The reinvention of LED printing: Xerox HiQ LED delivers colorful, high-resolution output
Executive summary

Over 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 but was also much more compact than a laser system.

Early LED printers achieved compact size and quite operation, however the quality of the printed output was not acceptable to many customers. Due to the fixed horizontal position and maximum 600 dpi resolution of the LEDs, along with their varying intensity and positioning, the printed output were often disappointing compared to laser output. As much as users liked the speed, space-saving design and quieter operation of LED printers, the need for the higher quality output laser printers provided often won in the end.

Over the last two decades, LED core technology matured at a high rate and spread to an incredible number of applications however, challenges still remained for LED printing. Enter Fuji Xerox and Nippon Electric Glass Co. Ltd., two companies that specialize in high-resolution print technologies and cutting-edge optics. 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 LCD (Liquid Crystal Displays) glass are examples of their core products. By working together to develop a new print head controlled by advanced high-resolution calibration technology, the two companies created an innovative HiQ LED print head. The new print head solves conventional LED’s print quality issues due to precise diode positioning as well as automated variation in output timing and intensity, and is now available in the new Xerox WorkCentre® 7525/7530/7535/7545/7556 and Phaser® 7500 and 7800 printers.

The WorkCentre 7500 series and Phaser 7800 deliver true 1200 x 2400 dpi color print resolution. They also leverage the attributes that conventional LED printer users appreciated; a much smaller size, quiet and environmentally friendly operation, plus exceptional reliability and affordability. The Phaser 7500 offers similar attributes with 1200 x 1200 dpi resolution.

LED print technology has been reinvented, to deliver on its initial promises and more. New Xerox HiQ LED helps the WorkCentre 7500 series, Phaser 7500 and 7800 printers drive quality document production to a new level, with an additional emphasis on environmentally conscious engineering for today’s offices.
Why laser predominated

In the mid-1990s, LED (light-emitting diode) page printing was purported to be the next big thing in the workplace. Invented by Casio and Panasonic, championed by Oki and incorporated into some Lexmark and 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 printing systems 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 less power and were much quieter than comparable laser printers. But years after they were introduced, LED systems still hadn't made much of an impact on the market.

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 straightforward design, with a shorter optical path along with fewer moving parts. But the light intensity, positioning 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 color 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.

Both systems utilize similar printing technology.

LED and laser systems employ the same basic method of applying toner to paper, by utilizing static electricity and light emitted from lasers or LEDs.

Described here is a simplified description of the process:

- 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 negatively 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 a latent image.

- Next, negatively charged toner is applied, which sticks to the neutrally discharged 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.
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 color registration creating jagged edges, missing detail in halftone images, and telltale color gaps in prints. Manual intervention at the factory or at the end customer site was the only way to recalibrate the LED bar and correct these quality problems.

For each dpi of resolution there is an associated LED. For example 600 dpi (dots per inch) resolution must have 600 LEDs per inch in the LED array. The horizontal resolution of the LED array is fixed based on how many LEDs could be packed in each inch of the print head. The vertical resolution is 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 rotating 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 can address. Today's laser printers commonly print at 600 dpi in standard print modes with some devices printing up to 2400 dpi in slower higher quality modes. The laser system's moving parts also contributed to greater noise in the workplace.

An innovative LED print head revolutionizes the printing process

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 affordably than most laser printers. If image quality and resolution 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) technology to create the new Xerox HiQ LED Printhead, which offers uniform optical characteristics and high-resolution imaging. When combined with market-leading Xerox toner and xerographic marking technology, the result was a new generation of LED printing technology, one that redefines the process and offers major improvements in image quality.

Each HiQ 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.

In a color printer, there are four individual printheads. With each LED array packing 1200 LEDs 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 Xerox’s new integrated application specific circuit (ASIC) driver chip. This high-performance driver precisely controls the intensity and timing of the 14,592 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.

With Xerox HiQ LED technology, users can benefit from the first true 1200 x 2400 LED printhead to offer high-resolution output that rivals and even outperforms comparable color laser printers. HiQ LED overcomes the problems that drove consumers away from conventional LED imaging—poor image quality due to the position and intensity variation. In addition, its LEDs are engineered to never need replacement and the printhead is designed to last the life of the device.

**Precise color registration with digital correction**

With an ASIC driver to control the light intensity of the LEDs in each printhead, HiQ LED offers better dot-to-dot intensity and timing control, and produces more precise color 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. HiQ LED handles all three of these mis-registration issues automatically, simultaneously and continuously, from LED to LED. In fact, tests show that HiQ LED corrects color registration better than comparable laser printers.

**Color to color registration**

The Phaser® 7500 and 7800 printers and WorkCentre® 7500 series digitally adjust for mis-registration. Notice the white lines on the laser product. Also notice the white edges on the “M”.

---

**Comparative Laser**

**Xerox HiQ LED**

---
New edge and image enhancing technology for better resolution

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 corrected simultaneously. New Xerox HiQ LED technology delivers true 2400 dpi resolution, 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.

(1) Correction of image mis-registration of individual LEDs from scan direction

LEDs can be misaligned submicrons, resulting in degradation of image quality.

HiQ LED digitally corrects for this misalignment by changing the timing of the firing of the LED. This ensures that the pixel is in the exact spot it was intended.

(2 & 3) Correction of color mis-registration – skew and bowing of the LED bar

The LED bar can be slightly skewed, resulting in color mis-registration

HiQ LED digitally corrects for the skew to ensure high image quality

Corrects (1) + (2) + (3) all at the same time
Featured HiQ LED color devices

The Xerox WorkCentre® 7525/7530/7535/7545/7556 multifunction printer and Phaser® 7500 and 7800 printers feature Xerox HiQ LED printheads, in addition to other breakthrough technologies. These include Low Melt EA Toner, which features a smaller, more consistent particle size for higher resolution and sharper image quality and reduced energy consumption.

The WorkCentre 7525/7530/7535/7545/7556 multifunction printer and Phaser 7500 and 7800 printers deliver 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 edge enhancement, are produced via ultra-fine 2400 dpi pixel control and Xerox’s Low Melt EA Toner.

Xerox HiQ LED products leverage all the other advantages of LED versus laser systems—fewer moving parts, a smaller size and much quieter, environmentally friendly operation at up to 50 ppm color speeds.
Exceptional engineering for the environment

The new WorkCentre® 7525/7530/7535/7545/7556 multifunction printer and Phaser® 7500 and 7800 printers are ENERGY STAR® compliant and quieter than similar laser printers. Where feasible, biomass plastic which is derived from organic residues is used. This produces 16 percent fewer CO₂ emissions during the manufacturing process, compared with traditional plastic. In addition, Xerox EA toner emits 65 percent less carbon dioxide during manufacturing.
For more information

Are you looking for tools to support your organization’s IT needs, including color 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.

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 Xerox can put our forward thinking to work for you. Contact your local Xerox provider, or visit www.office.xerox.com

HiQ LED wins technology award

The HiQ 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.

HiQ LED print head technology is featured in the WorkCentre 7500 Series multifunction printer and Phaser 7500 and 7800 printers.

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.
About the Authors

Robert E. Nuuja
Senior Systems Engineer
Xerox Corporation

Rob Nuuja works in the Xerox Enterprise Office line of business, where he’s responsible for technology assessment, with a particular emphasis on imaging and imaging quality. During his 16 years with Xerox, Rob has worked in a wide variety of engineering capacities. He’s a graduate of the Rochester Institute of Technology, with a bachelor’s degree in imaging and photographic technology.

Suma Potini
Worldwide Product Marketing Manager
Xerox Corporation

Suma works as a worldwide product marketing manager for Xerox, where she’s involved in elevating the relevance of Xerox MFPs among the company’s IT-centric customers. Suma has been with Xerox for the past ten years and has extensive experience working with enterprise customers. She started her career as a systems and network engineer. Suma is Lean Six Sigma Green Belt certified, and has a master’s degree in computer science from Southeastern University in Washington, DC, and an MBA from the University of Rochester in Rochester, NY.

Mark Schaures
Device Engineering Manager
Xerox Corporation

Mark works in the Indirect Channel Business Group where he is responsible for partnered desktop printing and multifunction new device platform planning and management of device delivery engineering. During his 15 years of imaging device development experience Mark has worked with a multitude of technologies and internal and external cross functional teams. Collaborating with product requirements planning as well as directly with end customers, he brings their requirements into the new technology and product development teams to help create award winning printing and multifunction products. Mark is a certified Design for Lean Six Sigma Systems Engineering Green Belt and has a bachelor’s in mechanical engineering from the University of Washington.