The Dawn of Micro-Dispensing

Micro-dispensing handles small-dot solder deposition when stencil printing can't.

By Russell Peek

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As the technology for small electronic products evolves, the printed circuit boards in these products become more densely populated, and with ever smaller components. While designers struggle to squeeze more components onto shrinking amounts of real estate, assemblers face the daunting task of depositing precise, tiny dots of solder paste. Measuring 10 mils or less in diameter, solder paste dots must attach components and complete electrical connections without creating shorts or bridges (Figure 1).

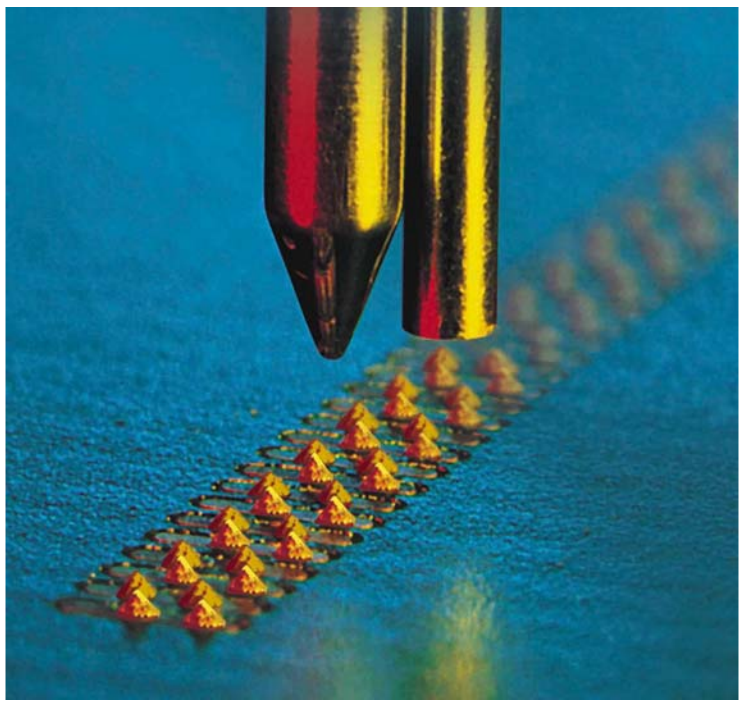

Figure 1. Because of the distance from pad to pad, fine-pitch solder paste dots must be dispensed in an offset pattern to avoid bridging during reflow.

Stencil printing is the fastest way to deposit large volumes of solder paste, but when PCBs are densely packed, this approach becomes less practical. For the toughest applications, manufacturers turn to "micro-dispensing" equipment.

Accurate, repeatable micro-dispensing depends on a variety of factors — from the air pressure at the inlet to the shape of the dispenser tip. Designed with these factors in mind, state-of-the-art micro-dispensing systems feature an array of hardware and software components that work together to put exactly the right amount of solder paste in exactly the right locations.

Material Considerations

A key to any micro-dispensing process is the composition of the solder paste. Important material considerations include the mesh size and metal content, plus how the material is packaged. These have a direct bearing on how the material functions during the dispensing process and ultimately, the quality of the interconnect.

For optimal dispensing, manufacturers should use a Grade 4 or 5 solder paste with 84-86 percent metal content. This is lower than the metal content of stencil printing pastes (normally 90 percent or higher). With lower metal content, the material flows better as it's dispensed.

Picking a Pump

Until recently, most micro-dispensing systems relied on time/pressure pumps. In these pumps, pulsing high-pressure air actuates a plunger that pushes material through a syringe. In the process, however, the pulsing air heats the material, changing both the viscosity and the dispensing volume. At the same time, the high air pressure breaks down the paste by separating the flux from the solder particles.

In new micro-dispensing valves, the time/pressure pump is replaced by a fully programmable auger pump. A low-pressure air supply keeps solder paste flowing into the pump cartridge without heating the material or breaking it down.

Attached to the pump is a motor that drives an Archimedian screw in the pump cartridge. Some systems employ DC motors that provide less-than-precise control of auger rotation. The reason: DC motors "ramp up" at the beginning of the dispensing process and "ramp down" at the end. These speed changes reduce the consistency of dispensed volume from one cycle to the next.

In more advanced systems, the DC motor is replaced by a brushless servo motor that provides constant speed. Attached to the motor is an encoder that precisely controls auger rotation. By breaking each turn of the auger into 57,000 segments, the encoder provides highly accurate dispensing.

Systems must also have software controlled auger speed to produce a repeatable dispense pattern. With finer mesh size and a large needle diameter, the pump speed can be increased. As the needle size is reduced, the pump speed must also be reduced. For example, pump speed of 250 rpm's is acceptable with a 20g needle and grade 4 material, whereas a 25-27g needle with grade 4 material must not exceed 45 rpm's.

As the auger screw wears down, dispensing volume changes — and accuracy and repeatability are lost. To minimize wear, both the auger and the cartridge liner are made of carbide steel. This carbide-in-carbide arrangement results in almost frictionless pumping of the solder paste. Having a tight tolerance of 0.0002” or less between the auger and cartridge is also very important for high accuracy dispensing. This tight tolerance will reduce any type of material clogging caused by trapped material particles.

Needle Tips

Micro-dispensing requires a special tip, or needle, on the valve. As the pump screw turns, it pushes the solder paste out of the cartridge and into the needle, which deposits the material onto the printed circuit board (Figure 2).

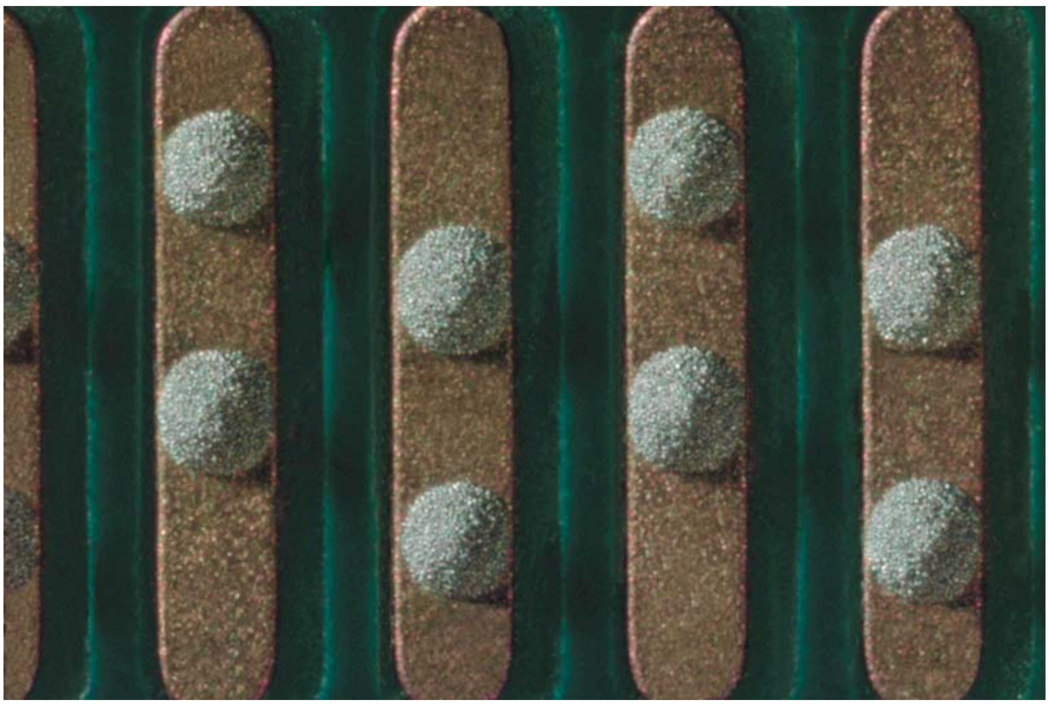

Figure 2. A footed needle is necessary to provide the correct Z-offset from the substrate and ensure the correct dot profile.

Most dispensing tips are made from rolled tubing. Often, though, this tubing has a poor interior surface that impedes material flow. This can result in clogging, a major problem in small-dot dispensing operations.

A better alternative is a stainless steel needle fabricated within tight tolerances. Needles that are precision machined from a single piece of solid stainless steel are ideal. A polished interior surface creates only minimal interference as solder paste moves over it, improving material flow and reducing the chances of clogging.

To reduce interior pressure, the inside needle diameter varies, with the largest cross section at the inlet end and the smallest at the tip. The tip is conically chamfered in the direction of material flow (Figure 3). This reduces surface tension between the needle and material at the point of separation, making it less likely that solder paste will cling to the tip. This, in turn, reduces the likelihood of tailing or bridging as the needle moves away from the dispensed dot. To find the dot diameter a needle will deliver, multiply the inside diameter by 1.5.

During dispensing, proper needle tip height must be maintained (Figure 4). A needle tip too close to the substrate can cause tailing and bridging, as well as carryover to the next dot location. A needle tip too far above the substrate can cause slumping of the dispensed material or bridging to the next location.

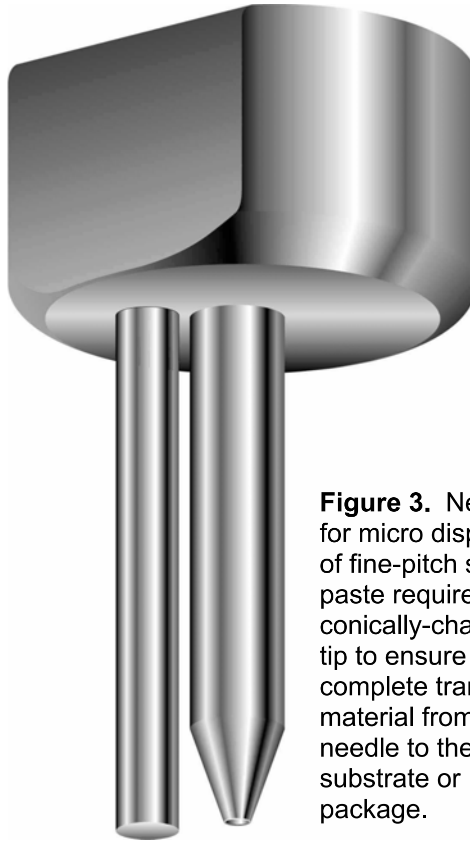

Figure 3. Needles for micro dispensing of fine-pitch solder paste require a conically-chamfered tip to ensure complete transfer of material from the needle to the substrate or package.

Needle tip height also determines the diameter-to-height ratio of the dispensed dot. For low-viscosity materials, the diameter-to-height ratio should be about 3:1; for high-viscosity pastes, the proper ratio is approximately 2:1. To determine the correct needle tip height, divide the inside diameter of the needle by two.

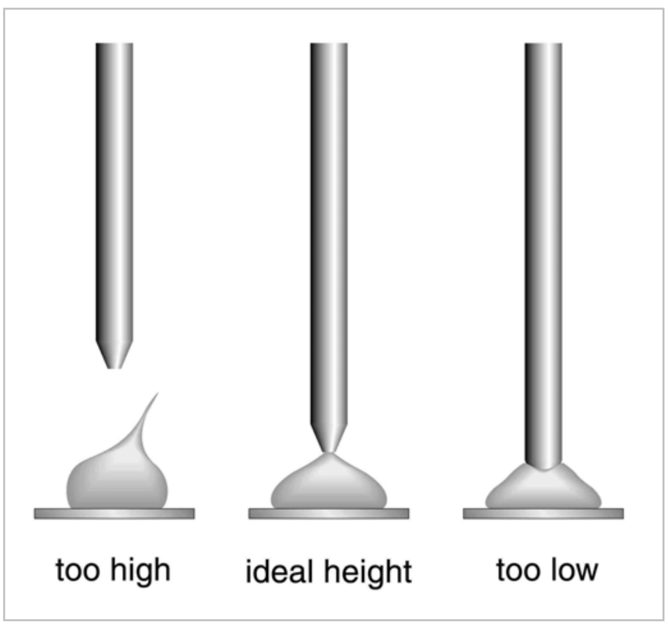

Figure 4. Needle tip height above the substrate determines the diameter-to-height ratio of the dispensed dot. A needle tip too far from the surface can cause slumping of the dispensed material. A needle tip too close to the surface can cause tailing and bridging of the material, as well as carry-over to the next dot location.

Platforms and Placement

While the pump assembly controls dot diameter and volume, the system's platform determines the accuracy of dot placement in X, Y, and Z directions. State-of-the-art platforms can achieve consistent positional accuracies within ±0.0015 inch and repeatability of ±0.0006 inch for all three axes.

Top-notch platforms include stainless steel components such as high-precision anti-backlash ball screws, linear bearing slides, and rails. They also include MIC-6 cast aluminum gantry plates, thereby ensuring additional X, Y locational accuracy.

The frame of these systems is made of a special composite material. Consisting of 90 percent quartz and 10 percent polymer, the material offers properties and weight that help the frame dampen shock and vibration caused by movement of the dispensing head.

Software Control

Essential to successful micro-dispensing is the software that controls deposition and gantry operations. Software compensates for deviations in motion and speed, ensuring precise, repeatable performance.

Advanced systems are managed by QNX, a Unix-like operating system developed specifically for precise machine control. QNX is a real-time multi-tasking software that provides process verification via closed-loop feedback within micro seconds. A Windows-type interface makes it easy for engineers to develop programs for a variety of applications.

Working within QNX is another software program, Contour Mapping®, that controls the gantry. This software maps each gantry position and automatically adjusts the system to correct inaccuracies in needle position.

Conclusion

As PCB space shrinks and component density soars, solder paste deposition gets too tough for conventional stencil-printing techniques. What's a manufacturer to do? Turn the process over to a micro-dispensing system. With hardware and software in control of every process variable, the system will accurately dispense the smallest dots in the tightest spots.

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