Successful Jetting in SMT

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Jetting technology is a preferred choice to needle dispensing in most electronics packaging and board assembly applications, allowing designers to rewrite the rules to make smaller, less expensive, and more capable devices. This article gives the background of jetting technology and examples of its uses in the industry.

Jetting is the process in which fluid is ejected rapidly through a nozzle, using the fluid momentum to break free from the nozzle. A discrete volume of material is ejected with each jetting cycle. Typical jetting frequencies are 100–200 Hz, but can be as high as 1000 Hz for short periods. The most common use of jetting is printing. Many home office printers use a thermal or piezo ink jet, which is limited to special low-viscosity fluids. A mechanical jet* was developed for higher-viscosity fluids commonly used in electronics manufacturing.*

Jetting vs. Needle Dispensing

There are several differences between jetting and needle dispensing. When fluid is ejected from the jet nozzle, it detaches from the nozzle tip before contacting the substrate. Fluid is delivered in discrete volumes on the substrate to form individual dots, or combined to form lines or patterns. When moving from one dispense location to the next, it is not necessary to move the Z-axis, which saves a considerable amount of time. With needle dispensing, fluid remains attached to the needle tip and substrate surface, while the robot mechanics traverse in the X, Y, and Z axes. Gravity and surface tension of the substrate are used to pull fluid away from the needle. After each dispense segment or dot, a distinct Z-axis movement must occur before moving to the next dispense location.

Another significant difference between needle dispensing and fluid jetting is that high flow rates can be achieved when jetting. A jet nozzle with an inner diameter of 100 µm, a dispense gap of 2 mm, and a 0.5-mm nozzle length, can produce a flow rate that is 5× higher than a needle with a similar inner diameter.

The first adhesive jet was developed for surface mount adhesives to improve dispensing process speed. Each new generation of jetting devices marked an improvement in speed, accuracy, range of materials that can be jetted, the distance between the jet and the substrate, and range of dot sizes that can be produced. The ability to calibrate the mass of material, dot spacing for uniform lines and patterns, and to compensate for position offset when jetting from a moving head has made jetting faster and more accurate than needle-dispensing applications. It has enabled designers of electronic packages and circuit boards to create new designs.

As with other high-volume dispensing equipment, jetting systems use process control to ensure consistent performance to optimize production yield. One example is the ability to sample the mass of the jetted material, which enables the user to program the amount of material and the pattern, then let the system determine the spacing and location to jet the material. If volume changes due to material changes, the equipment compensates automatically.

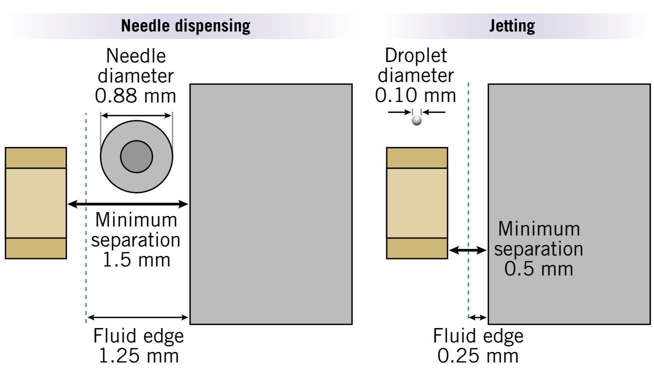

Figure 1. Jetting's non-contact technology is suitable for rapid and accurate fluid dispensing on densely packaged components.

Many fluids are sensitive to temperature variations. Multiple heating and cooling zones allow users to optimize the jetting process by controlling the material temperature at the point of dispense, and controlling material temperatures in the syringe or reservoir to extend the material working life.

Automated vision systems and control algorithms are used to calibrate dispense timing. This information is used to pre-trigger the jetting mechanism to ensure that fluid is delivered to the precise position when jetting from a moving robot, even at different speeds. The same vision system can be used to monitor and warn the operator if the jetted dot diameter falls outside of a predefined diameter or placement-accuracy range.

Many types of fluids can be jetted. Some commonly jetted fluids include underfill, SMAs, silver epoxy, liquid crystal, silicone (often filled with phosphor for the LED industry), UV-cure epoxy, getter fluids for MEMS devices, die-attach adhesives, flux, conformal coating materials, lubricants, biomedical re-agents, and inks. Each fluid category has a large range of variants; for example, some underfill fluids are densely filled to promote thermal conduction. In general, fluids that are formulated for high-speed dispensing can be jetted.

Most jetting devices used in electronics applications use fluid pressure and/or a needle-and-seat mechanism to generate the required fluid velocity. The shape and size of the needle, seat, nozzle, fluid pressure, stroke length and speed of the

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needle, and rheology of the fluid all influence the speed of the jetted fluid, as well as the volume of each discrete dot of fluid. Jets typically are configured for the fluid and desired application.

Jet valves have been configured with a variety of fluid reservoirs that match the volumes needed. Low fluid sensors are available for most syringe sizes, using a variety of sensing techniques. Fluid temperature control is a critical factor for any dispensing process. The same is true for jetting technology. Fluid temperature variation can cause variation with how the fluid drop breaks away from the nozzle tip. Jet valves use nozzle heaters to ensure consistent fluid viscosity at the nozzle-tip location.

Most jetting is done with a variation of the following two methods: stop-and-shoot jetting is a method, in which the robot positions the jet at a specific spot to jet one or more dots in one location, providing the flexibility to create different dot sizes with a single jet. Dispense positions can be programmed with computer-aided design (CAD) import to create complicated patterns. One jetting technique** can be used to create a specific profile for some applications. Another method*** takes advantage of the speed of the jetting mechanism, allowing the material to be jetted from a moving robot. Dots can be spaced by timing to optimize speed or by position to create specific line densities or an accurate overall mass when precise volume is needed. Either method can be modified by jetting at an angle non-orthogonal to the surface to allow placement of the fluid in difficult-to-reach areas, or to control the wetting of the fluid in specific areas, and by using timers for multiple jetting passes to allow material to wet or flow on the surface.

Applications and Technologies

Jetting is used throughout a range of industries. Electronic packaging was one of the first to incorporate this technology. Jetting through a shield, underfill for stacked die, jetting into closely spaced and BGA packages, and fluxing are a few applications needed to manufacture small portable devices.

Jetting through a shield is used in the manufacture of handheld devices. In such devices, RF shields are assembled over active components to minimize noise. Small holes are strategically placed on the RF shield to allow an opening for a fluid jet stream to pass through and underfill active components. The ability to jet through an RF shield after it has been placed saves assembly time and cost.

Densely packaged active die and complementary memory devices commonly are stacked atop each other to pack as much computing power and memory into the smallest volume possible. Because the proximity from die to die is so small, using a small-diameter fluid stream is critical. The ability to place fluid close to the edge of the die or package facilitates underfill flow with minimal wet-out area (Figure 1).

Many package and circuit board designers want to minimize the size of their designs. Jetting allows a designer to place flip-chip die as close as 350 µm and jet the underfill fluid between the die. The jet also allows “keep-out zones” to be as close as 250 µm from where the material is jetted.

Dipping or printing flux for flip-chip applications with small bump pitches can be challenging, if not impossible. Jetting can provide a process that delivers consistent amounts of a variety of fluxes in precise areas to improve production yields.

Although conformal coating has been done for many years, jetting has opened markets and applications for the process. Jetting makes high-speed, precise-edge-definition coating practical for many package designs and circuit board layouts, resulting in improved reliability in devices used in harsh environments. Jetting eliminates the expense of sealing mechanical handheld devices, which often is combined with traditional coating methods to provide selectivity around test points and connectors without the need for masking or sacrificing speed.

Medical applications for jetting have been increasing. Devices such as hearing aids, implantable pacemakers, and defibrillators, require small package sizes. Jetting also is used in non-electronic medical devices. One example is the placement of phase-change materials, such as waxes and adhesives, for “lab-on-a-chip” devices. Medical test devices that require aqueous and re-agent materials also use jetting technology.

The LED market also benefits from jetting technology, which provides the ability to place a variety of optical materials, including silicones and UV-cure epoxies filled with phosphor, precisely at very high speeds. Jetting accuracy improves production yield of high-value, high-power LED devices.

For flat-panel displays, the flexibility of creating precision dot patterns enables high-speed creation of gaskets for optical displays, while maximizing the display area with clean corners. Jetting also is used to make the “one-drop-fill” method of LCD assemblies faster and more practical.

In the disk drive industry, jetting underfill and conductive epoxies on high-density read heads enables smaller designs, improved yield, and faster production speeds. Methods of coating die to prevent particulate contamination also are used to improve product reliability and production yield. The fabrication and assembly of MEMs devices includes a number of demanding fluid-dispensing processes, including wafer-level assembly and package sealing. Jetting is used in these applications to improve product quality, production speed, and yield. Jetting systems are available in clean-room configurations meeting class 100 standards.

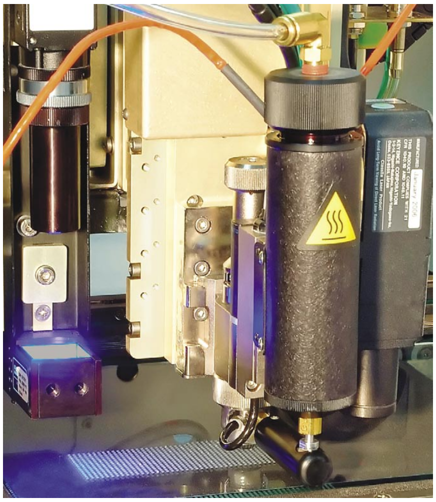

Figure 2. Jet with hot-wax feed system for use in the life sciences and hard disk drive industries.

Conclusion

Jetting is becoming the standard for dispensing in the electronics packaging industry, and it is still evolving. New fluids are being tested and qualified for jetting on a daily basis. Speed, accuracy, and range of volumes will improve. Ease-of-use will improve, and cost of ownership will be reduced. Jetting mechanisms for more abrasive and difficult-to-dispense materials, such as solder paste and high-viscosity thermal materials, will evolve to become more practical. As jetting's capabilities become better understood, designers will incorporate standards that leverage the technology. The process controls for jetting systems will also expand. The result will be lower cost production, higher yields, higher production rates, and improved quality. SMT

** Patented jetting technology, Asymtek, Carlsbad, Calif.*

*** Dot-on-dot technique, Asymtek.*

**** Jet-on-the-fly technique, Asymtek.*

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