NEW TECHNOLOGIES

Inkjet Technology Helps Nanotech Manufacturing Gain Scale

By Chuck Griggs FUJIFILM Dimatix, Inc.

Although it's easy to romanticize the ultra-small world of nanotechnology manufacturing, working with microscopic materials that are often caustic, corrosive, elusive and otherwise difficult to deal with isn't easy.

If your business involves moving new products and manufacturing techniques based on nanotechnology from the research lab into large-scale production, new tools are available that rely on a proven technology originally suited to graphics that is uniquely capable of addressing an array of nanotechnology manufacturing problems and opportunities from start to finish.

The technology is Piezoelectric drop-on-demand inkjet (Piezo DOD), modified for nanotechnology manufacturing through the application of silicon-based microelectromechanical systems (Si- MEMS) printheads that are well-suited for exploring, testing, prototyping and scaling up new products and manufacturing approaches into production.

In fact, Piezo DOD is so well matched to materials deposition that inkjet tools and methods already widely used in the research lab and for small-volume prototyping have been expanded to provide a growth path for manufacturing scale-up.

The new frontier of high-tech manufacturing

Piezo DOD inkjet offers a variety of advantages over other materials deposition methods. As a non-contact deposition technology, it avoids contamination or damage of substrates. Rather than flooding a surface with functional fluids it is precise and purely additive, able to deposit the exact amount of material at the exact locations where it is needed without waste.

Piezo DOD's efficiency helps eliminate manufacturing steps, while its precision makes imaging, patterning, etching and recovering waste material unnecessary. These features make it more attractive for use with the aggressive, conductive and reactive fluids and coatings that often must be deposited at precision locations and in precisely controlled amounts.

Materials deposition demands droplet size tolerances exceeding those used for graphics production by orders of magnitude. Instead of jetting ink at the 30 to 80 picoliter droplet sizes common to graphics, materials deposition routinely requires jetting fluid "drop" sizes of one to 10 picoliters (trillionths of a liter).

It also demands printheads offering high duty cycles and long life that are able to sustainably jet fluids at high frequencies and with exceptional precision without trading off drop placement accuracy.

The materials these unique systems can "print" range from UV-curable light-emitting polymers, liquid silver and conductive fluids to enzymes and DNA and other "organic inks" on all types of surfaces whose dimensions often must be controlled to within a few ten-millionths of a meter.

The deposition of these fluids, from adhesives, masking inks, anti-scratch/anti-glare compounds to UV-curable light-emitting polymers and conductive and electronics displays for life sciences, chemistry, 3-D mechanics, optics and photovoltaics, to name a few, are helping to fabricate a new generation of products not feasible only a few years ago.

Building Blocks for Nanotech Process Scale-up

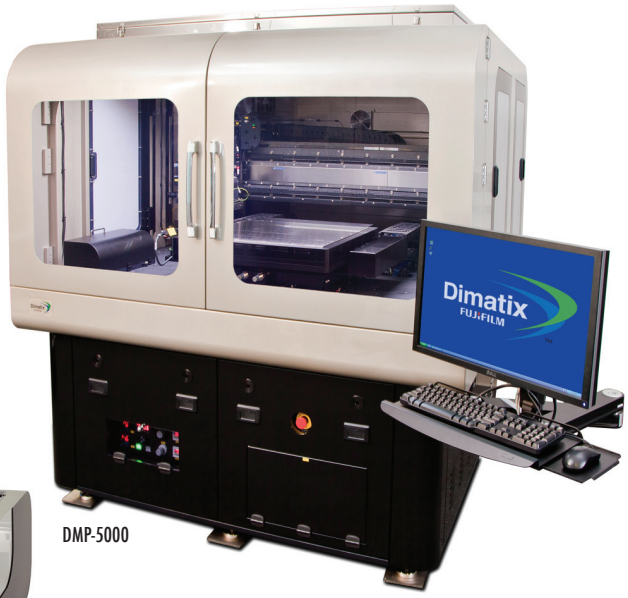
As a digital technology that can be scaled to accommodate process expansion, Piezo DOD inkjet is well suited to taking results from the lab into prototyping and production.

To address the market for materials deposition, FUJIFILM Dimatix in 2005 introduced the first of a series of Dimatix Materials Printers. More than 500 Dimatix Materials Printers have been installed worldwide to-date, used for a broad and expanding range of materials deposition applications and developments.

It also developed a line of interchangeable printheads and user-friendly PC-based software for DMP series printers.

DMP-3000


DMP-2800



DMP-5000

More than 500 Dimatix Materials Printers have been installed worldwide.

The printheads range from a single-use 16-jet cartridge printhead that users can fill with any type of jettable fluid, to production printheads with 128 jets, integrated cooling and driver-per-nozzle capability.

Single-use
Cartridge Printhead

Together, the printers, printheads and software comprise turnkey systems that enable users to develop new materials and products, and bring them to market faster, more simply and at significantly lower costs.

In the lab, Piezo DOD precision and accuracy supports even the most rigorous research and development requirements. On the manufacturing floor, systems outfitted with Piezo DOD inkjet printheads easily meet requirements for manufacturing speed and accuracy, able to operate at frequencies exceeding 50,000 drops/second (50 kHz) and at print speeds of one and one-half (1.5) meters per second.

Hastening R&D in the Lab

The smallest materials deposition printer is a bench-top system designed to minimize waste of expensive fluid materials and eliminate the cost and complexity associated with traditional product development and prototyping. Able to jet a variety of functional fluids onto virtually any surface with micro-precision, this DMP-2800 printer can build and define patterns over an area of 200 x 300 mm on substrates up to 25 mm thick. A vacuum-controlled substrate handling ensures accurate registration. The platen can be heated to 60 degrees Centigrade to thermally manage substrates during printing. An integrated drop watcher camera lets researchers capture and analyze droplet formation and firing.

The DMP-2800 employs single-use 16-jet Dimatix Materials Cartridge printheads available in 1 pl and 10 pl drop volumes that researchers can fill with their own fluid materials and snap into place. The 1 pl cartridge can deposit features as small as 20 µm (20 millionths of a meter) to fabricate products such as organic thin-film transistors (TFTs) and printed circuits or to closely pack large numbers of elements in DNA arrays to permit more accurate and efficient analyses. More than 85,000 Dimatix Materials Cartridges have been shipped since their introduction.

From Lab to Small-Volume Prototyping

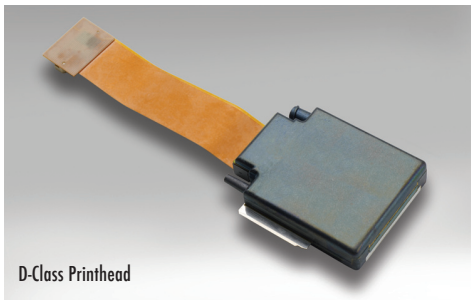
Filling the gap between experimental research and production equipment, the newer and larger DMP-3000 features a printable area of 300 x 300 mm while maintaining positional accuracy and repeatability of ± 5 μm (microns) and ± 1 μm (micron), respectively.

The temperature-controlled vacuum platen maintains accurate register and thermally manages substrates during printing, while an integrated drop visualization system captures droplet formation images dynamically as droplet ejection parameters are adjusted to enable tuning printhead and fluid combinations.

Sophisticated electronics allow the printhead to be calibrated on a per nozzle basis to compensate for any channel-to-channel variability. A second camera system allows substrate measurements and alignment, observations of fluid drying behavior, and droplet measurement and placement calculations.

Multiple FUJIFILM Dimatix printhead models including the 1 pl and 10 pl DMC cartridge-based printheads and larger SX3 and SE3 models can be used interchangeably. The compact and lightweight SX3 and SE3 are production-worthy hybrid jetting assemblies delivering 10 and 35 pl drop sizes, respectively, through 128 inline jets that can be individually tuned.

The DMP-3000 series can also be outfitted with either of two D-Class printheads also based on FUJIFILM Dimatix' proprietary Si-MEMS technology. The D-128/1 DPN and D-128/10 DPN printheads share identical physical features for easy interchangeability, and have 128 individually addressable jets with independent drivers per nozzle (DPN) to compensate for any channel-to-channel variability.



D-Class Printhead

Because all printheads designed for DMP systems can be used interchangeably, methods translated from the laboratory can be used to specify prototype and production system design and development.

From Prototyping to Production

The new DMP-5000 is a large format fluid deposition system that can use any DMP-series printheads interchangeably, offering drop volumes from 1 to 35 picoliters with both individually calibrated and tunable jets supported. It features a printable area of 500 x 500 mm (nearly 400 square inches) and maintains a positional accuracy of ±5 μm (microns) and repeatability of ±1 μm (micron).

This scalable approach means that initial research, sample and process developments are directly translatable from the laboratory and can be used to specify prototype printing system design and development. ■

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