The reinvention of LED printing:

Fuji Xerox S-LED delivers colourful, high-resolution output

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Executive summary

Almost 25 years ago, a new type of page printing called LED (light-emitting diode) was developed, specifically because it promised to make office printers smaller, quieter, more reliable and less expensive than laser printers. LED technology used the same fundamental electrostatic method of applying toner to paper. But instead of the complex series of lenses, rotating mirrors and scanning system employed in laser printers, LED worked by means of a straight array of diodes. When flashed, they created a latent image, through a pattern of dots, on a rotating photo-receptive drum. The image was then transferred, via toner to an intermediate belt or directly to paper, to produce printed pages. This method was not only mechanically simpler and less expensive to manufacture, but was also much more compact than a laser system.

But LED's simplicity was also its downfall. Due to the fixed horizontal position and maximum 600 dpi resolution of the LEDs, along with their varying intensity, printed results were often disappointing compared to laser output. LED pages frequently featured blurry type, jagged edges on images, fuzzy halftones and mis-registered colour reproduction. As much as users liked the space-saving design and quieter operation of LED printers, the need for laser print quality often won in the end.

Enter Fuji Xerox and Nippon Electric Glass Co. Ltd., two companies that specialize in high-resolution print technologies and cutting-edge optics. Fuji Xerox is the world's leading document management technology and services enterprise, with the industry's broadest portfolio of offerings, while Nippon Electric Glass Co. is one the world's leading manufacturers of specialty glass. Glass tubing and CRT (cathode ray tube) glass are two of their core products. By working together to develop a new printhead controlled by advanced, high-resolution calibration technology, the two companies created an innovative S-LED printhead. The new printhead solves conventional LED's print quality issues due to diode positioning as well as variation in output timing and intensity, and is now available in the new Fuji Xerox DocuPrint CP105 and CP205.
DocuPrint CP105 and CP205 delivers 1200 x 2400 dpi colour print resolution. It also leverages the attributes that conventional LED printer users appreciated—a much smaller size, quiet and environmentally friendly operation, plus exceptional reliability and affordability.

LED print technology has been reinvented, to deliver on its initial promises—and more. New Fuji Xerox S-LED helps the DocuPrint CP105 and CP205 drive document printing to a new level, with an additional emphasis on environmentally conscious engineering for today's offices.

Conventional LED vs. laser printing: why laser predominated

Back in the mid-1990s, LED (light-emitting diode) page printing was poised to be the next big thing in the workplace. Invented by Casio and Panasonic, championed by Oki and incorporated into some Lexmark and Fuji Xerox devices, LED offered a less complicated and quieter method of using the same basic technology as laser printers. And due to their simpler design, LED systems, even colour printers, were much more compact than their laser counterparts. These design factors also made LED devices less expensive to manufacture, which encouraged buyers. In addition, LED printers used significantly less power and were much quieter than comparable laser printers. But five years after they were introduced, LED systems still hadn't made much of an impact on the market—or on users.

While traditional LED devices provided more reliability than laser printers in some ways, their design limitations also proved to be problematic. LED printers featured a simpler, more straight forward design, with a shorter light path and paper path, along with fewer moving parts. But the light intensity and timing accuracy varied from LED to LED— which meant the image quality also varied. Resolution was typically no better than 600 dpi, and LED printers often produced images with fuzzy, jagged edges, gaps in fine halftone lines, and poor colour registration.

Print quality, especially in terms of resolution and reliability, became LED's primary disadvantage, and led to laser's dominant position in the marketplace today.

Both systems utilise similar printing technology

LED and laser systems employ the same basic method of applying toner to paper, by utilizing static electricity—the electrical charge that is built up on an insulated object— and light emitted from lasers or LEDs. Refer to Image 101 and Image 1.02.

Here's a highly simplified description of how the process works:

- In the case of both LED and conventional laser printing, a static charge is applied to a photoreceptor, typically a revolving drum or cylinder. The drum assembly is manufactured from highly photoconductive material that is discharged by light photons.
- As the positively charged drum revolves, the printer shines light across the surface to discharge certain points—effectively "drawing" the letters and images to be printed on the drum as a pattern of electrical charges, also called an electrostatic image.
- Next, positively charged toner is applied, which sticks to the negatively charged areas of the drum.
- The toner image is then transferred from the drum to an intermediate transfer belt or directly to the paper.
- Using heat and pressure, the toner is then melted to the paper through a fuser, producing the printed page.

LED System

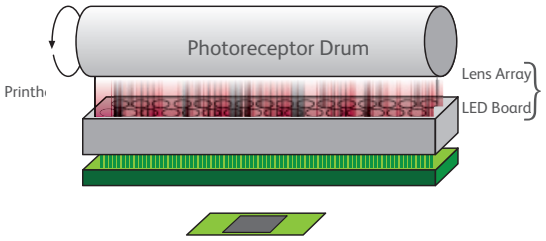


Image 1.01

Laser System

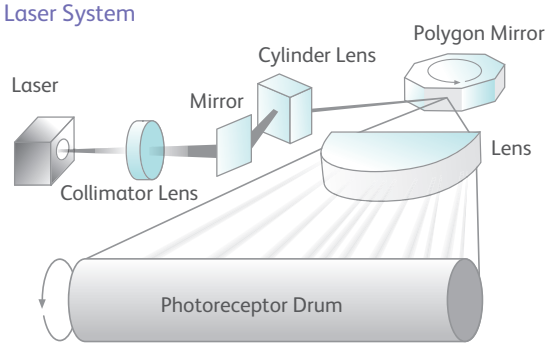


Image 1.02

Conventional LED vs. laser printing: why laser predominated

The difference is how the two technologies distribute the light source

In traditional LED printers, the printhead consisted of a wide linear array of digitally controlled, light-emitting elements, which were often built into the cover of the printer. Instead of scanning the image, as a laser printer does, the LEDs selectively flash to create a pattern of dots on the photo-receptive drum as it rotates; creating a latent image that is transferred to paper via electrically charged toner.

While this row of LEDs was simpler and less expensive to make than the complex moving parts of a laser system, the simplicity of its design didn't allow for the fine timing or intensity control of the LEDs to correct print quality and registration issues. In addition, the LED bar would frequently be skewed or bowed and deliver poor colour registration—creating jagged edges, missing detail in halftone images, and tell-tale colour gaps in prints.

Manual mechanical intervention at the factory or by the end customer was the only way to recalibrate the LED bar and correct these quality problems. Making matters worse, if individual LEDs failed in a traditional LED device, the entire printhead had to be replaced by the manufacturer. Only so many LEDs can be packed into a horizontal linear space, so a printer with 600 dpi (dots per inch) resolutions must have 600 LEDs per inch in its LED array.

In addition, the horizontal resolution of the LED array was absolutely fixed, while the vertical resolution was based on how quickly the LEDs flashed as the photoreceptor rotated past the diodes.

With a laser printer, an optical scanning system distributes a light beam not only through a polygon mirror, but also through focusing lenses in order to make the fine adjustments needed for better print quality. The laser scans from one end of a line to another, and then starts the next line, to form the latent image bit by bit on the photoreceptor drum. The components of a laser system must stay in alignment throughout their use in order to deliver the best results. Automatic adjustments are built into many of today's laser printers to maintain this level of accuracy. One of the primary characteristics of laser printers is their high resolution—or how many dots per inch they lay down. Today's laser printers commonly print at up to 1200 dpi. By comparison, in offset printing, resolution generally ranges from 2400 to 9600 dpi. The laser system's moving parts also contributed to greater noise in the workplace.

The case to revisit LED technology

Important aspects of LED printing worked well and offered real advantages to users. LED's mechanical reliability and compact design were major attributes. And its simpler design, with fewer moving parts than laser printers, also meant that LED printers could be manufactured much more affordable than most laser printers. It all came down to image quality and resolution: if these could be improved, LED promised to offer exceptional print technology at an affordable price for users.

Working together, Fuji Xerox and Nippon Electric Glass Co. leveraged new technologies, including self-scanning integrated circuitry and optical technology. Researchers paired these with a newly developed ASIC (application specific integrated circuit) chip driver to create the new Fuji Xerox S-LED Printhead, which offers uniform optical characteristics to provide high-resolution imaging. When combined with market-leading Fuji Xerox toner and electrophotographic marking technology, the result was a new generation of LED printing technology, one that redefines the process and offers major improvements in image quality.

An innovative LED printhead revolutionises the printing process

The new Fuji Xerox S-LED printhead contains an array of 10,240 light-emitting diodes, or LEDs. Miniaturized, self-scanning driving circuitry is partially located adjacent to each LED, with the remaining circuitry integrated into the ASIC driver chip, located on the LED bar itself.

Each S-LED printhead also features a new self-focusing lens array design. The array is configured in clusters of lens elements with uniform optical characteristics that systematically overlap to produce high-resolution imaging. The LEDs flash through this lens array to form latent images on the photo-receptive drum. Refer to Image 1.03

In a colour printer, there are four individual printheads. With each LED array packing 1200 diodes per inch, the printhead can create many more, and much finer, dots for exceptional resolution, while also saving space in the system's overall design.

The "brain" behind the entire print-head process is Fuji Xerox's new integrated application specific circuit (ASIC) driver chip. This high-performance driver precisely controls the intensity and timing of the 10,240 dots of light (LEDs) in each printhead to achieve 1200 x 2400 dpi resolution—print quality that's equivalent to, and often better than, comparable laser systems. By continually and automatically monitoring information about each LED, the ASIC driver can adjust each diode's light intensity and timing. This ensures uniformity across the entire LED array—and produces consistently high print quality.

The new Fuji Xerox SLED Printhead

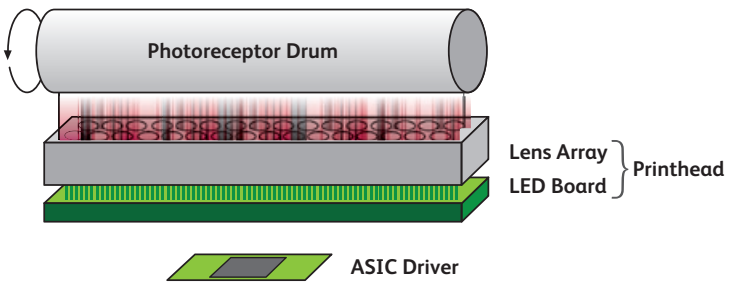


Image 1.03

The results: exceptional print quality

With Fuji Xerox S-LED technology, users can benefit from the first1200 x 2400 LED printhead to offer high-resolution output that rivals and even outperforms comparable colour laser printers. S-LED overcomes the problems that drove consumers away from conventional LED imaging poor image quality due to the position and intensity variations of the diodes. In addition, its LEDs are engineered to never need replacement and the printhead is designed to last the life of the device.

High colour imaging quality

S-LED along with a technology, DELCIS (Digitally-Enhanced Lighting Control Imaging System), which enables precise integrated control of all light-emitting elements by a single high performance ASIC. The ASIC driver controls the light intensity of the LEDs in each printhead.
It offers better dot-to-dot intensity and timing control, and produces more precise colour registration. Conventional LED has imperfections due to skewing and bowing of the LED bar, and differences in LED-to-LED placement within the array, requiring mechanical intervention to correct. S-LED handles all three of these mis-registration issues automatically, simultaneously and continuously, from LED to LED. In fact, tests show that S-LED corrects colour mis-registration even better than comparable laser printers.

High precision image correction technology

Conventional LED technology generally produced only 600 x 600 dpi. While skewing and bowing of the LED bar is inherent in all LED printers, now both problems can be digitally, versus mechanically, corrected simultaneously.

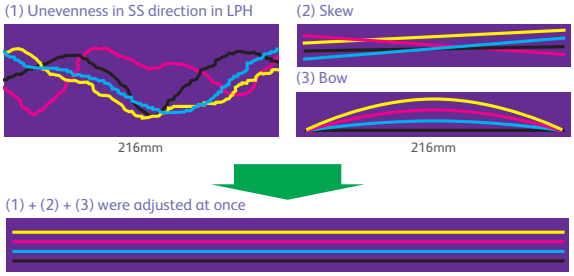
Image Registration Control Technology (IRECT) corrects images using ultra-fine pixel control that fills in gaps and smoothes jagged edges. The results are improved reproduction of individual characters and fine lines, and smoother edges on printed solids and halftone images, and delivers 2400 dpi resolution. Refer to Image 1.04

Micro Accurate Control Screen corrects image tone reproduction by controlling pixel production based on image density. Refer to Image 1.05.
This results in smooth gradations and beautiful highlight expression by suppressing tone jump (colour tone change) which is likely to occur in conventional digital/analog combined screens.

Image Enhancement Processing produces smoother lines, such as diagonal lines at low angle, resulting in sharper text & graphic. Images are processed in two-directional scanning, which allows minute pixel control, enabling smoother reproduction of black lines and character outlines.

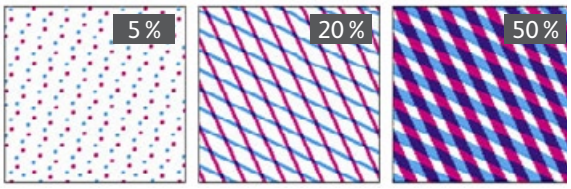
This technology capitalize on the output characteristic of high resolution of 2,400 dpi. Refer to Image 1.06

With its digital print resolution of 1200 x 2400 dpi, the DocuPrint CP105 and CP205 delivers exceptional image sharpness and clarity, whether for fine line drawings, solids or halftones. Smoother lines, without the jagged edges of traditional LED printers, and gap-free halftones with image enhancement, are produced via ultra-fine 2400 dpi pixel control. Refer to Image 1.07



(1) Correction of image mis-registration of individual LEDs form scan direction
(2 & 3) Correction of colour mis-registration - skew and bowing of the LED bar

Image 1.04



Control of pixels in accordance with each density

Image 1.05

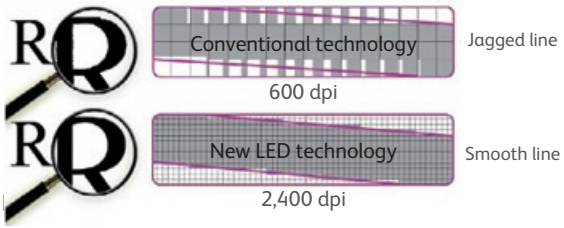


Image 1.06

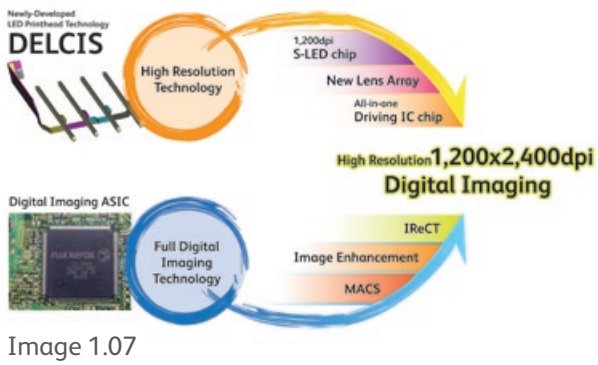


Image 1.07

For more information

Are you looking for tools to support your organization's IT needs, including colour devices that offer better print quality?
Do you need to improve your end users' productivity in the short- and long-term?

Our online resources, experienced sales teams, and extensive reseller network can help you find new sources of value within your workplace and improve the performance of your business.

Fuji Xerox, renowned for its technological innovation, has focused that innovation on the challenges IT faces on a daily basis. We offer proven expertise in improving document and business processes, and put that expertise to work every day around the world, liberating thousands of IT professionals from the tedious and resource-intensive hassles of managing their output infrastructure.
Whether you're implementing MFPs, printers, software, services or new innovative ideas, our people and technology can help you with cost savings, efficiency, security, document workflow, and sustainability in network management and beyond.

Learn more about how Fuji Xerox can put our forward thinking to work for you. Contact your local Fuji Xerox provider now.

S-LED wins technology award

The S-LED, a high-resolution LED (light-emitting diode) print head developed by Fuji Xerox Co., Ltd., won The Imaging Society of Japan's Technology Award.

S-LED print head technology is featured in DocuPrint CP105 and CP205.

The development of this 1200 dpi, self-scanning LED, together with a dedicated ASIC (application-specific integrated circuit), has overcome the issues presented by conventional LED print heads while also achieving high-resolution output.

The Imaging Society of Japan Technology Award recognizes digital photography technology, Non-Impact Printing (NIP) technology, and peripheral technology that displays outstanding originality and exceptional applicability.

The award is limited to technology used in products that have been on the market for more than one year and less than three years.

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