Laser Marking Solutions for Paper and Packaging

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Abstract

While industrial inkjet and thermal transfer printing have been the primary means of marking and coding packaging, laser marking is emerging as a complementary and even competitive technology that can provide both performance and cost benefits to the end user. Conventional laser marking typically relies on high energy processes such as ablation or engraving to permanently mark various materials. The method is limited to those specific substrates that can absorb the laser energy, and many materials cannot be marked unless specialty additives are included during manufacture. Furthermore, the high energies required to generate readable marks can damage thin substrates.

A laser responsive surface layer enables on-demand marking of variable data on materials that would otherwise be difficult to mark. Laser responsive inks and coatings are demonstrated which enable high density, stable images to be coded using a low energy IR laser, onto substrates printed or coated by standard methods during the substrate manufacture, printing or converting stage. Transparent or virtual labels that mimic conventional self-adhesive labels can be produced and marked on-demand. The laser responsive inks and coatings are ideally suited for use on food, beverage and pharmaceutical packaging to be marked with variable messages, security identifiers, or tracking codes.

Introduction

The advent of marks and codes like those found on nearly every retail package we buy today, began in the 1960's and 1970's when expiration dates were first marked on food products and a universal barcode system was established to speed the checkout process.[1] Since then, marking and coding has evolved into a multibillion dollar industry with human or machine readable codes being widely and routinely variably printed onto all kinds of packaging using automated equipment.[2] Food, beverage, pharmaceutical and cosmetic containers, boxes, and cases commonly are digitally marked with barcodes, dates, batch and serial numbers that provide the seller or consumer with product identification and other information.

The volume of items marked or coded will rise as track and trace, branding, and security become increasingly necessary to meet regulations and prevent counterfeit or unsafe products from reaching consumers. With more goods being shipped around the world and directly to consumers, the demand for efficient marking and coding of packaging is expected to grow.

As the need for better identification, authentication and traceability of packaged goods rises, the industrial coding market is looking toward new technologies that can advance the productivity and quality of their coding operations. The best method for a particular job depends on the code complexity, substrate, line requirements, equipment investment and running costs. While continuous inkjet is the most widely placed digital printing method for coding packages, infrared lasers are being increasingly adopted [3] as reliability, quality, environmental, and efficiency gains are realized upon implementing today's laser systems. High quality, consistent and durable marks are produced without the use of labels or inks that are not as permanent. The risk of contaminating food, tobacco or pharmaceutical products with ink is minimized. Very small codes can be generated which cannot be delivered by competing coding technologies.

Broad utilization of infrared lasers for coding packages is restricted by their inability to effectively mark several relevant materials. White and corrugated papers and many plastics cannot be readily laser marked. Laser ablation of ink produces only a negative image. Processing an entire package with laser sensitive additives is not always cost-effective when just a small area will be imaged. High energies are often needed to create a readable mark, and thin substrates are easily damaged by the laser.

Many such limitations can be overcome by treating the surface of the packaging material with a laser responsive layer. Results and opportunities for laser responsive inks and coatings in package marking and coding will be described.

Experimental

Inks and coatings were formulated based on laser active chemistries recently developed at Ciba and found to be responsive to low powered infrared lasers. The laser active chemistries were adapted into aqueous acrylic compositions that can be coated or printed in the same manner as typical paper coatings or liquid packaging inks. Compositions include clear coatings and inks that form a transparent layer, and white inks that can be used to create the look of a label without using one. Compositions were also developed to comply with regulations for sensitive applications in the food or tobacco industries.

Inks and coatings were applied to various papers, boards and plastic sheets or films at dried coat weights ranging from 2-15 g/m^2 with coating rods, by spraying, and by gravure and flexographic printing. A typical coating composition is 45% solids, pH 8 and 100 cps. Substrates tested include bleached board, corrugate, linerboard, Kraft, bond and other plain and coated papers, foil backed paper, clear and opaque BOPP, PVC, and PETG. Inks were printed at 22 seconds Ford cup #4 with a Moser rotogravure press at 40 to 80 m/min using different cylinders and were dried at 100 °C. Inks were similarly printed on rotary and sheet fed presses from a flexographic station using various cylinder arrangements, and with or without an overprint varnish. Samples were also laminated, for instance with a polyethylene extrusion coat at 325°C, at no detriment to the laser active layer.

Coated substrates were imaged with 10W and 30W CO_2 lasers emitting at 10,600 nm.[4] Imaging was performed using vector scribing and dot matrix lasers, among them a Videojet 3320, Smartlase 110i, and Alltec CS10. Laser power and dwell time were manipulated to mark readable text strings, linear barcodes, and matrix codes at various line speeds. Text readability was checked at arm's length and barcodes read with a scanner. Dense print patterns were generated and assessed for contrast by optical density measurements.

Samples were tested for resistance to solvents, aqueous solutions, heat and light exposure.[5] Liquids were dropped onto dried coatings to check coating appearance and image permanence. Coated and marked substrates were dipped and soaked in water to check for fastness. Imaged samples were tested for heat resistance at 80°C for up to 18 hours, and accelerated light testing was carried out with a QUV to simulate up to one year of indoor light exposure.

Results and Discussion

The process of using aqueous laser responsive compositions with packaging materials is illustrated in Figure 1. The active inks and coatings can be applied to packaging by conventional printing and coating methods, and can be done inline with routine printing and converting operations.

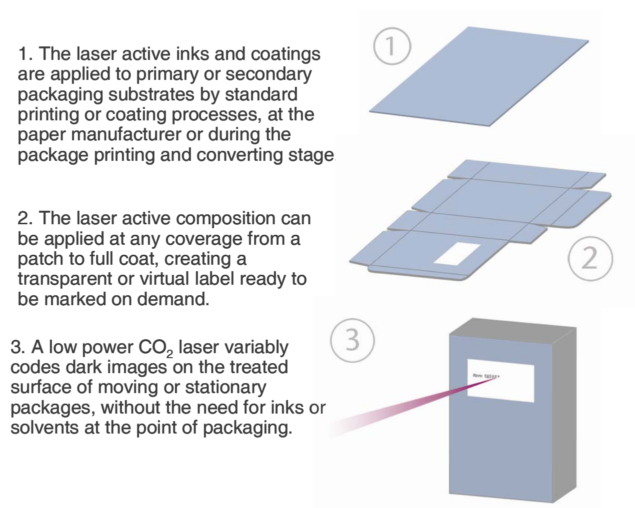

Figure 1. *Laser responsive inks and coatings applied to packaging enable low power laser marking of packages on demand.*

The active inks are normally printed on the package substrate from a flexographic or gravure station, over any area from a small patch to full coverage, during the same run as conventional inks. No extra processing steps are needed, only an additional aqueous station on the press. High volume print cylinders are recommended to maximize the amount of active material deposited and enhance marking capabilities. The printed substrate can be converted and stored until ready for use. The package is then imaged at the production line with a low power CO_2 laser, to produce text, logos, or barcodes on demand. The prints are stable and irreversible.

In a similar fashion, the active coatings are applied with a coater when the paper or board is manufactured or converted, and marked during the packaging operation without using inks, solvents or consumables. The compositions can also be applied to packaging using spray equipment.

This approach gives the end user capabilities not routinely available with other marking technologies. The ability to mark at low laser power provides safety and cost benefits over more conventional laser marking methods requiring high power sources. Inks, solvents, thermal print ribbons, labels and label applicators do not need to be stocked or handled. Removing inks and solvents can be particularly important in packaging operations concerned with environmental and product safety factors. Regulations for sensitive applications like food and tobacco packaging can be met.

The aqueous inks and coatings are best suited for use on primary and secondary paperboard packaging. Paperboard is the largest segment of the packaging market with paper based materials comprising more than one-third of all packaging globally. Nearly half of all food and beverage packaging is made from paper and board, and about ¼ of pharmaceutical packaging.[6] Paperboard containers and boxes make up the largest portion of paperboard packaging, followed by corrugate, typically printed by aqueous flexography.[7] Applications for the laser sensitive inks and coatings include cartons and cases for food and beverages, cigarette packs, corrugated boxes, tickets, and containers for medicines, fragrances or cosmetics. The laser responsive compositions can also facilitate marking on plastic substrates which can be used for tags, cards, labels, bags and other containers.

Applying the laser active composition to the packaging substrate enhances laser marking of the material, and allows materials not usually suited for laser imaging to be marked with high contrast images. At low laser energies, high resolution brown to black codes, Figure 2, were produced from transparent inks and coatings on white cartons and papers, brown corrugate or pigmented substrates. Text is clearly readable at arm's length and barcodes read successfully with a scanner. Readable images were also produced on treated plastic sheets and films imaged with a low power CO_2 laser. Thin substrates treated with the laser active compositions could be marked without damage. Laminated structures were easily marked through the top film.

Figure 2. *Images produced at low laser power on paperboard substrates demonstrate high resolution, high contrast codes which can be achieved on packaging treated with laser active inks or coatings.*

The images on substrates treated with the laser responsive compositions are distinct from those that can be produced by laser ablation of inks, better resolved than high speed continuous inkjet codes, and do not require labels which cover part of the substrate and can come off the package. The transparent layer does not distract from the package appearance and leaves more space for other messages or logos on small packages. A virtual label that can be marked on demand is produced by printing linerboard or other materials with laser active white ink. The white patch replaces conventional self adhesive labels with a print that has a similar look yet becomes part of the package. Substrates treated with the active inks or coatings can also be imaged through laminates and overprints transparent to the laser energy.

Substrates prepared with laser responsive inks and coatings were marked with well resolved codes rapidly enough for food, beverage and pharmaceutical carton and corrugated packaging lines.[8] As a representative example, simple text messages were crisply marked on coated bleached board using only 2W in 125 ms, or at 480 codes per minute. The codes were brown and readable on the bleached board, a common packaging material for food, tobacco, and pharmaceutical packaging. Marks were produced at stronger contrast or more quickly on some other samples. Several parameters factor into the mark quality and the practical rate of code generation. Factors range from laser conditions and code complexity, to the substrate type, ink chemistry, and amount of ink or coating applied. For most of the samples, coat weights of 5-10 g/m^2 had good marking performance using only a few watts of laser power. Inks and coatings based on even more sensitive chemistries are being developed and have shown excellent marking results at very fast rates. As an example, coated paper imaged well with text at about 2500 codes per minute for the given design. This is faster marking than required on many production lines.

The coated and printed substrates had good heat, light, and general solvent and water resistance; marks had good stability. The inks and coatings did not discolour or lose activity when dried at 100°C on press, and showed little colour change during heat resistance tests at 80°C. Coated samples did not discolour or lose activity when laminated with an extruded film at 325°C. Coatings and marks stayed intact when dipped and soaked in water. Exposure to liquids did not activate the coated substrates or remove the marks. Under accelerated light exposure tests, images lost up to 25-30% density but remained clear and readable. The background coating did not yellow or discolour during extended light fastness testing. A laminate or topcoat can be used over the laser responsive layer for even better fastness.

Conclusion

Laser responsive inks and coatings were developed and demonstrated to enable low power infrared laser marking of packaging materials. Human and machine readable, dark text and barcodes were produced at practical line speeds on primary and secondary packaging materials commonly used in the food, tobacco, and pharmaceutical industries. These codes cannot be laser marked on these substrates without using the laser responsive ink or coating. The laser active inks and coatings are pre-printed or coated during paper manufacture or standard package printing and converting operations. This process offers the end user the capability to mark packages on demand simply by installing a low power infrared laser in the production line to image the pre-treated packaging materials. The technology is environmentally friendly and suitable for sensitive applications including food packaging. The laser responsive inks and coatings can find applications in marking packages which may be exposed to solvents, moisture, pasteurization or cooking processes, other sources of heat or light in their environment. The inks and coatings can also be laminated and marked through the topcoat to embed marks. Very small features can be imaged with the laser and used as security markers. With this new technology, packaging materials can be more effectively coded to meet the growing demand for better identification, traceability and authentication of goods.

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Kathie is a lead scientist in the Inks and Printing Technical Center of Coating Effects at Ciba. She supports new business development and customer applications of ink products and print solutions in UV curing, digital printing, and diagnostic packaging.