# The Future of PCB Printing? An Introduction to Ink Jet Printing

*Giles Branthwaite*
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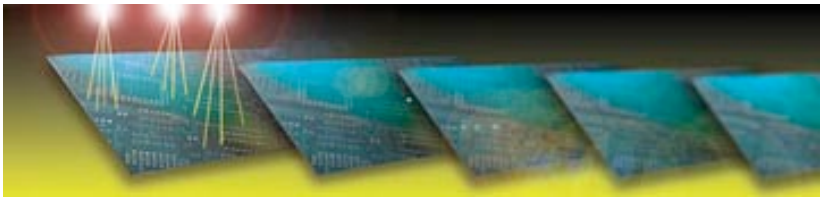

Ink jet printing is no longer a technology limited to plastic boxes sitting on your desk that quickly produce cheap color pictures from your computer. The technology, particularly the print-heads, has advanced to the stage where it is now a viable printing technology for many industrial markets and fluids—including PCBs. Ultimately, ink jet technologies look to hold the key to unlock much faster and lower cost production of PCBs. Their potential is initially being seen in legend printing through a series of companies, but is now moving over to etch resist and soldermask deposition, and ultimately has the potential for direct metal placement for conductive tracks, and ultimately embedded passives.

## The Technology

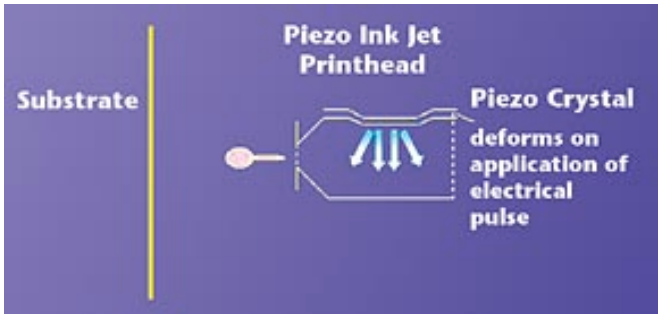


*Figure 1. The principle of piezo ink-jet print-heads.*

The underlying concepts remain the same (see Figure 1), with the fluid being ejected by the shape change of a piezoelectric ink chamber wall being exposed to an electrical current, squeezing out a droplet. Industrial markets have industrial needs, however, and the latest heads (from companies such as Spectra-Inc. of New Hampshire, U.S. and Xaar of Cambridge, U.K.) are now achieving these needs; reliability and

robustness are vastly greater than the desktop print-heads, removing them from consumables and into hardware costs. In fact, ToneJet just launched an electrostatic ink jet print-head, as seen in the MarkFine Legend printer.

The "industrial" print heads have a range of firing speeds (currently up to 20kHz and increasing), and a narrow band of ink characteristics (typical viscosity of 8-12 cPs; Surface tension of 25-35 Dynes/cm and temp of ~40°C). Although perceived as narrow, this range enables a wider range of chemistries (than desktop) and opens up applications such as PCBs. To account for the narrow ink parameters, ink companies are employing phase change chemistry, typically through exposure to UV light or a temperature change, converting the ink into a functional material once fired onto the board.

Droplets are typically fired in pico-liter quantities (current heads offer 8-80 pl) and are the key to the rate of penetration of the technology. The smaller the drop, the finer the feature that ink jet can print. Current technology can achieve line widths of 150-200 microns (720 dots per inch) when lines are printed using 2-3 overlapping pixels (to guarantee a line), although within the next 12 months line widths of 75-100 microns should be obtainable due to smaller drop sizes being possible. When these sizes are correlated with the typical feature sizes in the PCB market, a vast proportion of the market is potentially open to ink jet printing now or in the very near future.

## What Benefit Does Ink Jet Offer the PCB Industry?

Put simply, the potential for faster and lower-cost production of PCBs.

In the last 18 months there has been a flurry of activity in the development of ink jet-based legend printing machines, with no less than seven ink jet legend printer companies showing at EPC (Cologne) in October, all capable of screen-equivalent legend images. They include New System, Printar, Jetmask, First EIE, MicroCraft, Mivatec, and Stork, among others.

The benefits are based around the flexibility of printing and speed of set up that digital printing enables—removing the time or cost of screen creation, meaning short run lengths (and ultimately the one-off board)

are both cheaper and quicker to produce.

Current machines are all stand-alone and can input, register and print boards at 720 dpi in less than one minute (beware: speeds are variable and quoted figures debatable—higher speeds may be at lower resolution and potential purchasers need to look at the machines in detail). The battle is on to achieve higher image quality, faster speeds and continuous feed machines for the longer run PCB facility.

However, these companies are not in the ink jet business just for legend printing. All have recognized that ink jet could be advanced into the direct printing of etch resist, soldermask, solder paste, conductive tracks or even embedded passives, and in the process greatly simplifying the tried-and-tested production process. Potentially removing the need for photolithography and, ultimately, copper etching.

In this context, the goal of these companies is two-fold. First, they want to familiarize the industry with the technology and its capabilities. Second, they want to hone their skills in using the ink jet technology.

## So When Does the Revolution Start?

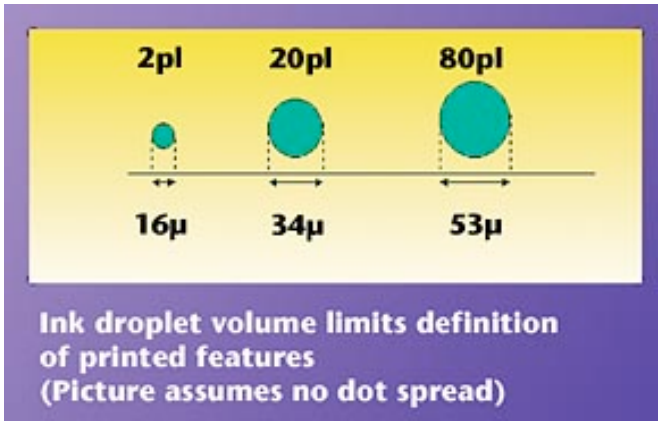


*Figure 2. Print-head developments.*

Legend printers are now part of the norm at shows, and installation numbers are rapidly growing. EPC saw the launch of the first etch resist and soldermask ink jet printers and fluids through the combination of New System and Avecia, a surprise presentation that appears to have

awoken the industry to the technology's potential.

Application of the technology has some significant challenges for the machine manufacture to overcome, including making sharp corners (drops will always produce a curve), getting track edges as smooth and straight as possible, replicating standard industry practises such as tenting, and ensuring print-head maintenance programs to avoid nozzle blockages.

The erosion of photolithography is therefore underway, although ink jet drop size limitations will initially restrict market penetration of etch resist to those applications with lower resolution features.

**Beyond Photolithography**

Research into the direct writing of conductive tracks using inkjet is on-going in many companies and academic locations around the world, although don't hold your breath for that one—getting copper-equivalent conductance at ink jet fluid viscosity levels is not trivial. A solution is unlikely to be commercialized for a number of years.

It has been suggested that when a conductive ink that could match copper conductance levels becomes available, a multilayer board could be produced solely through ink jet printed fluids, i.e., alternating between putting down conductive tracks and a dielectric fluid—no "boards" as we know them involved.

With embedded passives, ink jet is again seen as a leading deposition method of choice. Work is on-going in determining how specific conductivity or resistivity levels can be achieved during the printing process, in conjunction with the materials science needed to enable this.

For PCBs, ink jet should be considered as a micro-deposition device rather than a graphic image enabler, and with significant investment continuing into the technology, has the potential to heavily influence the future direction of PCB production.

Ink Jet will not be going away; it's more likely to be coming to a PCB facility near you soon.