Use of Clear Toner in Electrophotography for Security Applications

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Abstract

Most electrophotographic printers consist of four development modules to generate images based on CYMK process colors. Often a printer hardware design can accommodate more than the standard four development modules. In such cases, extra modules can be used to provide additional features to the resulting image. When colors other than CYMK are used in such fifth or higher electrophotographic modules of a color printer, various enhanced improvements that are possible in the printed image include: spot or corporate colors, extended color gamut colors, and pentachrome or even hexachrome color processes.

If a clear toner is used in one of these additional modules, a wide variety of image enrichments can be integrated into the final image. The most common application for the clear toners is to provide a protective barrier to physical abrasion to the image as well as to impart uniform image gloss.

Because of increased emphasis on incorporating security features in a color print, clear toner can also be utilized to provide both overt and covert security features within the image. There are several types of security features that can be enabled with the use of these special clear toners. Clear toner can be judiciously placed in or around the image to provide either a positive or a negative watermark to the image. Another security feature that can be enabled with clear toner is raised letter printing to provide a tactile appearance similar to thermography. Not only are these features difficult to copy, but they also provide an easy detection capability. By proper selection of suitable toner additives, clear toner can also be used for alternate features such as traceless security printing and UV fluorescent detection. This work will summarize the novel image features that can be implemented in an electrophotographic system by using a special clear toner in addition to the four process colors.

Introduction

With continuing growth in digital printing, there are increasingly different types of documents and images that are printed with electrophotography. Many of these documents require that some type of security feature be included in the print. Security features are necessary against counterfeits and forgery of printed materials such as documents, photos, packaging materials, checks, financial documents, ID cards, bank notes, travel documents, tickets, etc. In addition to brand protection, security features are usually incorporated to guard against counterfeit and forgery in order to reduce revenue loss and to maintain corporation profits. Further, safety issues caused by counterfeit products carries a higher risk to the consumer as well. Owing to the exceptional image quality that can be achieved today with electrophotography, it is becoming increasingly simpler for counterfeiters to make a high-quality forged document using a toner-based printer. It is now possible to incorporate a security feature within such a document, which not only provides various levels of security but also does so without compromising the image quality. All this can be achieved by using clear toner in addition to the standard CYMK toners by using a printer that has the capability of using more than four toners.

Security features that are typically applied to a document can be both overt and covert. Various levels of security features that can be implemented in a document along with their authentication technique are as follows [1]:

- **First Level**

- allows inspection of document with human senses alone

- **Second level**

- authenticates hidden security features using simple devices such as UV, IR, magnetic readers, etc.

- **Third Level**

- requires special equipment in a forensic laboratory to authenticate the document

When security features are added to a document, the goal is to make forgery as difficult a possible. At the same time, the authentication process needs to be simple to use and easy to access. Because these authentication requirements are normally at odds with each other, it is a common practice to incorporate more than one type of overt and covert security feature into a document.

Most electrophotographic printers are only capable of printing with four colors that include the standard CYMK colors. When printing documents with such equipment, it is very difficult to incorporate any security features into the documents. If some security features are added to any of the four process colors, then the image quality is often compromised. Further, the dusting inside the machine as well as image background also interferes with the authentication process if security features are incorporated into one or more of the standard process colors.

With the availability of high-speed digital printing presses, such limitations can be easily removed. By using special toners in the extra EP modules, it is possible to incorporate security features without compromising the image quality. When one of the special toners is clear, many different types of overt and covert security features can be incorporated into the document. Some of the security features that can be implemented with the use of clear toners are:

- Digital Watermarking
- Raised Letter Printing
- Traceless Printing
- UV Fluorescent Printing

KODAK NEXPRESS 2100 Digital Production Color Press

The Kodak NexPress 2100 digital production color press was first shown at DRUPA 2000 and introduced into the market the following year. The 2100 digital production color press with Kodak NexPress fifth imaging unit solutions was introduced at DRUPA 2004. Many new applications and solutions were now possible. With a changeable fifth color station and Kodak NexPress red, green, and blue dry ink to choose from, using a pentachrome five-color multilevel halftone mixing process, the 2100 press expanded the available color gamut.

If a Kodak NexPress clear dry ink is used in the fifth station, along with the standard CYMK dry inks in a Kodak NexPress intelligent coating solution that applies a clear dry ink (CDI) in selective areas of the image, significant improvement on image abrasion resistance and further reduction of color granularity have been demonstrated. The end result exceeds the capability of offset printing with aqueous coating for image protection. Other applications for CDI in the fifth station of the 2100 press are, e.g., spot coating or clear watermarking for design or security purposes.

With the introduction of a near-line NexGlosser glossing unit, the CDI image with clear overcoat can be further glossed up to a very high and uniform gloss (G20 = ~90 can be achieved) in the glossing process for photo rich applications. In addition, it has been shown that the optimized process can increase the color gamut of the entire printing system for many substrates (typically in a range of 10% increase in gamut volume).

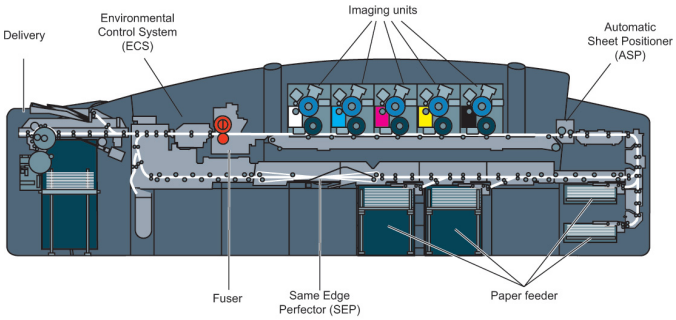

Figure 1. *Kodak NexPress 2100 plus, Kodak NexPress 2500, and Kodak NexPress S3000 digital production color presses equipped with four paper deliveries and high-capacity delivery.*

At Print 05 in Chicago, Kodak announced two new color offerings: the Kodak NexPress 2100 plus and the Kodak NexPress 2500 presses, followed by the Kodak NexPress S3000 digital production color press, announced at the On Demand Show in April 2007 [2] (Figure 1). All are differentiated from the Kodak NexPress 2100 press by a number of factors [3], including larger print format size, broader substrate capability, expanded feeding and finishing capabilities and options, new standard delivery or new single (or dual) high-capacity delivery, inline finishing architecture, an expanded number of operator-replaceable components (ORCs), and an improved throughput feature called "productivity optimizer."

The 2500 and S3000 presses offer a faster speed (2,500 and 3,000 4/0 and 5/0 A3 sheets per hour) as well in relation to the 2100 and 2100 plus presses (2,100 4/0 and 5/0 A3 sheets per hour).

At DRUPA 2008, Kodak unveiled the Kodak NexPress S3600 digital production color press, with dramatically increased productivity, which makes it the fastest digital press in the S series [4]. It is capable of printing 7200 impressions per hour.

One aspect still common to all of these presses is the capability of using one additional toner other than the standard CYMK for printing documents with enhanced features without sacrificing productivity.

Digital Watermarking

It is often desirable to prevent the copying of a document by a copy machine. This could be accomplished by having part of the content readily observable by a human reader but not by a copier or scanner. An image printed using clear toner or ink that creates a difference between reflected light and diffused light can be distinguished by a human reader who views the paper at an angle other than 90° but cannot be detected by a copier or scanner that is restricted to reading the image at right angles to the page [5].

To accomplish this task, sometimes a clear or white toner is used to produce digital watermarks that cannot be copied or scanned but can be observed by a human reader.

Such clear or white toners can be used for producing clear watermarks, low-density watermarks, and high-density watermarks using clear toner or ink [6]. This digital watermark technology controls the differential gloss of an image using the steps of: (1) selecting a first halftone image having a first anisotropic structure, (2) selecting a second halftone image having a second structure different from that of the first halftone, (3) applying the first halftone to at least some portion of the halftone image, and (4) applying the second halftone to another portion of the halftone image. The second structure may be anisotropic as well.

In a specific embodiment, two halftone structures are used. The second halftone may be applied to the remaining part of the halftone image or to only a part of it. It may cover part of the print or the remaining part of the print area not covered by the first anisotropic structure. The first anisotropic structure and the second anisotropic structure orientation may be 90° apart.

The method described also relates to a process whereby the gloss of the paper and the gloss of the toner measured separately on 100% of the covered areas are about the same. In this case the existing methods achieve differential gloss using clear toners without using anisotropic structures, as in this case no differential gloss exists [7].

The substantially clear toners used are of essentially the same composition as color toners used in the art, except for the dyes and pigments. The clear toners are substantially transparent, such that the inherent colors of the applied color toners are not materially masked and the relative amount of reflected light from the image is essentially maintained and not materially diminished by the clear toner. The clear toner may be slightly tinted, pigmented, or dyed up to a degree where it is substantially transparent uniformly over the visible spectrum (400–700 nm).

The method is particularly suitable for electrophotographic printers using dry toners as these toners have a median particle size in the range 5–10 μm, which when fused may show a significant digital watermarking behavior.

Raised Letter Printing

In the earlier days of electrographic printing, the marking particles were relatively large (e.g., on the order of 10–15 µm). As a result the print image had a tendency to exhibit a relief appearance (variably raised surface). Under most circumstances, this relief appearance was considered to be an objectionable artifact in the print image. In order to improve image quality and reduce relief appearance, over the years, smaller marking particles (e.g., on the order of less than 8 µm) have been formulated and are more commonly used today.

With improved print image quality, print providers and customers alike have sought ways to expand the use of electrographically produced prints. In certain classes of printing, a tactile feel to the print is considered highly desirable. Specifically, ultrahigh-quality printing such as for stationery headers, business cards, or greeting cards and invitations, utilize raised letter printing to give a tactile feel to the resultant print output. This is currently carried out in the offset industry via thermography in an offline process. Some other instances where tactile feel in the print would be desirable are Braille prints or print documents, which have security features provided therein.

Raised letter printing is also well suited for security authentication. As the first level, the tactile feel can be easily detected by sight as well as touch. Further, these features cannot be copied using other equipment. Presently, however, printing documents with raised information to have a tactile feel with electrographic techniques, particularly with commonly used small-size marking particles, has not been practical, and past printing techniques where large particles were used produced low-quality images.

In view of the above, Kodak NexPress printers can utilize a special developer composition useful for such electrographic printing and provide a tactile feel to select areas of the image. Further, it is also possible to apply unique relief patterns to the entire image.

Such electrographic printing comprises the steps of electrographically forming a desired print image on a receiver member utilizing standard size marking particles; and in an area of the formed print image where tactile feel is desired and raised information is to be formed, selectively forming such tactile feel, raised information utilizing marking particles of a substantially larger size than the standard size marking particles of the desired print image [8]. It was found that desired optimum performance was achieved when:

i. toner particle size is larger than 18 µm volume average diameter and preferably between 20 and 50 µm and more preferably between 20 and 30 µm volume average diameter;
ii. carrier particle size is larger than toner particle size employed and ranges between 25 and 60 µm;
iii. the difference between the volume average diameter for carrier and toner particles used is equal to or greater than 5 µm or the ratio of carrier-to-toner volume average diameter exceeds 1.25;
iv. the overlap in the volume average distribution of toner and carrier particle size is less than 35%.

When the above-stated toner and carrier constraints are not met, either there is not sufficient raised height to provide tactile feel, or one of many image artifacts is generated. One such example of loss of image quality is shown in Figure 2, where large quantities of carrier particles have also been developed along with the text characters.

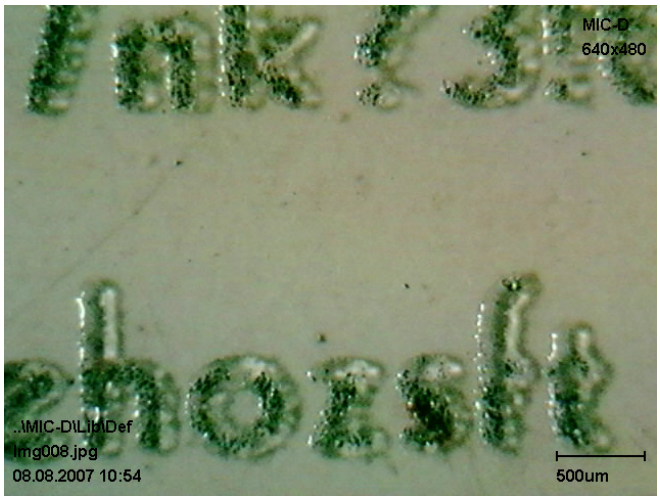

***Figure 2**. Optical micrograph of a raised letter print image showing the carrier being developed along with toner in the text area of the image. A 22 µm carrier was used in this example along with a 21 µm toner.*

Image artifacts such as those depicted above can be avoided when certain size specifications for both the toner and the carriers are satisfied. One of these specifications requires the percent overlap for the toner and carrier to be less than 35%. Figure 3 shows this constraint adequately. When the carrier size is sufficiently separated from the toner, development of carrier in the image area can be avoided.

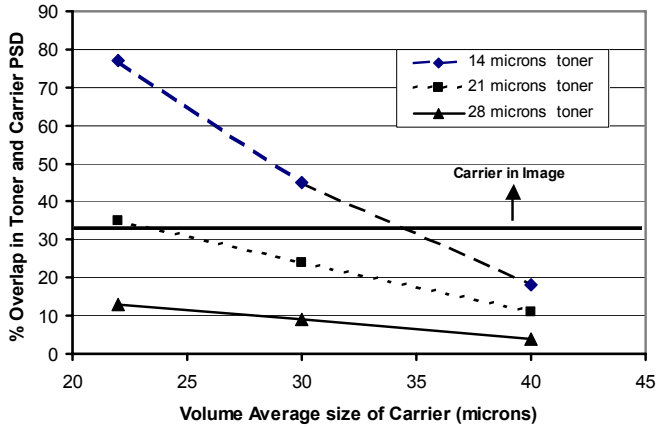

***Figure 3**. Plot showing the relationship between percent overlap in PSD for various sizes of toner and carrier particles useful for raised letter printing applications.*

Traceless Printing

The Kodak Traceless system for anticounterfeiting is a forensically invisible authentication technology that protects against fraud and counterfeiting [9]. It is easy to implement and integrates into a wide range of materials with no disruption to product design or production processes. This technology is based on proprietary Kodak Traceless markers that can be integrated into a wide range of host materials with no impact on material characteristics. These markers are only detectable with Kodak Traceless imaging readers and are invisible to standard optical, forensic, or chemical analysis. These uniquely developed Traceless readers are precision-built for reliability, durability, and accuracy under extreme conditions. The combined Traceless markers and reader system has built-in safeguards to make reverse engineering virtually impossible. Various levels of security features are possible with the same marker and reader—from basic pass/fail to additional levels of security as required. The system can be custom tailored to individual needs.

The Traceless system is already providing anticounterfeiting protection for customers in a wide variety of applications, including:

- Pharmaceuticals
- Cosmetics
- Premium wines and spirits
- Fashion apparel and accessories
- Documents and identification

At DRUPA 2008, Kodak demonstrated the ability to deliver the Traceless system on Kodak NexPress digital production color presses. The Traceless system can be easily integrated into existing production processes, allowing virtually any industry to use this sophisticated solution to protect its products. Kodak has already implemented its solutions in many segments of the markets. New applications demonstrated at DRUPA will make it even easier for print service providers to offer Traceless system protection.

The Kodak NexPress digital production color presses will be able to apply anticounterfeiting measures using the Kodak NexPress fifth imaging unit solution. This easy-to-implement method has no effect on the characteristics of the end product, providing printers with maximum flexibility for delivering an effective anticounterfeiting measure for their customers.

In 2007, the Traceless system received the GATF InterTech™ Technology Award for its highly effective capabilities and easy implementation for commercial printers.

UV Fluorescent Printing

It is also possible to incorporate certain UV fluorescing dyes and/or pigments in clear toners for security applications. A number of UV fluorescing materials can be added to the toner formulation such that when exposed to UV-A or UV-B light, these materials transmit the absorbed excitation into the visible portion of the spectrum. The visible light could range from violet, blue, green, yellow, red, and even white. A suitable excitation wavelength can be selected depending on the desired final application. This second level security authentication only requires a (typically portable) UV black light. Various applications of this technology are already used in credit cards, driver licenses, currency, and mailing barcodes.

The choice of the UV fluorescent dye or pigment is dictated by the light stability of these dyes, triboelectric charging behavior, and the cost of the material itself.

Summary

Clear toner can be used to provide various overt and covert security features to safeguard against counterfeiting and forgery. Many of these features can be simultaneously incorporated into clear toners to provide various levels of protection in the same document. Digital presses, such as Kodak NexPress S3000 press, which can print with more than four toners, can easily utilize these toners without compromising image quality.

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Author Biography

Dinesh Tyagi received his Ph.D. degree from Virginia Tech in 1985 from the Department of Chemical Engineering with a thesis entitled "Structure-Property Relationships in Segmented Polymers." After one year of post-doctoral position there, he joined Eastman Kodak Company as a Research Scientist where he started work in the toner development area. He was promoted to Senior Research Scientist in 1989 and in 1993 he was appointed Research Associate. The following year he was inducted into Kodak's Distinguished Inventors Gallery. In 1999 he joined NexPress Solutions, which later became part of Kodak. He has continued to work in the area of toners and electrophotography through most his professional career. Dr. Tyagi has over 90 patents worldwide.