Inkjet Technology and Products for Flexible Display Manufacturing

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Abstract

Major display equipment suppliers introduced equipment using inkjets for manufacturing steps such as printing polyimide alignment layers and color filters. This paper discusses how inkjets can be used in the development of flexible displays and materials printing systems designed to meet the challenges of fluids and process development.

1. Introduction

Digital materials deposition with inkjets has changed the way displays are being built in Gen 7 plus manufacturing facilities. Because it is an additive, not subtractive process, inkjets 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 inkjets 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 inkjet operation and to work closely with fluid formulators.

2. Inkjet Tools for R&D

FUIFILM Dimatix is a major manufacturer of industrial inkjet 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. This system is shown in Figure 1.

Fig. 1. Dimatix table-top materials printer.

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.

In addition, fluids can be patterned onto substrates so that properties such as conductivity, adhesion, and scratch resistance can be measured.

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. The cartridge is shown in Figure 2.

Fig. 2. Single-use cartridge is filled by the user prior to printing.

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.

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 inkjets 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 inkjets 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 inkjet 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 Inkjets

Although inkjets have been very successful in commercial graphic arts printing, inkjets 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]

Ishii Hyoki[2] has announced the availability of Gen 5+ polyimide coaters. There are other companies, mostly in Asia, that are building inkjet-based manufacturing equipment.

To meet this growing market for inkjet printheads to be used in manufacturing, FUJIFILM Dimatix Technology Integration (DTI) offers inkjet printhead systems for customers whose unique requirements are not addressed by commercially available printer products. Figures 3 and 4 show examples of DTI printhead cluster platforms.

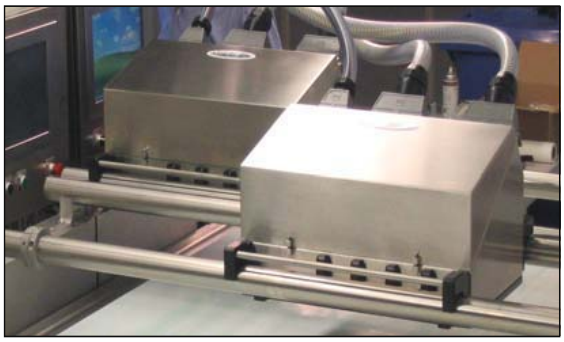

Fig. 3. DTI multi-lane array, 12-inch cluster.

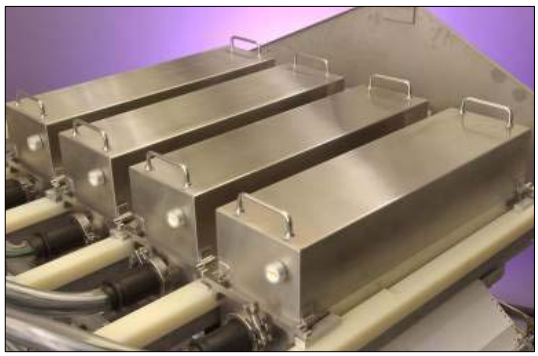

Fig. 4. DTI 4-color array, 20-inch cluster.

FUJIFILM Dimatix advanced printing system is designed to be a high precision deposition prototyping and pilot line production tool. This printing system, shown in Figure 6, enables functional fluid developers and process owners to move from R&D and fluid optimization to process development for digital production.

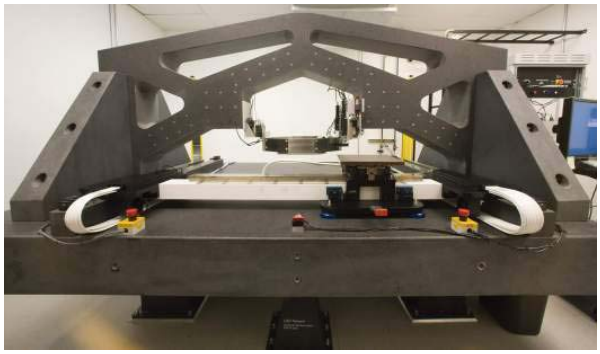

Fig. 5. FUJIFILM Dimatix printer system has 1 micron accuracy over 1 m x 1 m and incorporates small drop printheads for evaluation.

5. Conclusion

With continued adoption, and further system progress, it is expected that inkjet will be a dominant manufacturing process that many will consider for a host of production applications. One can explore the potential of inkjets in display manufacturing without investing large amounts of time and money early on. FUJIFILM Dimatix printing systems will enable one to determine process conditions as well as to print samples for testing. This data may be the basis for specifying a prototype printing system with production printing speeds.

6. References

1. Robert Nolan [top.blog@nanomarkets.net] May 18, 2007.
2. http://www.ishiihyoki.co.jp