A Comparison of Reverse Image Dye-Sublimation Printing and Resin Printing Technologies

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Executive Summary

There are many printing technologies that can be used to produce identification cards. Over the past ten years there has been a sweeping change from photographic, film-based analog printing to digital printing using dye-sublimation inks. The vast majority of identification cards produced today are personalized using direct-to-card dye-sublimation printing technology. Recently, reverse image printing technology, with the capability of applying dye-sublimation inks onto a special transfer film, has become the technology of choice for cards using embedded electronics.

This paper explains the many advantages of the industry-standard, dye-sublimation technology as it relates to reverse image printing on technology-rich identification cards. It also illustrates the superiority of dye-sublimation technology for identification card production as opposed to printing with resin "dot" technology.

Dye-sublimation technology is the superior technology for the personalization of identification cards in three critical areas:

- Print Quality
- Card Security
- Card Durability

In the fourth critical area, bar code printing, both of the evaluated technologies are equal since both use resin "dot" technology for the printing of machine-readable bar codes.

Reverse image dye-sublimation printing technology continues to be the optimum choice for the personalization of high quality, durable identification cards containing proximity circuits, contact chips or contactless integrated circuit chips.

Introduction

There are many printing technologies that can be used to produce identification cards. This paper will illustrate the strengths of reverse image dye-sublimation technology and why use of this technology leads to highly secure and durable identification cards.

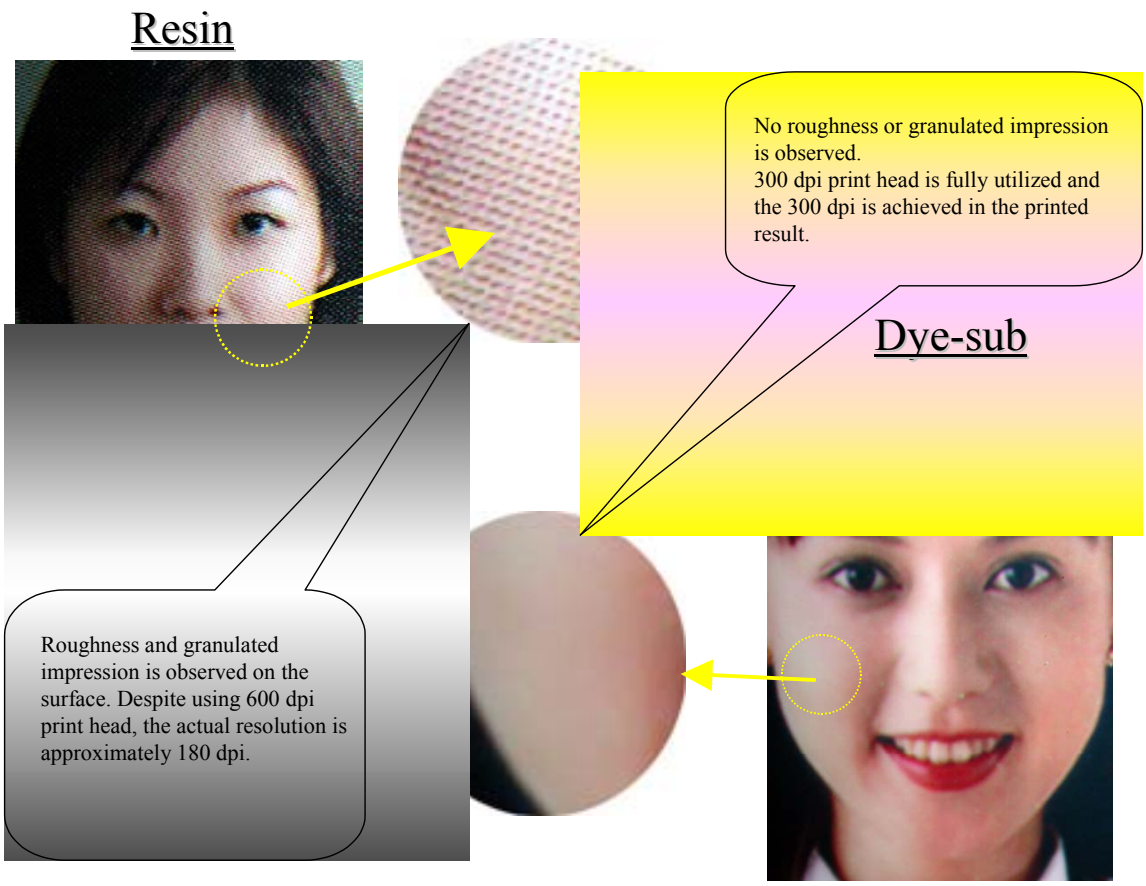
There are two methods to print identification cards using dye-sublimation technology -- direct-to-card (DTC) and reverse image. In direct-to-card printing, the printhead comes in contact with the card. With the reverse image process, the printhead prints dye-sublimation images onto a clear film called Intermediate Transfer Media (InTM). This image is then fused to the surface of a card with heat and pressure. When combined with advanced encoding and lamination technology, the reverse image printing process offers the best solution for critical card security applications utilizing technology cards. (Technology cards are those cards with embedded electronics such as proximity circuits, contact chips or contactless integrated circuit chips.)

To ensure the highest quality print images and bar codes on technology cards, reverse image technology is also recommended over traditional direct-to-card dye-sublimation printing technology. Since reverse image printing transfers dyes and resins directly onto smooth, flexible InTM Film, the printhead never comes in contact with the card surface itself. As such, technology card surface imperfections such as smart chips that are not even with the card surface, ridges caused by internal RFID antennae and debris do not affect print quality.

1. Image Quality

The reverse image dye-sublimation printing process does not use individual “dots” of ink or resin. Ink dots are common in inkjet, laser and resin printing as the ink (or resin) is transferred to a paper page, card or other substrate in the form of a “dot” of ink. Dye-sublimation printing technology is a diffusion process that melds colors together into a smooth, continuous tone, producing over 16.7 million colors. In Illustration 1 (below), a comparison is made between the resolution of dye-sublimation printing and resin “dot” printing. Dye-sublimation produces continuous tones that achieve extremely high resolution.

Illustration 1.



Color resin printing uses yellow, magenta and cyan to create a limited range of colors. To create this limited color range, each individual colored dot is place on top of another color in order to create color combinations. Even though resin printing may use a higher dots-per-inch (dpi) printhead, the colors produced by the dye-sublimation technology are crisper, provide more realistic photographic quality, and fully use the capability of the printhead. Using a 600 dpi printhead, the actual quality of a resin printer is approximately 180 dpi because the spacing and granulation of the resin dots prevents image clarity. (See Illustration 1, above).

In contrast, the sublimation process diffuses the dye, eliminating granulation and achieving much greater image clarity. Dye-sublimation printing technology actually equals or exceeds 2400 dots per inch (dpi) resolution using a 300 dpi printhead. Dye-sublimation printing does not require denser pixel printheads such as 600 dpi or higher because the dye is diffused producing higher levels of resolution than is possible with "dot" resin printers. It is misleading to simply compare the numerical value of the printhead dpi in dye-sublimation printing technology to the dpi measurement of an inkjet or resin printer.

Resin printing uses pigment-based colors while dye-sublimation uses dye-based colors. Pigmented colors are made from a group of molecules while dye colors are a single molecule. The pigmented color is not soluble and is encapsulated in a dot of the resin so that it can be transferred to create multiple colors and an image.

As the chart below shows, pigment inks do not accept light in the same way as dye inks. Dye inks *focus* light while pigment inks *reflect* light. It is well known in the photographic market that dye-based inks provide superior image color resulting in better images.

Illustration 2.

In one study, the author states, "Pigments and dyes differ in size, resistance to external conditions, and light-reflecting abilities. Small dye particles reflect light evenly for more vibrant color. The larger size of pigment particles means . . . they tend to scatter the light they reflect, which leads to less vibrant color."[1]

In a second study contrasting color performance of dye-based ink versus pigment-based ink, the authors say, "The criteria for evaluating color performance . . . are color gamut, optical or image density [and] light-fastness. The color gamut is defined as the limits of the array of colors that can be captured by an image-capturing device, represented by a color-encoding data medium or physically realized by an output device or medium. Therefore, a large color gamut . . . means the capacity to produce a wide window of mixed colors. The gamut number of dye [ink] was 1.5 times larger than that of the pigment [ink] and 2.4 times [larger] than inkjet ink".[2]

Some colors are not reproducible by inkjet or resin dot technology. Certain graphics, logos and specifically reproducible Pantone©[3] colors are not available using inkjet or resin printing technologies. Specifically, no less an authority on imaging than Kodak Corporation states that "Pigmented ink[s] are also less suitable for the simulation of

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[1] Source for illustration 2 and quote is O'Leary, Sean, Formulating a Sourcing Strategy for Inkjet Inks, www.screenweb.com/inks/cont/inkstrategyb/htm.

[2] Jongkwan Kim, Chul-Hwan Kim, Eui-Jun Choi, Hyun-Nam Hoon, Color Performance of Dye-Based and Pigment-Based Color Toners, Society for Imaging Science and Technology Final Program and Proceedings, International Conference on Digital Printing Technologies, September 19 – October 4, 2002.

[3] Pantone Corporation has created a chart of colors that have specific values so that any color using a Pantone number will always be exactly the same shade. If a specific Pantone color is specified, it must match exactly the color scale created and maintained by Pantone.

Pantone® and specialized spot colors, which are especially popular in today's corporate brand palettes."[4]

Better colors plus the full gamut of actual colors result in the highest quality print images. Since dye-sublimation printing technology utilizes color gradation more accurately, the images are clearer and better defined, allowing images with less contrast to be produced more accurately. This becomes important when creating small photographic images such as those typically printed onto identification cards.

Recognition of a person's eyes is a crucial part of photo identification. Fine detail is more accurately reproduced with dye-sublimation printing which gives greater resolution to the eyes (See Illustration 3), making for easier, more accurate identification.

Full color reproduction capability is even more significant when printing a wide range of skin tones. Inkjet and resin printing technologies cannot match the ability of dye-sublimation to accurately reproduce all of the different skin tones of a diverse population. As one of the key reasons for using a facial image on a card is easy recognition of that person, dye-sublimation's high color image quality is a crucial factor in getting the desired results of an identification card.

2. Bar Code Accuracy

In order to produce bar codes that can be read by all bar code readers, dye-sublimation, inkjet and resin printers use pigmented-black ink.

Bar code readers do not distinguish between "good", "fair" and "bad" bar codes in the way that a human would. Simply put, either the bar code is readable or it is not. Almost all companies that produce bar codes use the A through F grading system developed by the American National Standards Institute (ANSI). Testing of bar codes is done by scanning the printed bar code through a Webscan TrueCheck Verifier, which then registers a reading of A through F based on the ANSI standards for each alphabetic level. However, a "D" reading is still readable by a bar code reader. The key is to produce bar codes that can be scanned very reliably by bar code readers. Even though the human eye may see one bar code image as better than another, this is immaterial to a bar code reader.

Two common bar code fonts used in the identification card industry are "Code 3 of 9" and "PDF417". These two fonts are also used in the DOD Common Access Card. Tests were performed on FARGO HDP825-LC printers to determine the quality of bar codes produced by reverse image dye-sublimation printing. To verify compliance, both Code 3 of 9 and PDF417 bar codes were tested with a Webscan TrueCheck Verifier.

- For Code 3 of 9 bar codes, the Webscan verifier consistently assigned a grade of either "A" or "B."
- For PDF417 bar codes, a grade of either "A" or "B" is also consistently achieved.

[4] Kodak Polychrome website at http://www.kpgraphics.com/gen/prod_support/learning_ctr/ink_inkjet.html

This means that reverse-image dye-sublimation printers can consistently produce bar codes generating robust scanning success.

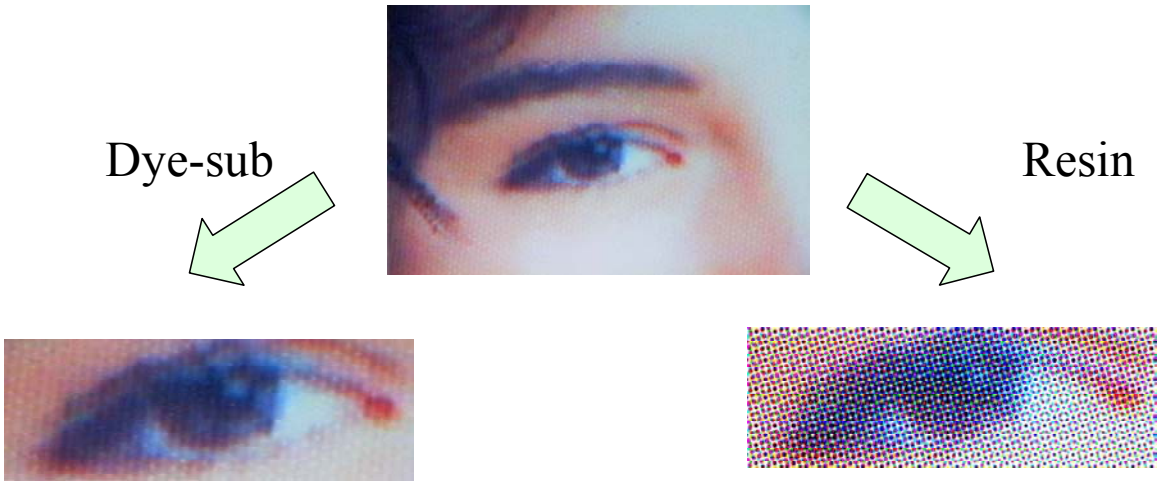
It is possible to use non-ANSI compliant bar codes that scan successfully, however these can present issues. Bar code readers typically require a bar code line that is at least 7.5 mils in width to read successfully. As both 300 dpi and 600 dpi printers can produce these minimums, the fact that one image looks "better" than another is not material.

Printers are normally optimized at the factory for the printing of ANSI standard bar codes, but can be optimized to print accurate, machine readable but non-compliant bar codes. Bar codes that are non-compliant with ANSI standards may fail testing in verification test devices, but may still be successfully read by a bar code reader. As the verification device is set to detect bar codes that comply with the ANSI standards, the ANSI A-F scale may not accurately reflect the readability of the bar code.

3. Card Security

Another advantage of reverse-image dye-sublimation printing technology is that it is harder for counterfeiters to reproduce. In Japan, for example, dye-sublimation has become the printing technology of choice for driver license and passports.[5]

Illustration 3.



Most unsophisticated counterfeiters use any technology that is readily available. Proof of this tendency is shown by the fact that once ink jet printers became readily available, there was a significant increase in the counterfeiting of travelers checks.[6] Since all copiers, laser printers, resin printers and ink jet printers use the dot technology as shown in Illustration 3, the image produced by the counterfeiters will look like the resin print on

[5] Dai Nippon Printing, Unpublished abstract, 2003
[6] Speech by McHugh, John, Vice President of Security, American Express Corporation, Document Security Alliance Meeting, Washington, DC, December 17, 2002.

the right. Looking at the image with a simple magnification device such as a magnifying glass, dye-sublimation provides an easy, visual check to defeat these counterfeiters.

4. Card Durability

The photo below (Illustration 4) shows an overlaminate with holographic images that is laminated to a card using heat and pressure. Overlaminates are used to provide additional durability from abrasion, protect against fading and add additional security features such as holograms to the identification card. This technology has been used in conjunction with dye-sublimation printing for over eight years.

Illustration 4.

One criticism sometimes leveled against reverse image dye-sublimation printing technology is that the dyes used may fade. Overlaminates solve this problem. To test the susceptibility of reverse image dyes to fading after an overlaminate has been applied, the card and overlaminate are exposed to ultraviolet light for a period of ninety-six hours using a standard QUV test apparatus. The cards are then measured to determine how much fading has occurred. The measurement is the difference in color from non-exposed cards and exposed cards expressed by calculating "Delta-E". Delta-E is used to mathematically describe the distance between two colors by the use of a color measurement made by a spectrodensitometer.

To a casual viewer, a difference of less than 5 – 6 Delta-E is imperceptible. A trained eye is capable of differentiating two colors that are closer to 3 – 4 Delta-E apart. Tolerances of less than 2 Delta units are indistinguishable to the eye.[7]

When this standard test was performed on cards laminated with Fargo Electronics' PolyGuard Overlaminate, fading of 12 Delta-E occurred. The same test on cards produced with a newly improved PolyGuard Overlaminate from Fargo exhibited fading of only 2 Delta-E. This fading exhibited with the newly improved PolyGuard Overlaminate is imperceptible to the eye.

Another very important factor to consider when selecting a printing technology is the adhesion of the laminate to the card. Significant effort on the part of overlaminate manufacturers and reverse image dye-sublimation printer manufacturers have been made to ensure that the overlaminates securely fasten to the card.

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[7] This information was taken from http://www.colorspan.com/support/tools/deltae.asp. For a more detailed explanation of the measurement process, please access this site.

Unlike dye-sublimation printing that impregnates the surface of the card (Illustration 5), resin lays on top of the card (Illustration 6). In fact, each resin color layer lies on top of the other causing a build up of up to 4 layers of resin dots. These layers interfere with the ability of the lamination to adhere to the card, making it easier to compromise the integrity of the card. In addition, because resin is thermally designed to move from the carrier to the card during the printing process, the same movement can reoccur after lamination, allowing the laminate adhesion to be compromised. Further, the resin layer is susceptible to removal by chemical means and may not remain on the card if the appropriate amount of heat and pressure are applied. Dye-sublimation on reverse image transfer film will still leave an image in the card as the dyes diffuse into the card at the time of transfer.

Illustration 5.

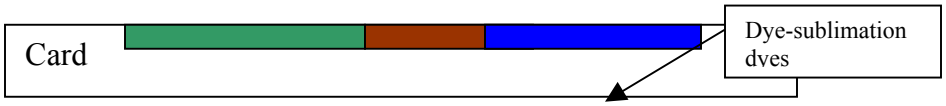
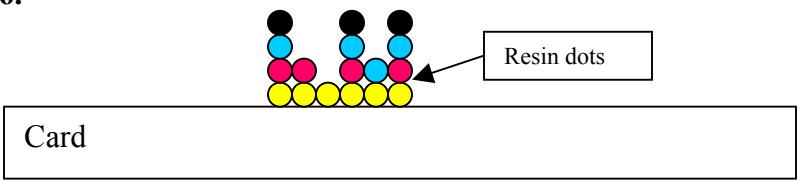


Illustration 6.



In a preliminary test on a limited number of resin printing technology identification cards, the overlaminate did not remain securely fastened to the identification card. In contrast, overlaminates have been developed specifically to work with dye-sublimation printed cards. With years of testing and field use, overlaminate failure on dye-sublimation reverse image transfer cards is very unlikely.

CONCLUSION

Reverse image dye-sublimation printing technology is the solution of choice for technology based identification cards. It produces the best image quality, reliable bar codes, and the most durable and secure identification card printing.