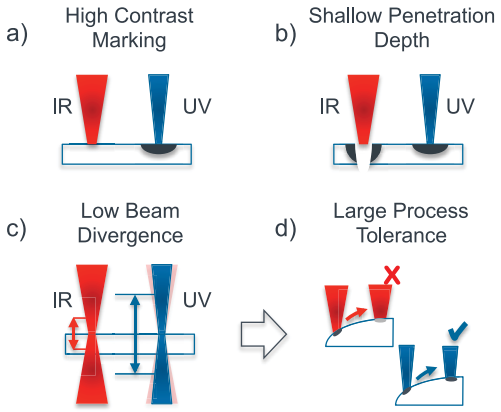

Figure 1
Advantages of UV laser marking compared to IR laser marking.

Besides these quality criteria, high process speed is still essential, especially when it comes to marking of packaging material in mass production. High throughput requires not only beam deflection systems with high dynamics, but also lasers which can take advantage of this dynamics by providing sufficiently high pulse energies even at pulse repetition rates of several hundred kHz.

The Spectra-Physics Explorer® One™ HP 355-4 laser combines high precision with high process speed and is therefore ideally suited for many marking tasks for the food and beverage industry.

Figure 2
Photo of an industrial beverage processing facility.

The Explorer One HP laser's excellent beam quality, suppression of giant first-pulses and active pulse energy control ensure highest process accuracy. This laser is the world's smallest in its UV power class and is air-cooled. The laser provides up to 4 W UV power and pulse energies >1 µJ up to 500 kHz which enables marking speeds around 5–10 m/s for most packaging materials. Therefore, on-the-fly marking applications with e.g. 20 characters in <80 ms are easily realizable with the Explorer One HP 355.

Figure 3 illustrates the high marking quality of the Explorer One HP 355-4 on two different types of packaging material. The marked letters (Figure 3a) show no burn-in effects, and the actual marking speed of 2 m/s was only limited by the scanner dynamics. The laser-marked 2D-barcode (Figure 3b) features excellent contrast and readability.

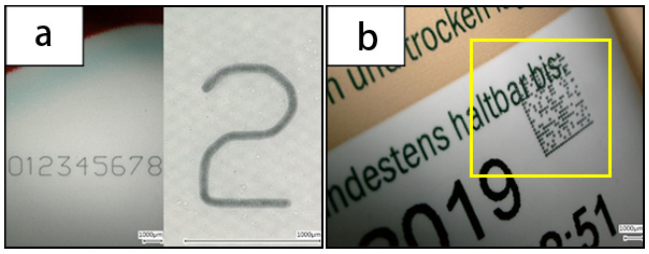

Figure 3
Font and barcode marking on two different packaging plastics using the Explorer One HP 355-4.

A further critical aspect in the marking of packaging is to avoid punching through the packaging to prevent exposure of the contained product to light or ambient atmosphere. In particular for thin packaging, this undesired perforation can only be prevented by using a suitable wavelength with careful adjustment of the pulse energy.

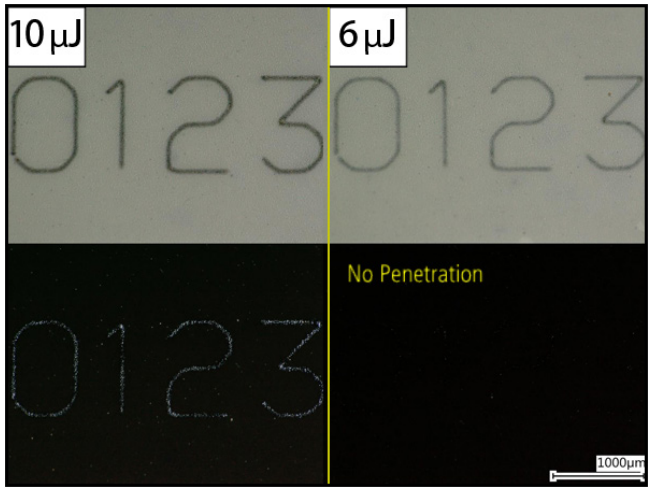

Figure 4
Perforation through the packaging foil (10 µJ) can be avoided by adjusting and controlling the pulse energy to 6 µJ.

In the example shown in Figure 4, the packaging foil is perforated at pulse energies of 10 µJ, as can be seen with transmitted-light illumination (bottom). This perforation can be completely avoided by adjusting the pulse energy to 6 µJ, which still generates a clearly visible mark. The Explorer laser's unique E-Track™ feature can be extremely valuable in such situations, as it enables precise control and active stabilization of the pulse energy (see Application Focus #32 for more details on E-Track).

Marking on uneven surfaces is a requirement for many types of packaging. Focusing the collimated Explorer One 355-4 beam with a f=250 mm objective results in a Rayleigh length of ~7 mm, which is more than sufficient for marking curved surfaces (Figure 5a) or e.g. across the transition of two overlapping foils (Figure 5b) without the need of costly adjustable focusing optics.

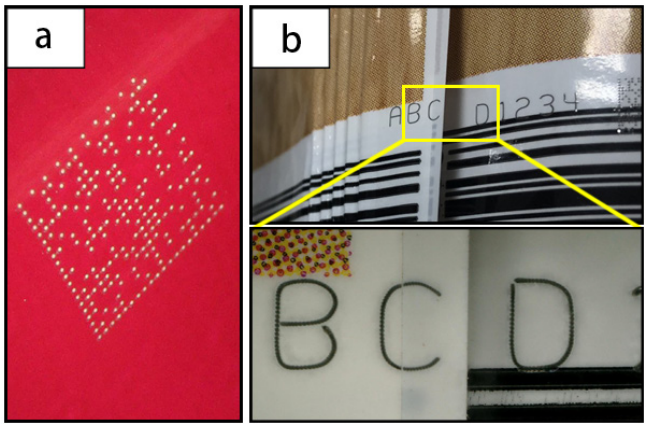

Figure 5
Constant marking contrast for a barcode marked on a curved surface (a) and letters marked across the overlap of two packaging foils (b).

Finally, we can think of direct food marking as an upcoming market, e.g. to avoid packaging costs or to minimize environmental impact. The industry has already started to offer directly laser marked vegetables and fruits. Figure 6 shows the direct marking of an even smaller object such as an almond.

Figure 6
Direct food marking using the Explorer One HP 355-4. The Spectra-Physics logo was marked by ablating the almond shell.

PRODUCT: *EXPLORER ONE UV LASERS*

The Explorer One laser series are the world's most compact active q-switched lasers in the power range up to 4 W UV. High performance standards such as the extra ordinary mode quality with a M_2 of typical 1.1, the short pulses, and high peak power, as well as capability for fast power modulation and rise times ensures optimal process quality in customer applications. High quality standards including tight system-to-system specifications, longevity, and the rugged and durable design yields lowest cost of ownership. Advance software features and the compact size result in fast and cost efficient integration and enable our customers to realize fast time-to-market with their own products.

	Explorer One 349	Explorer One 355	Explorer One HE 355	Explorer One XP 355-2	Explorer One HP 355-4
Wavelength	349 nm	355n m	355 nm	355 nm	355 nm
Power	120 µJ/60 µJ @ 1 kHz	800 mW/300 mW @ 50 kHz	80 µJ @ 10 kHz	2 W @ 80 kHz	4 W @ 80 kHz
Repetition Rate	Single shot to 5 kHz	Single shot to 200 kHz	Single shot to 50 kHz	Single shot to 300 kHz	Single shot to 500 kHz
Pulse Width	<5 ns	<10 ns	<15 ns	<10 ns	<15 ns

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