Emerging Applications for Ink Jet Technology

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Abstract

Digital printing technology, originally developed for office and data processing applications, has moved beyond those in the past decade and is now finding use in virtually every field of printing, and even beyond printing in the usual sense.

In the past, ink jet printing has been used in product marking, carton marking, addressing, and large format printing and plotting, as well as office and home printing. Today, ink jet technology is also being applied in textile printing, the printing of packaging (beyond marking and addressing), postal franking, commercial photo processing, the printing of decorative materials, and even "printing" of three-dimensional objects. Tomorrow, we will see ink jet technology applied in even more esoteric fields, such as the printing of microcircuits and flat-panel displays, and in some areas that cannot be called printing at all.

Introduction

Since the mid-1990's, there has been an explosion of new applications for ink jet printing. This has been driven by several factors: First, by the arrival of new printheads that increasingly offer the combination of speed with quality; second, by the widespread knowledge of the technology that came with its arrival in homes and offices around the world; and most recently, by the development of a wide range of inks and other jettable fluids that address a great range of new applications.

Enabling New Applications

Over the past few years, we have seen the emergence of a new generation of printheads that may truly be called "industrial grade". They offer up to 500 channels, and may be arrayed to gain speed, quality, and up to eight subtractive or custom colors. They also offer various combinations of fast firing rates, tolerance for a wide range of fluids (varying in viscosity and chemistry), high reliability, excellent drop placement accuracy, and long service life.

Ink manufacturers have followed with a wide range of inks, based upon various approaches including water- and solvent-based, phase-change, and uv-curable. These use dyes or pigments suited to the application and often contain other application-specific additives. Other "inks" are fluids that are application-specific, such as low-melting solders for electrical connections.

All this has enabled a wide range of new applications. In addition, aggressive marketing by printhead and ink manufacturers and the appearance of ink jet printers in most homes and offices have sharply increased the range of potential users that are aware of ink jet technology and its capabilities.

New Printing Applications

The field of digital textile printing seems poised for new growth, moving from sampling (proofing) and very short custom runs to somewhat larger volumes. Already we have seen semi-production devices capable of printing more than 200m^2 per hour in widths exceeding 3m.

In the graphic arts arena, one ink jet color digital press (using continuous ink jet technology) is already commercially available. Several hybrid devices, using ink jet printing to add variable information on a conventional press, or to add color on a monochrome electrophotographic printer, have also been offered.

Ink jet appears to be quite suitable for printing directly on packaging materials. Several systems with uv-curable inks for package printing are available, and several flat-bed ink jet printers are also available for this application.

Ink jet technology is also being applied to the printing of bottles and cans, the decoration of music and software CD's, and even to the printing of decorative ceramic tiles.

Ink jet technology is also used to create digital screen masking devices, allowing direct production of screens from digital files, and direct-to-plate digital platemakers for offset printing. Both take advantage of phase-change inks to produce short-run masters.

One of the most promising opportunities lies in commercial photo processing Most digital photo printing will be on silver-based digital photowriters in the near term, but improved non-impact printing will quickly capture the market. It is likely to be shared by electrophotography and by ink jet. Already, ink jet-based minilabs have been introduced by several companies.

Still another opportunity lies in the printing of decorative materials such as wall- and floor-coverings and automotive trim. The printing of carpets by air-deflected jets has been practiced for more than thirty years, but more conventional ink jet systems are being used now to print at up to 400m^2 per hour.

Other opportunities lie in the printing of plastic cards, using solvent or uv-curable inks, and in the printing of glass, for both functional and decorative reasons.

Applications that Resemble Printing

An application that could be called "three-dimensional printing" is rapid prototyping. Here, three dimensional objects are built up through printing of layer after layer of phase-change or uv-curable ink, or by printing a binder on layers of powder. These systems currently build in the vertical dimension at up to 5cm per hour.

Ink jet printing is also finding its way into electronics manufacturing operations. Several companies offer legend printers, and others are developing inks containing micro metal powders to create the lands on circuit boards. Another approach involves the direct printing of resists onto metal-clad boards before etching. Solder bumps and printed solder interconnect towers are created by jetting molten solder. Polymer resistors are manufactured using ink jet technology as well.

More exciting still is the use of ink jet printing in conjunction with other printing technologies to produce diodes and transistors from semiconductive and conductive plastic materials. Arrays of such devices can form integrated circuits or backplanes for flat-panel displays.

Organic semiconductors are far slower than their silicon-based equivalents, and the scale of printed componentry is about 200 times that of the best silicon chips. One application area for which they are quite suitable already is TFT display backplanes, as well as other display components. The polymers used in organic light-emitting diodes (OLED's), and the phosphors and filters used in liquid crystal, plasma, and other displays can be applied using ink jet technology.

Similar techniques can be applied to the manufacture of radio-frequency identification (RFID) tags for use in product tracking and in production of low-cost solar cells.

Ink jet technology is also used in photonics manufacturing applications, to produce micro-lens arrays for photonic switches and light waveguide splitters.

Applications Beyond Printing

Ink jet technology is very useful for micro-metering or very accurate control of coatings. It is also useful for the precise placement of drops of very regular size. In this last capacity, it has found use in chemistry and biology.

In chemistry, the technology is finding use in combinatorial chemistry, an automated technique in which many reactions are carried out in parallel and the products screened for useful properties. It is also used in DNA and peptide synthesis.

In the biosciences, ink jet technology has long been used in cell sorting and in protein deposition for immunoassays. More recently, it has found application in DNA probe microarray fabrication.

Experiments in tissue engineering and in drug delivery are also being conducted.

Conclusion

Ink jet printing has found wide acceptance in many fields. Indeed, there are more ink jet printers in service today than all other electronic printing devices of all types combined.

While the desktop printer market is now maturing, there exist many opportunities for digital printing in commercial and industrial settings. Ink jet printing is uniquely suited to many of them.

Biographies

Tom Ashley received an A.B. degree in Chemistry from Transylvania University in 1963 and an M.S. in Organic Chemistry from Marshall University in 1967. Since 2001, he has worked as an independent consultant in digital printing, and is presently a Director of Pivotal Resources. Prior to this, he spent twenty years in research and development at IBM and Control Data corporations and fifteen with Dataquest, BIS Strategic Decisions, and CAP Ventures, all consulting firms specializing in digital printing.

Mike Willis received his degree in from the Polytechnic of Central London, with honors in Photographic Sciences, in 1975. He founded Pivotal Resources in 1995 and has served as Managing Director since that time, providing consulting services and educational conferences and seminars to the digital printing industry. Prior to this, he developed imaging processes at Gestetner and was a founder member of Xaar, a prominent ink jet technology developer and printhead manufacturer.