# Ink Jets as Display Manufacturing Tools

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## Abstract

*Major display equipment suppliers have introduced equipment using ink jets for manufacturing steps such as printing the polyimide alignment layer and printing color filters. This paper will discuss the status of ink jets as precision deposition tools and the new technology being introduced for ink jet manufacturing.*

## 1. Introduction

Digital materials deposition with ink jets has changed the way displays are being built in Gen 7 plus manufacturing facilities. Because it is an additive, not subtractive process, ink jets are enabling manufacturing processes that are cost effective, much less wasteful and more economical in small production volumes than many standard techniques.

As this potential for piezo-based drop-on-demand ink jets has become recognized, printheads have been designed to meet the exacting demands of manufacturing. These include reliable, consistent operation, precise drop location, precise drop volume control and precise drop velocity control.

However, printheads are only a part of what is required for a manufacturing printing system. A successful printing system integrates fluids, maintenance, printheads, substrate handling, pre- and post-processing with existing manufacturing equipment. To accomplish this, it is necessary for the equipment manufacturer to understand ink jet operation and to work closely with fluid formulators.

## 2. Ink Jet Tools for R&D

FUIFILM Dimatix is a major manufacturer of industrial ink jet printheads that have demonstrated reliability and productivity useful for manufacturing color filters, PLED displays, organic TFTs, RFID components, and other emerging technologies. These production printheads, however, are not ideal tools in early stages of process development or in trials for jettable fluids. In addition, it is expensive and time consuming to start a project using production equipment.

In order to jump start new projects and to make it easy for chemists to develop new functional fluids, FUJIFILM Dimatix introduced a bench-top printing system in 2005. The Dimatix Materials Printer (DMP) can define patterns over an area of about 300 x 230 mm and handle substrates up to 25 mm thick. The heated vacuum platen enables sample printing on sheets of flexible materials such as PET and Kapton®. A CCD-based fiducial camera permits observation and measurement of features immediately after printing.

To develop reliable jettable functional fluids it is important to understand drop breakoff and drop formation as well as performance after deposition. The DMP has a built-in drop visualization system that makes it easy to observe drop formation as a function of various operational input parameters.

Figure 1 is an example of drop formation as captured by the DMP drop visualization system.

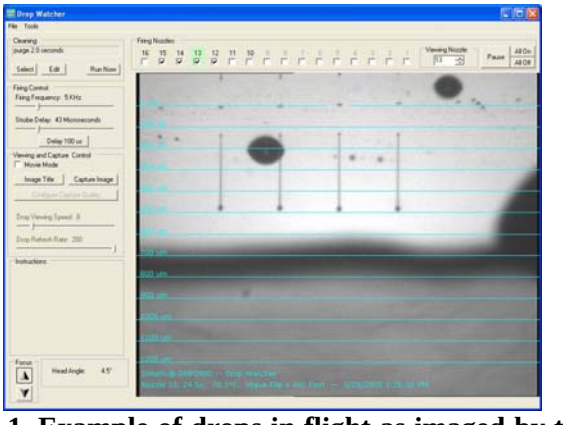

**Fig. 1. Example of drops in flight as imaged by the internal drop visualization system in the FUJIFILM Dimatix Materials Printer .**

In addition, fluids can be patterned onto substrates so that properties such as conductivity, adhesion, and scratch resistance can be measured. Figure 2 depicts a simple pattern of conductive silver printed onto a synthetic “paper” substrate. This is an example of how the DMP can be used to generate test pieces for evaluation.

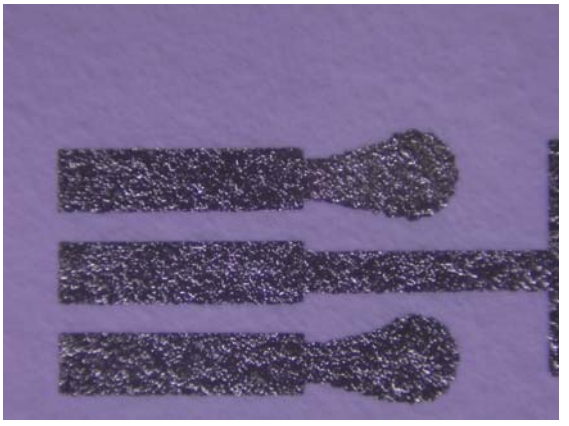

**Fig. 2. Conductive silver test pattern printed with 1 picoliter drops using FUJIFILM Dimatix Materials Printer.**

A unique feature of this table-top printing system is the printhead itself. These FUJIFILM Dimatix printheads are intended to have a limited lifetime, intended to be filled once by the user and then discarded. Each single-use cartridge has 16 nozzles linearly spaced at 254 microns. Because the jetting array uses FUJIFILM Dimatix proprietary MEMS technology, the jets can be multi-pulsed to generate larger drops.

To minimize waste of expensive fluids, each cartridge reservoir has a capacity of 1.5 ml. Cartridges can easily be replaced to facilitate printing of a series of fluids sequentially. The silicon nozzle structure is coated with a proprietary non-wetting material to reduce wetting of low surface tension fluids and to improve maintenance.

The DMP has a preloaded waveform optimized for fluids with viscosities between 10 and 12 mPas and surface tensions between 28 and 33 dynes/cm. This waveform can be changed in pulse shape (amplitude, slew rate and duration), frequency, and voltage, as may be required for new fluids. If waveform parameters are modified systematically, fluids that are challenging to jet may be deposited successfully.

## 3. One Picoliter Printhead

Cartridges are available in two basic drop sizes: 10 pL and 1 pL. The 1 pL cartridge has been introduced to meet manufacturing needs for ink jets to print features smaller than can be obtained directly with 10 pL drops. Consequently, the DMP can be used to evaluate fluids, substrates and process for printing features on the order of 20 microns.

Many possible manufacturing applications for ink jets require features finer than it is presently practical to print directly with 10 pL drops. For example, it is very desirable to be able to directly print fine conductive traces in the manufacture of photovoltaic cells. From the ink jet printhead point of view this implies decreasing the drop volume below 10 pL. Because of the design flexibility of FUJIFILM Dimatix’s MEMS approach, it is possible to manufacture a series of cartridges that can be utilized in the DMP.

## 4. Manufacturing with Ink Jets

Although ink jets have been very successful in commercial graphic arts printing, ink jets have moved slowly from R&D into manufacturing. As Robert Nolan says, “Advocates of TOP electronics (thin film, organic & printable) sometimes face opposition from those in their businesses who see TOP electronics as too risky, too speculative, too early stage to get involved with. And as TOP electronics shifts from R&D to production, the amounts of money involved become much larger and opposition inevitably stiffens.”[1]

Today Litrex[2] builds Gen 5+ capable equipment to order. Ishii Hyoki[3] has announced the availability of Gen 5+ polyimide coaters. There are other companies, mostly in Asia, that are building ink jet-based manufacturing equipment.

To meet this growing market for ink jet printheads to be used in manufacturing, FUJIFILM Dimatix is introducing print engines using 128-jet cartridges. These print engines have automatic features such as precision alignment of multiple cartridges. Fluid may be supplied to these cartridges via a large on-board reservoir or from a remote reservoir. Because the new cartridges are extensions of the original 16-jet cartridge that is used in the FUJIFILM Dimatix Materials Printer, the processes and fluids developed with the small printing system can rapidly be extended to pilot scale manufacturing.

## 5. Summary

FUJIFILM Dimatix is introducing print engines using 128-jet cartridges that are derived from our MEMS technology. These print engines have automatic features such as precision alignment of multiple cartridges. Because the new cartridges are extensions of the original 16 jet cartridge, the processes and fluids developed with the small printing system can rapidly be extended to pilot scale manufacturing.

## 6. References

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