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Improvements in the Image Quality of Thermally Printed Security Cards

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Abstract

Thermal transfer technology is generally considered to be a relatively mature technology; yet advancements continue to occur. Most recently, thermal technology has begun to transition from 300 dpi to 600 dpi. The increased resolution has resulted in a significant improvement in image quality that is apparent in photos, bar codes, text, and Kanji characters.

Introduction

Thermal transfer printing has proven useful in the production of IDs and security cards using relatively low-cost desktop printers.[1] Various companies, including Fargo Electronics, introduced this technology to the market in the 1990s. Early models included the Fargo Persona card printer with inline magnetic encoding in 1993, the Fargo Cheetah II with lamination in 1996, and the Fargo HDP720 Retransfer Printer in 1999.

Retransfer printers are particularly popular for the production of technology cards incorporating edge-to-edge graphics. Unlike standard thermal transfer printing, retransfer printing uses an intermediate transfer film to transfer the image to the security card.[2]

High resolution printheads with resolutions up to 4800 dpi have existed for a number of years,[3] but they have achieved relatively little market penetration. Most thermal printers operate at 300 dpi; however, there has recently been a move to higher resolution 600 dpi printers. Recently introduced 600 dpi card printers include the Nisca PR-C201/Toppan CP500 in 2012, the Evolis Avansia in 2014, the Matica XID87600/XID9600e in 2015, the HID Global HDP5600 in 2016, and the Datacard CR805 in 2017. These printers use retransfer technology and dye sublimation or resin transfer ribbons. They are able to more easily reproduce small text sizes and intricate graphics, including Asian fonts.

Thermal transfer is asymmetric in that the spacing of the individual heater elements in the printhead governs resolution in one dimension, while the ability to rapidly change temperature of individual heating elements in the thermal printhead governs resolution in the other dimension. Resolution in this dimension is related to element size, since smaller heating elements can heat up and cool down more rapidly. It is also inversely related to printing speed.

In thermal printing, resin transfer is generally used for black text and bar codes, while dye sublimation is optimized for colored text, graphics, and photos. Resin transfer may also be used for photos; however, the continuous tone dye sublimation image is lost.

Resolution

Files with a native resolution of 300 dpi lack the detail to reproduce many fine details. This loss of detail is clearly apparent with lines at a frequency of 3-4 lines per mm (lpm). Similar loss of resolution does not occur at 600 dpi until frequencies of 5-6 lpm, Figure 1.

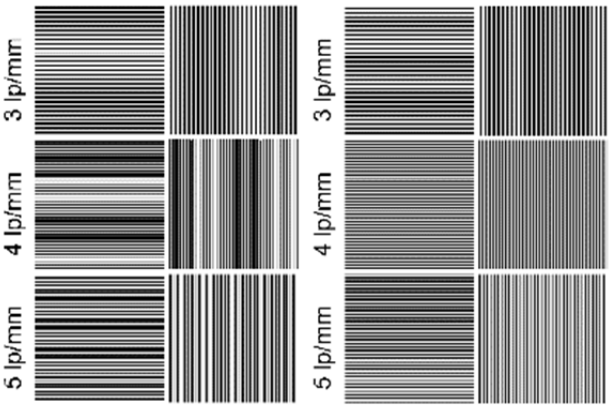

Figure 1. *Comparison between resolution test targets at 300 dpi (left) and 600 dpi (right).*

For a pattern of equally spaced lines, the contrast transfer function (CTF) is defined by the density of the lines, as well as by the density between the lines.

$$CTF = \frac{Density_{line} - Density_{blank}}{Density_{line} + Density_{blank}} \quad (1)$$

Higher resolution is also advantageous for text. Text remains legible at 1-2 points with 600 dpi printing, while a minimum size of 3-4 points is required for 300 dpi printing. Higher resolution also serves as a security feature as it is more difficult to accurately reproduce high-resolution features. Improvements in the reproduction of Kanji text are also seen with higher resolution printing.[4]

Theoretically, black on white and white on black text can be printed equally well at a given resolution. In practice, dot gain improves black on white text but reduces the quality of white text on black.

Dye sublimation printing typically uses 256 levels for cyan, magenta, and yellow. At 300 dpi, the effective resolution is 4800 dpi, and at 600 dpi it is 9600, equation 2. The high effective resolution for the reproduction of continuous tone images allows dye sublimation to compete against printing systems, such as inkjet, with far higher native resolutions.

$$Effective\ Resolution = dpi \times \sqrt{grey\ levels} \quad (2)$$

Resin Transfer

Resin transfer thermal printing gives a high-contrast black or white image for text and bar codes. Either the resin transfers or it does not. Resin transfer has no gray levels.

For resin transfer, 600 dpi printheads extend the ability of the system to reproduce higher frequencies. Resin transfer accurately reproduces frequencies up to 3 lpm for 300 dpi and 5 lpm for 600 dpi, Figure 2. In the vertical direction, the inability to rapidly change temperature results in a lower ctf and reduces

resolution and since it is difficult to rapidly control heating and cooling at the desired frequency. For this reason, vertical resolution is less than horizontal resolution.

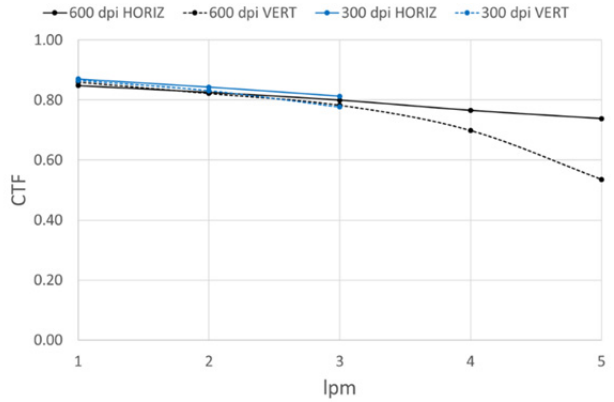

Figure 2. *CTF for black resin transfer at 300 and 600 dpi.*

Improved CTF is consistent with increased MTF50 determined by the slanted edge method.

Table 1. Effect of resolution and technology on MTF50.

Resolution (dpi)	Technology	MTF50
300	Resin Transfer	5.78
600	Dye Sublimation	1.59
600	Resin Transfer	6.95

Higher contrast lines translate into higher quality bar codes, Figure 3.

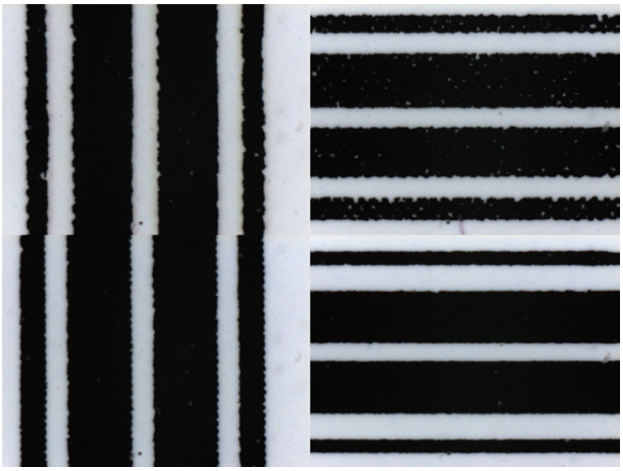

Figure 3. *Horizontal and vertical barcode resin transfer at 300 dpi (top) and 600 dpi (bottom), 12x magnification.*

For bar codes, blur and raggedness are reduced at 600 dpi, compared to 300 dpi. Blur and raggedness are better for vertical barcodes than horizontal bar codes.

Table 2. Effect of bar code orientation and resolution on blur and raggedness.

Bar Code Orientation	Resolution (dpi)	Blur (μm)	Raggedness (μm)
Horizontal	300	64	8
Horizontal	600	44	4
Vertical	300	45	6
Vertical	600	38	2

Reproduction of Kanji characters is also dependent on printhead resolution. One 19-stroke character is used to represent Kanji characters.[4] This character includes horizontal and vertical lines, angled lines, and lines of varying thickness. Kanji characters at 600 dpi show improved image quality, compared to 300 dpi, Kanji characters, Figure 4.

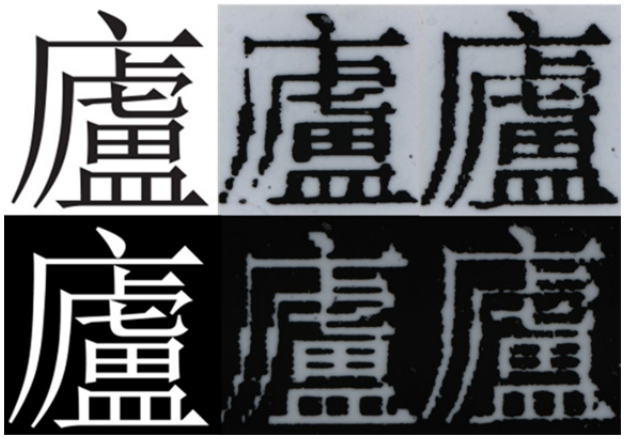

Figure 4. *8 point Kanji text showing reference Kanji character (left), 300 dpi resin transfer (center) and 600 dpi resin transfer (right), 12x magnification.*

Different power settings are required for black on white text, compared to white on black text. In this case, the power setting is able to partially compensate for thermal effects that cause dot gain during the printing process.

Dye Sublimation

Dye sublimation at 600 dpi is also able to reproduce lines with a frequency of 4 and 5 lpm, Figure 5. For cyan lines, the ctf also shows improvements for 1-3 lpm.

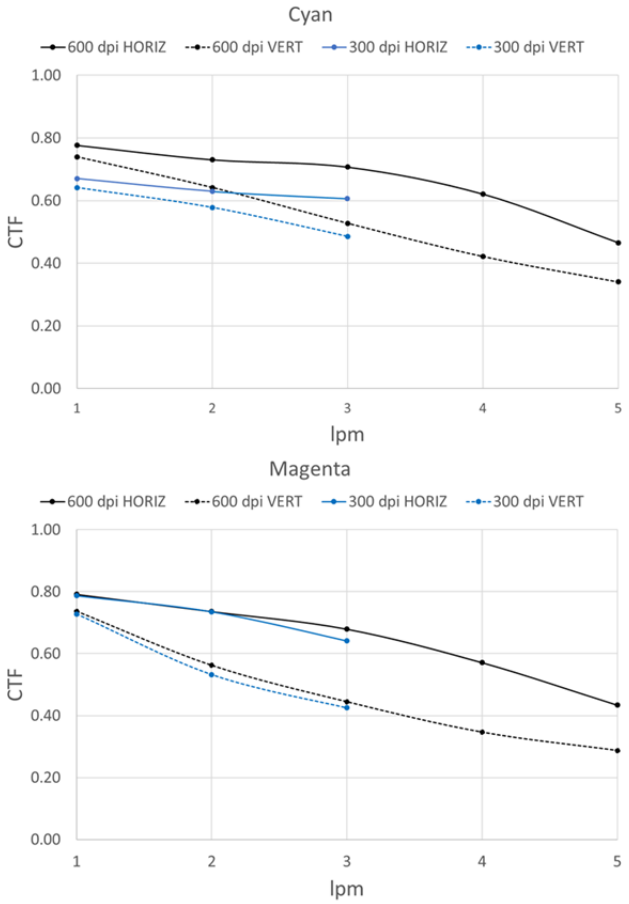

Figure 5. *CTF for cyan (top) and magenta (bottom) dye sublimation at 300 and 600 dpi.*

The CTF for dye sublimation shows reduced edge sharpness, compared to resin transfer. Reduced edge sharpness is a result of the intermediate gray levels that are possible with dye sublimation printing.

Dye sublimation is used for the photo portion of ID cards. Photo reproduction is critical since the photo is frequently used to validate ID cards. With dye sublimation, 600 dpi resolution improves the apparent sharpness of photos, Figure 6. The eye is noticeably sharper when enlarged. Because dye sublimation produces what is essentially a continuous tone image, graininess does not change appreciably when comparing 300 dpi and 600 dpi images.

Figure 6. *Photo at 300 dpi (left) and 600 dpi (right). Face magnification, 2.3x; eye magnification, 12x.*

Conclusion

High-resolution printheads improve image quality with resin transfer and dye sublimation printing. For text and bar codes, higher resolution gives greater legibility to small text sizes and greater readability to bar codes. For color graphics and photos, higher resolution improves the printer's ability to reproduce fine details.

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Author Biography

Dr. Mark B. Mizen is currently Principal Advanced Development Engineer for HID Global. His responsibilities include technical issues related to new technology for printing IDs, driver licenses, and credit cards. He has a Ph.D. in Organic Chemistry from the Massachusetts Institute of Technology and a B.S. in Chemistry from the University of Illinois.

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