# The Fundamentals of Indigo's Digital Offset Color Printing Process and How It Rivals Mechanical Offset Printing

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## Abstract

At DRUPA 2000, Indigo unveiled a new generation of ultra-high-speed Digital Offset Color presses, both sheetfed and web. The seven newly-introduced presses include the industry's fastest digital color printing products.

"Digital Offset Color" is a process combining Indigo's unique electrically-responsive ink, "ElectroInk", with a specially-developed thermal transfer process and a fast color switching technique. These are complemented by an ultra-high performance multi-beam laser scanner and unique image processing software.

Pumping through the heart of Indigo's digital presses is its propriety ElectroInk. ElectroInk enables these liquid electrophotographic printing presses to deliver prints of true offset quality. Only one to two microns in size, charged ElectroInk particles form highly defined characters, line work and halftone dot patterns. The "look and feel" of offset is achieved by a combination of ElectroInk's high saturation and extended color gamut and its unique ability to replicate the surface gloss of the underlying paper stock. The very small particles form extremely thin ink layers – less than one micron thick – enabling both high quality and low cost.

Latent image formation, "Binary Ink Development", and thermal offset transfer are discussed.

## Introduction

Throughout the 500-year history of printing, the common element in virtually all printing processes has been the use of liquid ink. Liquid ink printed images are of high resolution and brilliant color. Indigo's unique electronic printing process, called Digital Offset Color, prints directly from electronic data, completely bypassing the need for film and plates. Indigo's range of printing presses, based on this process, combines high quality imaging, speed, wide color gamut, the ability to print on a wide range of substrates and the option of variating each printed copy. In this paper we will review the fundamentals of Indigo's unique process and how it rivals traditional mechanical offset printing.

## Digital Offset Color

**Digital -**

The printed image is created directly from digital data. Unlike conventional printing processes, there are no intermediate pre-press processes between the digital document file and the final print. No film, no imagesetters, no plates, no platesetters, and no photo-chemicals. There is also no press make-ready: no plate mounting, no registration adjustments, and no ink keys. Indigo's process is fully digital from creation to print. And since it is fully digital, every image can be varied, enabling each print to be unique.

**Offset -**

In the printing industry, the term 'offset' is commonly used as a term for the lithographic process. The litho presses use an intermediate cylinder covered with a rubbery blanket that transfers the ink image from its origin on the plate cylinder to the final substrate. Indigo's technology also uses an offset cylinder and blanket.

There are two main reasons for using an "offset" process. First, it protects the printing plate surface from excessive wear due to substrate friction while printing. Secondly, it compensates for any unevenness of the substrate surface by enabling ink to reach the bottom of any depression. In other words, it acts as a pressure pad, ensuring even pressure distribution, and consequently, even ink transfer from blanket to substrate. Therefore, offset presses can print on a very wide range of substrate surfaces and thicknesses, and in this respect, are superior to non-offset printing. Indigo's process uses offset for the same reasons, thus making it capable of printing on a wide range of substrates. One notable difference between conventional offset and Indigo's offset printing technology is that Indigo's ElectroInk transfers completely from the blanket to the substrate without the ink splitting common to all conventional offset printing systems. This means that a new separation, in a different color, can be created for every rotation of the press. We call this 'on-the-fly color switching'.

**Color -**

Indigo's technology enables digital printing in full color. Unlike conventional offset litho color presses, which require one complete printing unit per color, our presses print all colors in a single unit.

## The Fundamentals of the Indigo Process

Indigo's technology is based on ElectroInk – Indigo's liquid ink. This is a unique tentacular, electrostatically charged pigmented polymer dispersion in an organic dielectric liquid carrier (see fig. 1).

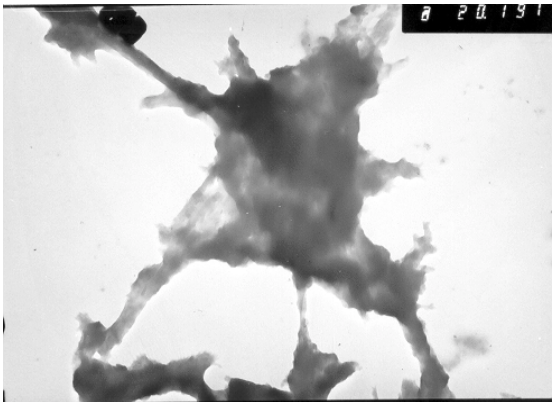

*Figure 1. TEM Picture or ElectroInk*

As you can see, the particles are not spherical in shape, but rather tentacular, having extended ink tentacles that enable the ink and image to form a mechanical interlock capable of withstanding pressures and facilitating the 100% transfer efficiency of the Indigo process.

To achieve high color quality in xerography there is a need to reduce the particle size to less than approximately 7 microns. This brings us close to the airborne dust cloud threshold, especially for higher process speeds. Imagine driving on a dry, dusty road behind a truck creating clouds of airborne dust, intensifying as the truck's speed increases. What a dust cloud this will raise. Compare this to driving under the same conditions, but on a gravel road or after a good rainfall – Xerography solves the dust problem the first way, Indigo the second. It is possible to run at high process speeds using a powder toner, however, the faster the speed the larger the particle size must be to prevent uncontrollable dust. On the other hand, if one wets the particles. Even very small ones, with water ot oil in Indigo's case – extremely high speed are possible, with no dust.

Indigo's ElectroInk particles are about microns average mass diameter and wetted by an oil, thus achieving numerous benefits:

- the thin ink layer is similar in nature to high quality offset with no "dust effects"
- the inherent limitation on process speed is eliminated
- the relative particle mass is low (since mass goes with volume to the third power of radius)
- high resolution
- high uniform gloss
- high color coverage per mass, combined with thin images enables fundamental low cost per page.

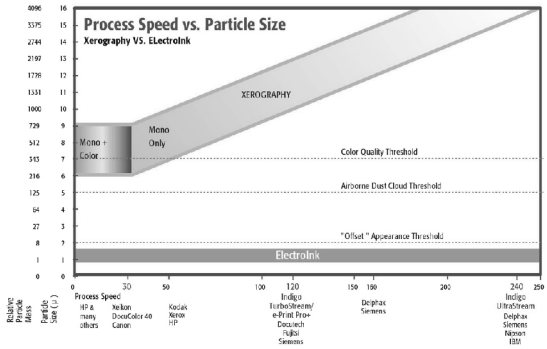


*Figure 2. Process Speed Vs. Particle Size*

ElectroInk gives a wide color gamut with the basic CMYK, expanded with the Indichrome six color set incorporating the Orange and Violet and extended further with the Indichrome spot colors mixed from the basic 11 colors. Indigo's customers can mix their own spot colors on site from a set of basic inks and match most of the Pantone color range. Indigo also provides white ink for industrial markets and Fluorescent inks for other specialty uses.

**Thermal Offset -**

The Indigo process uses a blanket heated to approximately 100 deg. C. This causes the specially shaped pigment. ElectroInk particles to melt and blend into a smooth polymeric film. When it contacts the cooler substrate, the ElectroInk immediately solidifies, strongly adhering and transfering to the substrate. The print is effectively dry as soon as it leaves the blanket, eliminating any risk of ink 'set-off' marking other copies. This is a major benefit over conventional lithography which requires either assisted drying systems, or a 'natural' drying time of several hours, before any print finishing processes can be applied.

**Color Switching -**

Indigo's Digital Offset Color printing technology enables printing all color separations in a single station. After one color separation has been created, the next one, with a different color, is created and printed in the same station.

## The Indigo Process

The Indigo process merges the digital advantages and flexibility of laser printer technology with the quality and speed of offset printing.

Every Indigo UltraStream engine has a 12 beam laser imaging head delivering 1.6 GB/sec (peak of 2.2 GB/sec) of data to the Photo Imaging Plate (PIP) with an addresability of 3200 x 800 dpi.

One of the predefined 7 colors is then selectively applied.to the latent image formed on the PIP.

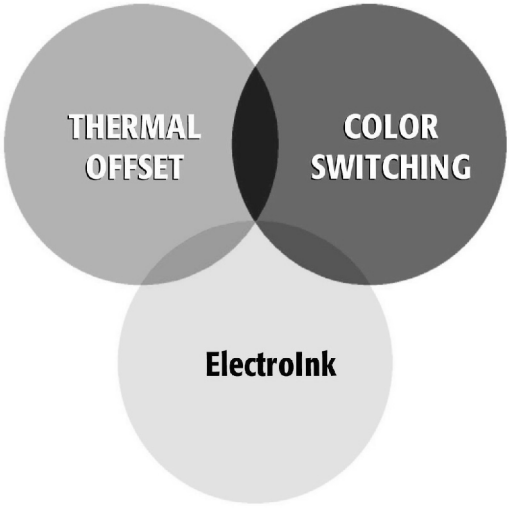


*Figure 3. Indigo Core Technology*

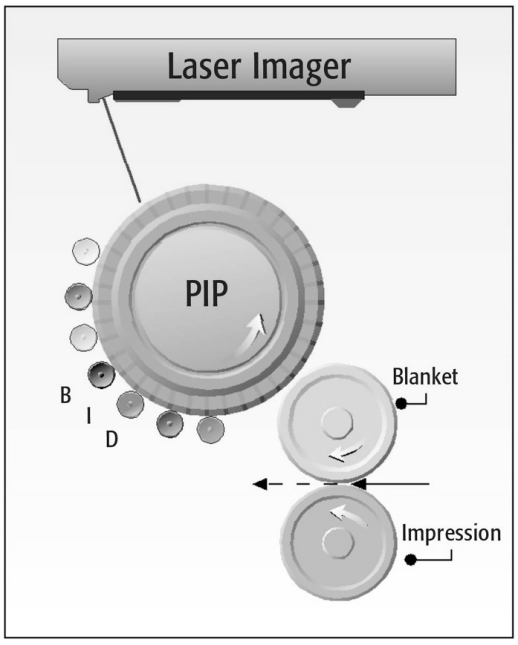


*Figure 4. Indigo Series II Technology*

We call our development process – BID, Binary Ink Development.

The ElectroInk layer is first created as a uniform film on an elastomeric roller and transferred, image-wise to the imaging plate by electrical forces at the end of the nip. The negatively charged ink layer will transfer to the more positive charged areas on the imaging plate, while the background areas which are more negatively charged will remain clean. This BID process enables very high speed development and is applied in Indigo's UltraStream machine family.

*Figure 5. BID Schematics*

The development or process speed in these machines is 240 ft./min or 73m/min. This high speed development with small particle size is possible only in a process employing liquid ink.

From the Photo Imaging Plate the image is electrostatically transferred to the Imaging Blanket. On this heated blanket, the particles partially melt and blend together until the image becomes cohesive and tacky. You can think of the ink image as a micron-thick hot melt adhesive. The image is then ready to be transferre completely to the paper - without splitting of the ink film. When the ink comes into contact with the substrate, which is significantly below the melting temperature of the ink image, the ink solidifies, sticks to it, and 'peels' off completely from the blanket, ensuring 100% transfer from blanket to substrate. The blanket is therefore clean and ready to accept the next impression as it rotates past the PIP cylinder. (The particles, plasticized by the oil. Have a reduce filming temperature. When the residual oil eventually migrates out of the Image, the ink resin returns to it's original high melting temperature, enabling the tough ink Image to withstand high tempertureswithout suffering.

Indigo has two alternate transfer sequences: the Multi-Shot process and the One-Shot process. In the Multi-Shot process", all color separations are accumulated on the final substrate. The substrate is held on the impression cylinder for several rotations as it receives all separations in sequence. In the One-Shot process, accumulation of the separations occurs on the blanket, and the full color image is transferred in one shot to the substrate.

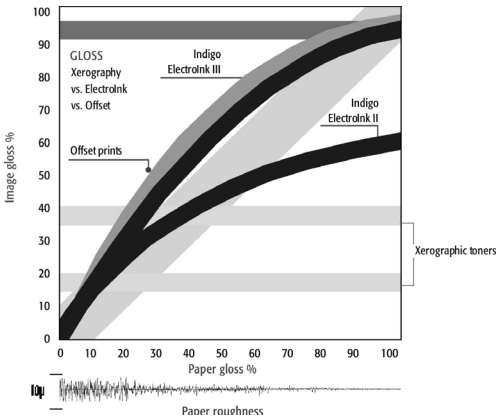


*Figure 6. Look And Feel Of Offset*

## Indigo Quality Characteristics

'Look and Feel' of Offset - The ink layer of the Indigo print is comparable in thickness to that of offset prints. This gives Indigo prints the look and feel of offset. A prerequisite for the look and feel of offset is ability of the ink image to replicate the surface gloss of the underlying paper stock. This important quality factor of gloss uniformity, meaning that both shadows and highlights can have a similar gloss, is enabled due to the very thin layer of ElectroInk. This 1 micron ink layer can follow the various paper surfaces, matte , semi-matte or gloss. It is possible to plot the gloss characteristics of the various digital and lithographic processes on a graph which demonstrates that both ElectroInk and offset printing have almost ideal reflective characteristics, nearly matching the paper gloss for almost the entire range of paper types. Xerographic toners on the other hand, plot as straight horizontal lines on a graph, indicating they have their own gloss regardless of the type of substrate used. This is explained by the large powder toner particles that create thick images which cannot replicate the surface roughness of the paper.

## Edge Sharpness and Definition

Viewed at high magnification, it is easy to see that the ElectroInk forms much sharper edges than xerographic dry toners, and is even superior in edge sharpness to offset lithography (fig. 7,8).

The sharpness of ElectroInk is particularly visible at the edges of halftone dots, or fine type characters. Also evident is the contamination free background of ElectroInk images. As discussed previously, this is due to the small size of the ink particles, the liquid medium and the manner in which the ink image is transferred as a cohesive film, not as individual particles. When the ink is transferred to the heated blanket and the ink particles melt and blend, the surface tension of the liquid ink facilitates the formation of a sharp, clean edge.

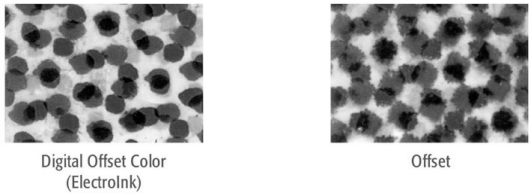


*Figure 7.*

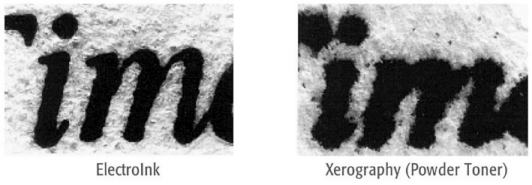


*Figure 8.*

*Figure 9. Publisher 8000*

**Dot Gain and Color Consistency -**

Indigo presses have an automatic closed loop control on both the dot gain and optical density to maintain a consistent dot size and lightness (optical density) for each color. With a conventional offset lithographic press, there are wider fluctuations during a run caused by factors that include: fluctuating ink and water temperature, water/ink balance, plate and blanket wear and atmospheric humidity altering the absorbency of the paper. In adjusting offset presses, a time lag exists between appearance of the problem and the adjustment taking effect, during which many copies are printed. With Indigo presses there are fewer operating variables and the optical density of the printed image can be electronically set by the operator within a wide operational range. Once set, a proprietary closed loop mechanism, called Color Adjust, monitors and regulates the print density and the dot size throughout the job run. The machine will also save the specific job settings for repeat runs in the future, meaning that a repeat job will be identical to the original. This is difficult to achieve with lithography which depends to a great extent on operator skill.

## The Family of Indigo Digital Presses (fig.)

Indigo's commercial and industrial printing product lines enable customers to choose the product best suited for their unique needs and applications, print volume and budget requirements.

This year, our first Publisher 8000 customers will be running their four engine digital web presses at a print rate of 8000 four-color A3 images per hour, meaning 272 letter size color pages per minute! This is the world's highest performance digital color printing press. The press can handle a broad range of web stocks, down to the lightest weight paper. It brings the quality, power and versatility of Indigo Digital Color printing to the mainstream commercial printing, publishing and direct mail markets.

## Biography

Udi Chatow received his B.Sc. and M.Sc. degree in Physics from Tel Aviv University. Since 1988 he has worked at Indigo in Israel in several R&D positions among them Project Manager, and currently as Ink Department Manager.