Simple Tools for Ink Jet Printing of Functional Fluids

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Abstract
Success in moving ink jets into newer areas such as printing on to-be-defined flexible substrates or developing new functional fluids requires both process and fluid research and engineering. Today, leading-edge concepts are slow to be explored because of the expense and complexity of commercially available ink jet deposition systems, time and resources required to specify and acquire commercial ink jet systems and the expertise required to operate commercial ink jet systems.

This presentation describes a new ink jet printing system designed to meet the challenges of fluid and process development for flexible substrates.

1. Introduction
Because it is an additive, not subtractive process, digital materials deposition with ink jets is changing the way products are built. 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. One such printhead is Dimatix's SX3, shown in Figure 1.

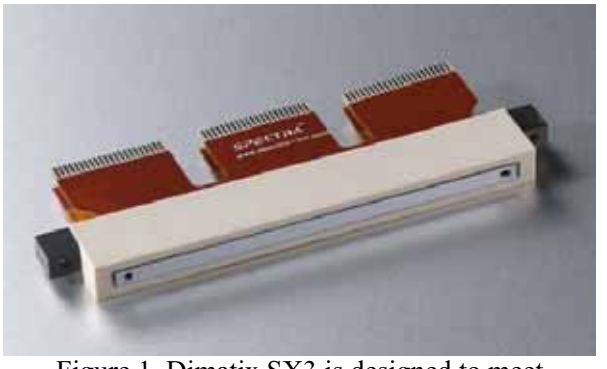

Figure 1. Dimatix SX3 is designed to meet production requirements for applications such as LCD displays and PLED displays.

However, printheads are only a part of what is required for a manufacturing printing system. A pilot manufacturing line for PLED displays may have 4 individual printing centers, one for the hole injection control material (i.e., PEDOT), and an additional work station for each color of polymer light emitting fluid [1] as illustrated in Figure 2.

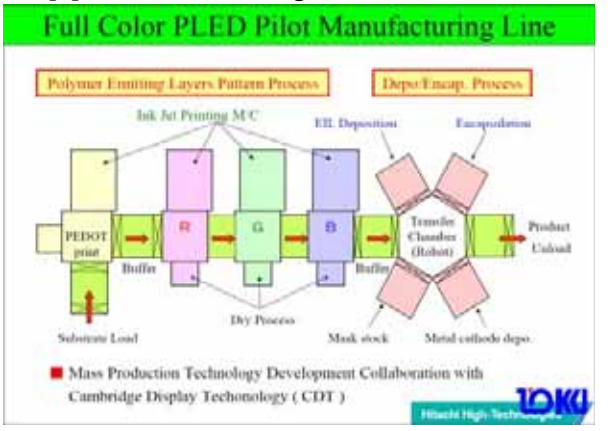

Figure 2. Pilot manufacturing line for full color PLED displays.

A roll-to-roll manufacturing line that required only one type of jetted material might have one large custom designed carriage with many ink jet printheads. For example, iTi's new web press (Figure 3) can run up to 46 m/min and supports 4 to 24 printheads.

Figure 3. Roll-to-roll ink jet printing equipment by iTi Corporation. [2]

This type of equipment obviously requires a sizable financial investment plus sufficient experience and process development so that specifications can be established. For ink jetting onto flexible substrates to be evaluated and for specialized jettable fluids to be developed, a low cost, easy-to-use system is required.

2. Simple Ink Jet Tools

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 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, Dimatix introduced a bench-top printing system in 2005. This system is shown in Figure 4.

Figure 4. 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 is available.

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. For the first time, Dimatix is producing printheads that are intended to have a limited lifetime, intended to be filled once by the user and then discarded. The cartridge is shown in Figure 5.

Figure 5. Disposable cartridge is filled by the user prior to printing.

Each single-use cartridge has 16 nozzles linearly spaced at 254 microns. Drop size is nominally 10 picoliters. Because the jetting array uses Dimatix MEMS technology that has high resonant frequency, 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 cartridge consists of two parts: jetting module and fluid module. The jetting module is based on Dimatix's proprietary MEMS technology. The components of the ink jet are etched in silicon. The piezoelectric element is bonded to a thin silicon membrane and silicon-to-silicon bonding is used to form a planar structure. As a result, the ink jet printhead is not only very precise in dimensions but also very robust to a wide variety of inorganic and organic fluids. The silicon chip is bonded to a molded liquid crystal polymer frame that also has the electrical interface. The jetting module chip has 16 square nozzles as shown in Figure 6.

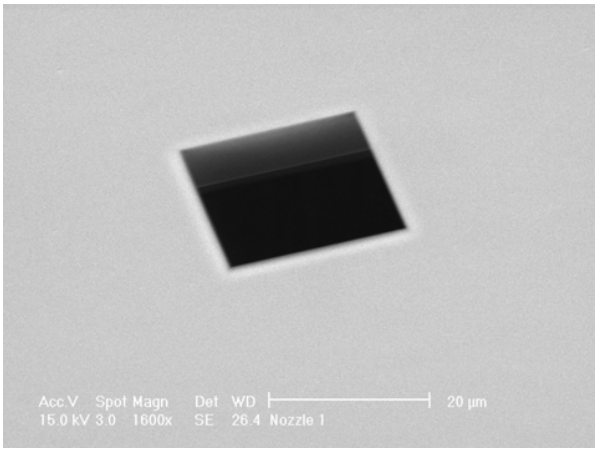

Figure 6. Cartridge nozzle is 21.5 microns on a side.

The silicon nozzle structure is coated with a proprietary non-wetting material to reduce wetting of low surface tension fluids and to facilitate maintenance.

The fluid module is made up of a flexible polypropylene reservoir and protective rigid polypropylene housing. The volume of the reservoir is small to conserve expensive fluids.

The digital materials printer is essentially a monochrome printer. To print different fluids, just make a quick exchange of cartridges.

Because of the design flexibility of Dimatix's MEMS approach, it is possible to manufacture a series of cartridges that can be utilized in the DMP. 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. Dimatix is investing heavily in the research and development of cartridges capable of jetting drops as small as 1 pL.

3. Conclusion

The Dimatix Materials Printer is a cost effective, easy-to-use system that greatly simplifies the evaluation of ink jets precision deposition tools. The compact design makes it possible to explore the potential of ink jets in display manufacturing without investing large amounts of time and money early on. This printer enables the evaluation of functional fluids and of process conditions as well as printing samples for testing. This data may be the basis for specifying a prototype printing system with production printing speeds.

4. References

[1] M. W. Schoeppler, IMI "Ink Jet Developers' Conference," April 2005, Geneva, Switzerland.

[2] Boulder, Colorado, USA. www.inkjetsys.com.