# Application of Industrial Inkjet Technology to Packaging

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Piezoelectric inkjet technology has advanced to become a key enabler for the digital revolution in manufacturing, and will transform analog production processes just as digital technology replaced analog in telecommunications.

Digital manufacturing offers fast turnaround times, economies-of-scale in small production runs, precise metering of expensive fluids, and minimization of material usage by substituting additive for subtractive processes. The demand for digital fabrication is fueled by the need to reduce the overall process cost of devices, and produce variation in a product without having to worry about high set-up costs associated with producing low unit volumes. Digital manufacture allows a designer to create a product using software, send the information to a computer-controlled manufacturing system, and have the computer precisely manufacture the product to specification. Turnaround time from design to production is minimized, and many cost disadvantages are eliminated.

Traditional analog manufacturing methodologies are inefficient at low volumes, and much of today's high-volume production is moving to low-cost labor markets overseas. Economies-of-scale are necessary to spread large set-up costs across many units, making one-offs and low-volume runs inefficient.

Inkjet is one of several digital manufacturing technologies. As an additive process, inkjet precisely controls the order and amount of fluids applied so expensive fluids and materials are not wasted. Analog methods such as etching are subtractive and involve applying fluid over an entire surface, masking the production region, and washing the rest away. For a manufacturer screening metal pastes onto ceramic, having a screen break while prototyping means starting over from scratch. Losses like these are unnecessary with inkjet technology.

As an extended range of jettable nanoparticle conductive, semi-conductive, and adhesive fluids become commercially available, new opportunities for inkjet are emerging in the packaging industry (Figure 1). Consider printing adhesives to precisely fix components to a wafer and printing conductive inks for making electrical connections. Nanoparticle conductive fluids could change electronics assembly because the particles in these materials can bond together at low temperatures. Silver nanoparticle inks can cure as low as 100°C.[1] New adhesive composites form nano-sized hook and loop structures to achieve thermal and electrical conductivity, and are 30× stronger than conventional adhesives on an area basis.[2] Inkjet can deliver metered amounts of a fluid at a precise location in time and space. Using these technologies can eliminate costly, labor-intensive steps involved in electronics packaging.

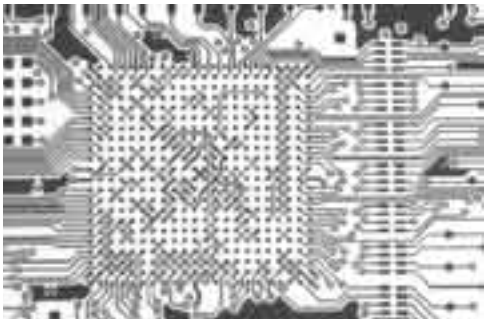

**Figure 1.** Silver conductive ink* printed using digital inkjet print heads**.

To take advantage of the flexibility and adaptability of industrial inkjet requires an investment in system design and implementation. An industrial inkjet system suitable for electronics packaging applications will consist of the print heads, print-head drive electronics, print-head support and maintenance subsystems, jettable fluid, fluid supply, and substrate. Motion control hardware, electronics, and software will be necessary to position the print head and substrate relative to each other. A curing or drying system may also be required to fix the jetted fluid to the substrate, or to obtain the desired material properties such as conductivity. Digital information must be communicated to the print head through electronic data interface hardware and software. Application-unique software is required to glue the system together and provide a user interface.

Industrial inkjet integration specialists can help with system design and implementation, and many system manufacturers are developing turnkey digital systems for specific applications. The key to success is finding a combination of fluids, substrates, and material handling systems to get the job done. This will require research and development efforts, though inkjet development tools are available to minimize research efforts and shorten time-to-market. **AP**

* Cabot Silver

** Konica Minolta

[1]Cabot Corp., Inkjet Silver Conductor Data Sheet.

[2]Rae, Alan. *Advanced Packaging*; 11/05.

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