

# LumeJet – Inkless Ultra High Quality Photobook Production

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## Abstract

The result of 10 years research, LumeJet is commercializing a new photonic 'inkless' printer, the S200, for ultra high quality photobook production. Similar to Ink Jet – but without the inks – LumeJet comprises custom designed print heads (moving or static) with multi-LED arrays and special fiber taper optics. Using light, rather than ink, increases throughput and image quality, whilst reducing media costs for image intensive documents. LumeJet is a continuous tone process that can resolve down to 2pt colored text and graphics, which would require at least 10-colours and over 4000dpi with inkjet and toner systems. Applications for LumeJet technology have also been identified in label and package printing and printed electronics.



Fig.1 The LumeJet S200 at Duplo's 'London Calling', October 2014.

## The LumeJet S200 Digital Printer

LumeJet has developed and is now commercializing a revolutionary short-run digital printer aimed at the image intensive, ultra high quality photobook markets. The LumeJet S200 (Fig.1) is the world's first photonic 'inkless' printer designed specifically to leverage the proven continuous tone, color gamut and archival qualities of the Silver Halide (AgX) process, in order to meet the needs of the most demanding commercial and consumer printing applications. This includes combining, for the first time in the same page, outstanding contone images together with pin sharp colored text and graphics down to less than 2 point – all without any visible dots, density breaks or jaggies.

The S200 has gained plaudits from renowned industry figures. Frank Romano, Emeritus Professor at RIT, blogged on WhatTheyThink.com "The real point is that this is the highest quality print I've ever seen". Debbie Castro, Director of Training, London School of Photography enthused "LumeJet is the best print and photo quality that I have ever seen in the market. Competitively priced and most of all, effectively beautiful".

## Seeing is Believing

Customers are also acclaiming the S200 print quality as 'Stunning' and 'Seeing is Believing'. They are winning orders from their competitors across a wide range of high value applications, including real estate, fine arts, architecture, automotive, wedding, self-publishing and many more.

TG Print and Design, a London-based S200 user, recently won the prestigious Digital Printer Award for the *Mark Wood Everest Photobook* (Fig. 2)



Fig.2 Examples of LumeJet Layflat Photobooks

## Layflat Photobook Production Systems

In partnership with Taopix (photobook design software) and Duplo (photo book production systems), and utilizing the S200's 40" (100cm) extended print format, LumeJet can provide a complete, cost-effective photobook production system up to super A3+ landscape format 12x20" (30x50cm).

Launched at the *London Calling* event in October 2014, it is now installed at 4 UK sites and customers are reporting significant growth in both sales values and gross margins (over 60%) compared to their ink and toner systems.

We invite you at PMA to judge for yourself where we will be showcasing real jobs from these customers and others.

## eHouse uses the S200 for property brochures

Property marketing agency eHouse is working with London based TG Print & Design to produce high quality property brochures on the LumeJet S200 photonic printer.

The books are designed and originated by the eHouse team and are then created on the S200 using precision light rather than ink, producing a wide range of realistic colours and pin-point sharpness in the images and text.

Managing director, Ben Fillmore said, "We pride ourselves in our print design and production teams' capacity to consistently produce dynamic, attractive and informative print media, and we spend a huge amount of time, effort and money in creating premium products. We were very happy to see clients such as Savills, Strutt & Parker and Hamptons as all early adopters of this exciting new technology, and we understand they each have some very satisfied vendors". An eHouse property booklet has recently won a coveted Print Weeks award (Fig.3).



Fig. 3 eHouse award winning property booklet.

## Design without Compromise

Designers have hailed LumeJet quality as ‘Design without Compromise’. No longer limited by the restricted color gamut or lower image quality of inkjet or toner system, or the unfavorable short-run economics of offset, they can focus on their designs and let their creativity run free!

LumeJet works in RGB, the same as modern displays, iPads and tablets, enabling the designer to work in this extended color space throughout. They don’t have to convert to CMYK or second guess characteristics of the final printing device (so often a big disappointment from their stunning Mac visuals). This has the added benefit of reduced files sizes and increased portability between devices.

With most campaigns now being cross platform LumeJet seamlessly joins eMedia to pMedia. Enabling, for instance, an ad agency to pitch on an iPad retina display and then leave the client a final brochure with ultra high visual impact and value.

Furthermore, as will be explained later, LumeJet requires only 400dpi (the maximum the eye can resolve for prints held at 14”) and three coloured dyes, CMY, to reproduce a broad colour spectrum. And with a tone curve of better than 1% from highlight to shadow, and dense blacks (>2.5D) even hard to reproduce colours such as silvers and golds, reflex blues and oranges are all possible.

The S200 can produce the whole of the Fogra chart to a DeltaE of 0.7, edge-to-edge and end-to-end of a 300ft (100m) roll, and machine-to-machine. This is ideal for campaign printing where jobs can be spread across a number of machines, even in different parts of the country if required.

## Contone versus Halftone

For high end colour printing applications, there’s a traditional divide between continuous tone (contone) and halftone output. Contone prints on AgX photographic paper are widely regarded as the benchmark for image quality, longevity, colour fidelity and competitive cost; whilst halftone methods have become something of the default for text, line art and convenience.

Continuous tone photographic images contain an almost infinite range of colours and no dot structure. They’re produced via a process that uses the reaction of light on substances in photo-sensitive paper to achieve incredibly smooth images. This is

wonderful for pictorial graphics and photographs, but less successful for text, which becomes blurry and illegible at small point sizes.

Halftoning was developed in the nineteenth century as a way to reproduce photographs in newspapers. It reduces shades to patterns of dots of different sizes, shapes or spacing which could be printed with a single ink. At that time, the majority of printing was for words on paper – black text on a (white) background. Halftones simulate continuous tone images by optical illusion: the human eye effectively blends the dots together.

For a single colour ink (B&W images), halftoning is relatively straightforward. Colour printing with multiple screens is more complicated, as it’s important to keep the different coloured dots close together to fool the eye into seeing different colours. However, overlaying dots of different arrangements may cause unwanted visual effects like moiré patterns. Positioning the colours at different angles reduces this problem, and groups the dots into characteristic rosettes, but this requires extreme mechanical precision and often leads to registration errors.

Digital halftoning was introduced during the 1980s in new imagesetters with PostScript RIPs, capable of handling all page elements (photographs, type and graphics) at higher resolutions. Thirty years later, PostScript technology has become industry standard, both accessible and affordable: however the problem of printing words and images on the same page at ultra high quality still remains. Until now.....

The LumeJet S200 features new, photonic technology to print digitally on standard photographic roll paper. The LumeJet Digital Print Head (DPH) achieves ultra high resolution, pinpoint accuracy with all the benefits of photo paper – true contone images.

So for the first time, it’s possible to combine photographic images, fine vector artwork and pin-sharp text (right down to two point size, in colour, reversed out of a black background) on the same page (Fig.4).

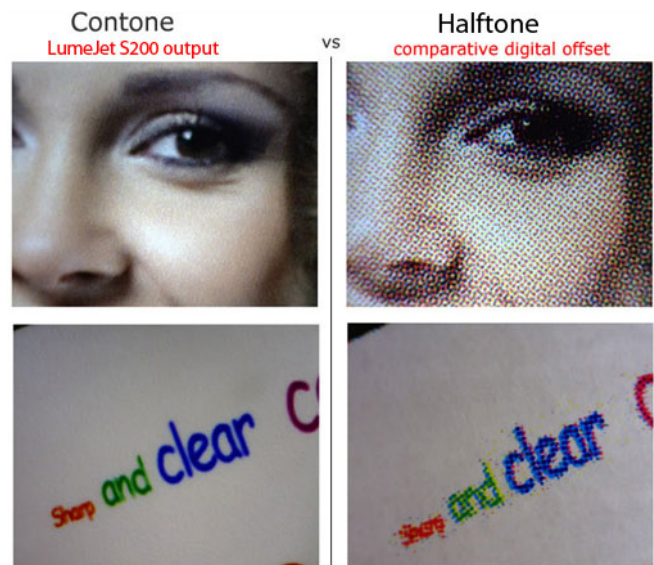


Fig.4 LumeJet contone quality compared to halftone digital offset.

## How the LumeJet DPH works

As the name implies, the LumeJet system works in a similar manner to an inkjet print head but uses multiple-parallel beams of independently addressable LED light to image onto photo sensitive media rather than inks onto paper (shown schematically in Fig.5).

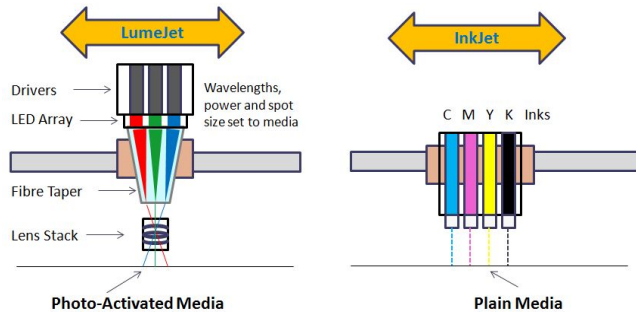


Fig.5 The LumeJet Concept – think inkjet with light!

The DPH comprises a custom designed array of 96 Red, 96 Green, 96 Blue 0.3mm LEDs and special focusing optics to produce 63.5µm spots (400dpi) at the media surface. This creates a 6mm image swathe for each pass of the DPH across the media, which prints in both directions like an inkjet.

However, whereas inkjet can use multi-pass and dithering to disguise artifacts, LumeJet is photonic (inkless) and single pass, so relies on very precise timing and mechanical precision to place the pixels to an accuracy of a few microns (1/1000<sup>th</sup> mm).

In the S200 there are two DPH (Fig.6), one a master and one a slave, to produce a 12mm swathe. But in principle there could be more slaves to produce a wider swathe and faster print speeds.



Fig.6 The LumeJet Twin Head DPH

The key benefit of LumeJet over Inkjet is that it is ‘inkless’ and works at the speed of light. There are none of the issues of nozzle blockage and rouge satellites that bedevil inkjet. Also, light can print at very small (sub-micron) sizes, whereas inkjet struggles below about 30microns due to ink wetting characteristics.

The LumeJet mantra is if you want to ‘print finer and faster, do it with Photons’!

## Why use Silver Halide, isn’t this outdated?

This is clearly what some of the inkjet and toner guys would have you believe. Mainly to mask the fact that in 2015 their technology is still not able to produce true photo-quality prints comparable to AgX (the benchmark), owing to the fundamental limitations of the halftone process they all use.

AgX paper is the result of many 1000’s of man years of research by companies such as Fuji, Kodak, Agfa and others. And, as explained, it still retains a number of key benefits in terms of image quality, archival properties and price, particularly for image intensive documents requiring high visual impact.

It has been estimated that to produce anywhere near LumeJet quality would require 10-inks and 4000dpi, with the commensurate increase in ink coverage and costs. LumeJet only requires 3 dyes and 400dpi to outperform the image quality of all other print technologies (as explained below).

It is encouraging to hear at this conference that AgX is enjoying a revival, that Fuji is extending the range of media, particularly for commercial applications, and that the newly formed Kodak Alaris is increasing capacity at its Harrow plant in the UK to meet demand. And with LumeJet technology significantly increasing the image, text and graphics quality, to meet even the most demanding commercial application, AgX’s future looks assured beyond just traditional photographic applications.

A significant amount of work has also taken place on the chemistry side. It is odorless, comes in neat cartridges, can be auto-mixed and replenished on demand, and disposed of safely to international standards with full recovery of the silver components as an additional revenue stream.

All these features are built into the S200 printer, making it easier to maintain and less polluting than most inkjet or toner presses. In fact, in a recent NIP paper, CEWE (producing 7m photobooks/year) judged AgX to be one of their least polluting processes, as against Indigo and others where de-inking of paper remains a key problem.

## What make LumeJet the world’s best quality?

So what makes LumeJet the world’s best print quality? Fundamentally by custom designing, ground up, the world’s most accurate digital print engine, specifically to leverage the maximum quality from the world’s best continuous tone medias.

Color negative AgX papers are basically 3-layer, light sensitive coatings. The top layer reacting to Red light, the middle layer to Green and the bottom layer to Blue. It is a subtractive reversal process with Red > Cyan dyes, Green > Magenta and Blue > Yellow, whose densities are directly proportional to the log of the exposure.

Each DPH head contains 288 RGB LEDs whose wavelengths are tightly matched to the peak spectral response of the RGB layers. Precision 5:1 drawn fiber tapers (essentially millions of micron-sized light funnels) focus each individual RGB LED to 63.5µm micro-spots (=400dpi), ensuring minimal cross-talk between adjacent pixels, with bandpass filters to eliminate unwanted exposure between the 3 layers.

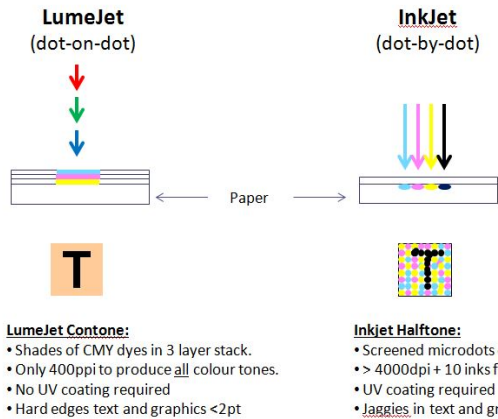


Fig.7 How LumeJet creates its unit pixel cell

Key to the LumeJet quality is that the pixel unit cell is created by very accurately placing, to microns, each RGB spot as a vertical dot-on-dot 3D stack (Fig.7). The exposure for each RGB pixel is precisely, and independently, set to one of 2048 levels (11-bit per color), using time-based pulse width modulation. All this is done while the head is moving across the paper at 1.5m/s, which has required GHz ‘telecoms-level’ technology to be developed by LumeJet engineers.

The end result is a 3D stack of little CMY filter plates that precisely fill the unit cell, whose density is proportional to the original RGB bitmap pixel, but tone expanded to 2048 levels per color – giving over 8.5Bn possible color combinations per pixel!

In comparison halftone systems create their pixel cell using a dot-by-dot screening approach that require a much higher dpi and relies on white paper and the eye into integrate into a pseudo color. It has been estimated that it would require 10 colors and over 4000dpi to approach LumeJet print quality, and at much greater media costs.

## Other Applications

LumeJet photonic technology may have wider applications than just high quality photobooks.

‘Lumebars’, page-wide print heads with many 1000’s of addressable microLEDs, are being developed in partnership with Plessey Semiconductors in the UK. These will be tailored for new classes of color change photopolymers for inkless labeling and packaging applications.

There is significant interest in being able to print variable data, at inline production speed, directly into predefined areas of pre-printed labels and packages for localized information e.g. nutrient content, tracking data and marketing promotions. Ultimately it may be possible to print the whole label, in full color, on the fly – a marketing man’s Holy Grail!

LumeBars are also being developed for ‘maskless’ patterning of etch resists used in the fabrication of flexible OLED displays, lighting and OPV.

## Summary

A 10 year development of state of the art photonic and mechatronic technology, purpose designed to leverage the maximum quality from the very latest silver halide digital emulsions, has created the LumeJet S200 – the world’s highest quality digital printer for commercial and consumer photobook applications, with the key benefits of:

- Ultra high quality continuous tone images together with pin sharp text and graphics, of any colour, down to <2pt including reversed out text.
- Super A3+ Landscape format, with page sizes up to 12 x 40”
- A wide range of media finishes and surfaces, including built-in UV coatings that are being added to continuously by Fuji, Kodak and others for the commercial and consumer markets.
- Single pass printing with only 3 CMY dyes to produce a wide color gamut (no black, special inks or layer registration required).
- No jaggies or screen moiré.
- Ideal for multi-media campaigns to match with iPad retina displays
- Design without compromise. Utilising the full RGB colour spectrum, set your designer’s talents free from halftone print constraints!
- LMS Job management software with Adobe colour managed RIP to fit into any pdf and jdf workflow.
- ICC colour calibration and profiling tools with Xrite Eye-One Spectrophotometer included
- Compliant with international waste regulations with built-in eco-chemical management systems; including cartridge replenishment, auto chemical mixing, silver recovery and waste treatment units producing just water to < 5ppm solute.
- Biodegradable paper stocks.
- Integrated photobook software and layflat production systems (optional extras)
- Achieving significantly increased sales values and gross margins in a broad range of high value markets and applications.

Has there ever been a better time to get back to this superb, tried and trusted media, now meeting the 2015 requirements of both the commercial and consumer photobook markets for ultra high quality, short-run, image intensive documents?

## Author Biography

Trevor Elworthy received his BSc (Hons) in physics from the University of Bath UK, and studied for a PhD in geophysics at the University of Witswatersrand, Johannesburg S.A.

A former Kodak research scientist, since 1991 Trevor has founded 4 companies developing digital technology for the printing and photographic markets. The most recent, LumeJet was spun out from research he initiated at Warwick University. Trevor holds a number of industry awards and patents and was appointed a Fellow of the Royal Society of Arts (FRSA) in 2011.