# ToneJet: A New Standard in Digital Printing

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## Abstract

ToneJet is a powerful digital printing technology which establishes new standards of performance and quality. This paper represents the first public presentation by ToneJet Limited. It describes some key aspects of the technology, its high quality output, and its applications in production printing.

## Introduction

ToneJet is a non-impact, digital printing technology that enables the direct digital deposition of printing ink. Its characteristics make it especially suitable for the deposition of conventional ink pigments or other particulate materials on impermeable substrates. In ToneJet ink, pigments or particles are dispersed in a non-polar carrier liquid and are selectively charged by incorporation of appropriate charging agents.

In a ToneJet printhead the dispersion of charged particles is subjected to a constant applied voltage that causes the particles to concentrate at a number of discrete ejection locations positioned at the surface of the ink. Each ejection location has an electrode that allows the application of a local electric field. Addressing an ejector by applying a further voltage results in the ejection of the concentrated particles in a droplet and propels the droplet towards the print substrate. ToneJet is therefore a drop-on-demand technology. The ejected droplets have a concentration of particles up to 20 times greater than the bulk ink. With their high solids loading and relatively low solvent carryover, these concentrated droplets are highly viscous. On impact with a non-absorbing substrate there is low local flow and the droplets create a well-defined printed dot. Figure 1 shows 3 point text printed at 600 dpi on a non-absorbing polymer substrate.


*Figure 1. 3 point text printed at 600 dpi on a polymer substrate*

The droplet viscosity can be such that very little flow takes place, permitting subsequent drops to be deposited immediately on top of those previously ejected. The pile height can therefore be controlled addressably by depositing multiple drops at each print location, allowing 3-dimensional structures to be created. This gives rise to potential microfabrication applications. To illustrate this, Figure 2 shows 35 micron high pillars created on a glass substrate at 42 micron pitch using multiple drops of nominal pile height 1 micron.

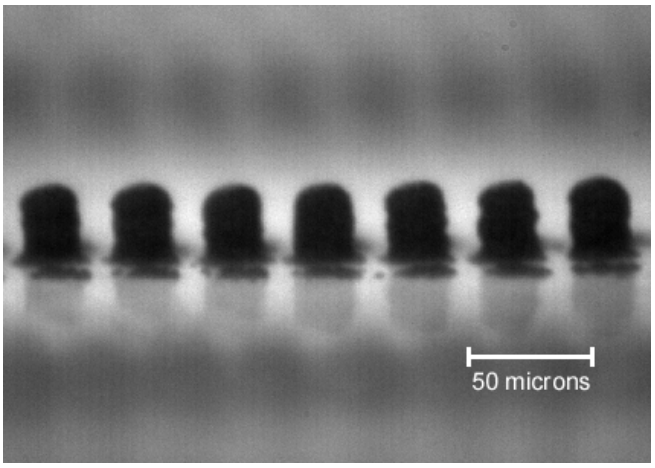


*Figure 2. 35 micron high pillars printed using multiple drops*

Despite the high viscosity of the ejected ink, the ejection timescales are determined principally by the low viscosity of the bulk ink in the printhead. This means that the achievable ejection frequencies, and hence the print throughput, can be very high. The throughput achieved in practice is application dependent.

The local concentration of pigment in the printhead is restored by continuous flow of ink through the printhead from a bulk reservoir. In addition to restoring the local pigment concentration, the flow assists in maintaining the printhead ink supply channels free from contamination or blockages, resulting in reliable, consistent operation over an extended period. Although the channels provide a source of ink for the ejection locations, they do not define the ejected drop size, and the open structure of the printhead means that large particles, in the range of several microns, can be accommodated. This is an important distinction between the ToneJet head geometry and that of thermal or piezo drop-on-demand ink jet systems.

A further distinction is that the ejection process is driven by electrostatic forces acting directly on the ink surface rather than by a pressure generated by a transducer or heater and transmitted through the ink. There are no transducers or actuators in ToneJet printheads and hence the printheads are inherently durable while the simple, passive, printhead structure enables wide arrays to be built.

The printed dot size is dependent on the applied pulse length and amplitude. Continuous control of the printed dot size over a wide dynamic range is possible, enabling high quality continuous tone reproductions to be printed. Figure 3 shows the range of print densities achieved using cyan ink through dot size modulation implemented by varying the print pulse duty cycle at constant pulse amplitude.

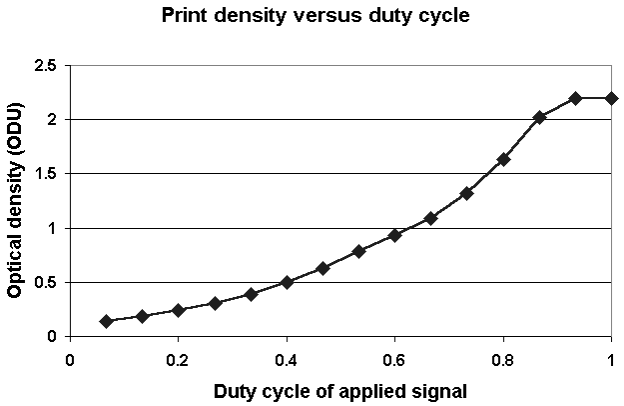


*Figure 3. Continuous modulation of printed dot size*

ToneJet therefore offers a unique combination of features:

- high viscosity of ejected ink
- wide range of particulate material types and size
- ink flow through head
- simple, scalable printhead structure
- continuously variable drop size
- high ejection rate
- reliable, long-term operation

Add to this low operating costs through the inherent reliability, high up-time and simple ink formulations and it is clear that ToneJet offers an ideal solution for many industrial and commercial digital printing and related applications. One such application, which is the first use of ToneJet technology in a commercial product, is described below.

## PCB Legend Production Printing

Many printed circuit boards (PCBs) are produced on a short-run basis for development or prototyping work, or where there are many product design variations. Conventionally, PCB legends are printed using silk-screen printing. The production of each new design of PCB requires a new screen to be made, with the attendant process time, cost and waste. A PCB manufacturer may therefore need to produce thousands of screens each year, many of which are used to produce a very small number of boards. Direct digital printing of PCB legends presents an attractive alternative to conventional silk-screen printing of PCBs. It enables printing to be carried out directly from the PCB data, thus eliminating the cost and time for screen manufacture and setup. It also permits customisation of individual boards to include, for example, unique identification numbers.

The capabilities required of a digital printing technology in order to succeed in this application are:

- ability to print on impermeable substrates
- ability to reproduce small font sizes legibly
- solvent, heat and abrasion resistant inks
- production level print throughput

ToneJet technology is ideally suited to these requirements and a ToneJet print engine has been created for production printing of PCB legends.

### Print Engine Specification

The printer specification for this application is detailed in Table 1.

**Table 1. Printer Specification**

Print output specification

| | |
|---|---|
| Print resolution | 600 dpi binary |
| Printhead ejector pitch | 150 per linear inch |
| Throughput (final quality) | 90 secs per A4 board |
| Maximum substrate size | 560mm x 680mm |

Ink specification

| | |
|---|---|
| Heat fixing temperature | 160°C |
| Abrasion resistance | 6H pencil test |
| Solvent resistance | alcohols, ketones and chlorinated solvents |

A print system has been designed to meet this specification and is shown in Figure 4. The system uses a 252-ejector ToneJet printhead, shown in Figure 5.


*Figure 4. Print system for PCB production printing*

*Figure 5. 252 ejector ToneJet printhead*

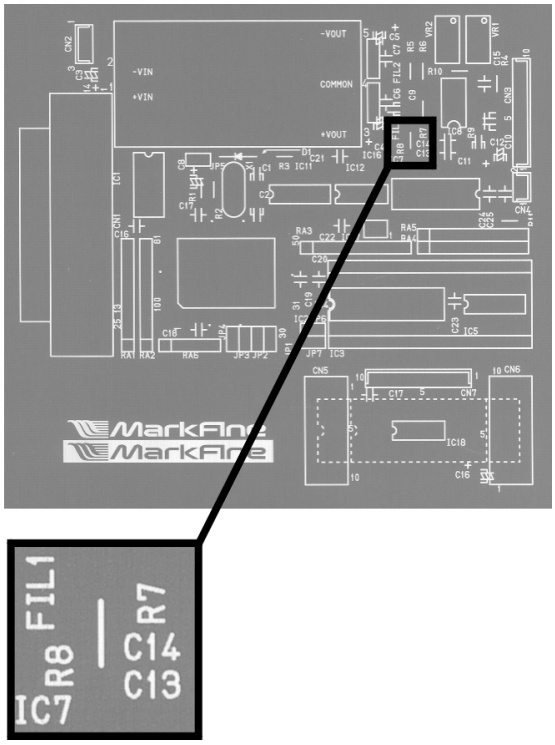


*Figure 6. Output from print engine*

**Printed Output**

Figure 6 is an image of a 110x100mm PCB produced by the print engine. The text exploded out of the main view is 6 point. The print output meets or exceeds the requirements of Table 1.

## Conclusion

ToneJet is a technology that is well suited to many digital printing applications. The variable printed dot size offers excellent continuous tone reproduction for photographic and other high quality images. The simple, but flexible and robust, ink chemistry allows a wide range of pigments and particulate materials to be concentrated and ejected, enabling applications in microdeposition and micro-fabrication as well as production printing.

The first commercial product using a ToneJet printhead is aimed at the PCB printing market. ToneJet's ability to deposit concentrated pigment on a non-absorbent substrate to produce durable, high resolution images, creates a unique opportunity for the print engine manufacturer and end users.

## Biography

Dr John Teape manages the Printing Technology Division at The Technology Partnership, Cambridge, UK, one of ToneJet's two principal shareholders. He has been involved in the development of digital printing systems for over 20 years.