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Microvolume Dispensing

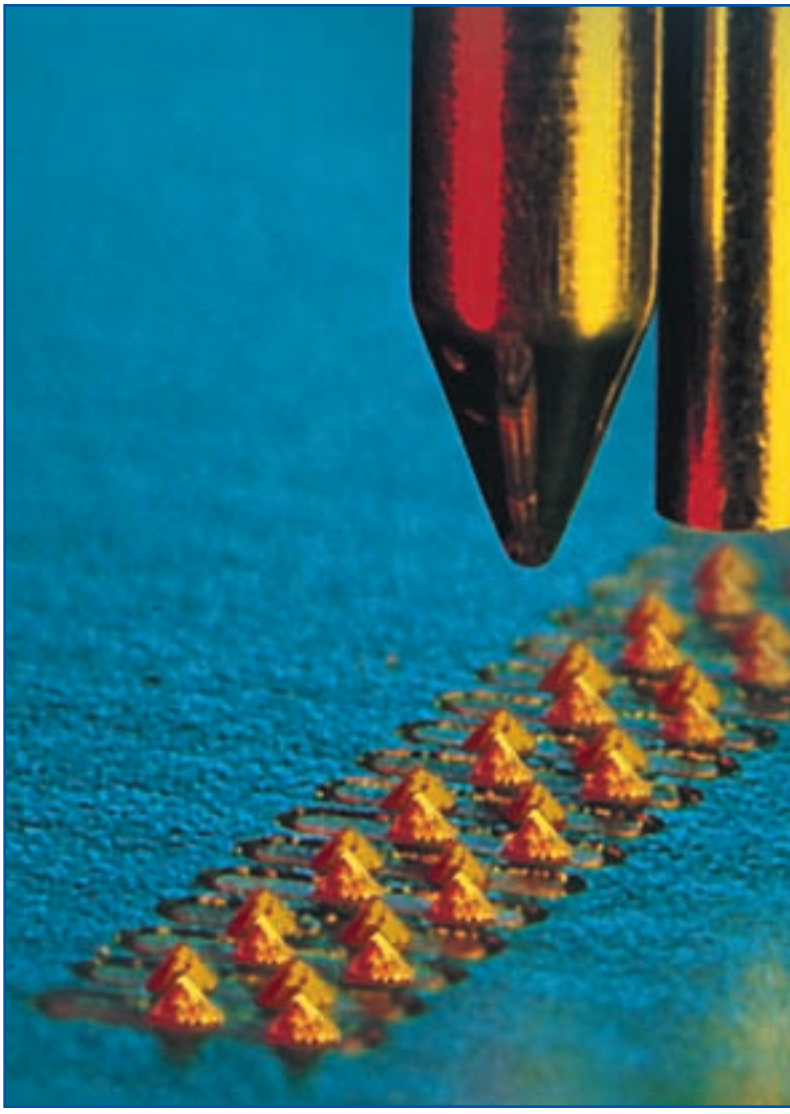
Die Bonding for Optoelectronics

Acoustic Microimaging of Edge Bumps

Microdispensing Pastes and Adhesives

A dispensing technology for solder pastes and adhesives makes dot sizes as small as 10 mils.

By Jeff Fugere



Flex circuits and printed wiring boards (PWBs) continue to shrink in size. Thanks to the evolution of cell phones, pagers and personal digital assistants (PDAs), designers are employing faster and smaller IC chips and packages, while looking for ways to place more capacity on available real estate. As a result, manufacturers face the difficult challenge of depositing solder paste and adhesives in extremely precise and repeatable patterns for mounting ultra fine pitch leaded devices and a variety of area array devices, including ball grid arrays (BGAs); chip-scale packages (CSPs), most notably micro-BGAs; and direct chip attach (DCA) components, such as flip chips.

Microdispensing is the process of dispensing small volumes (less than 0.010-inch diameter) of solder paste and adhesives with consistent precision. Numerous factors must be considered in a microdispensing system, including platform, controlling software, syringe, dispensing needle and material feed pressure. However, the heart of any liquid dispenser is the pump, and equipment performance is typically

measured by the quality and consistency of the dispensed material. Over the years, numerous differing pump configurations have appeared, including simple time/pressure, positive displacement, rotary auger and variations in between. However, for dispensing microvolumes of material, none of these types has been completely satisfactory.

Rotary Auger Pumps

The dispensing process involves the placement of material, either solder paste or adhesive, to secure the component to the substrate or to protect a component already secured on the substrate. Time/pressure pumps rely on pulsed high-pressure air to provide force on a plunger, thereby moving the material through the syringe.

In contrast, rotary auger pumps employ an Archimedian screw (auger) turning in a cartridge or sleeve to push the material through the pump. Powered by a pulsed DC motor with brushes, the pump may utilize an electromagnetic clutch to engage and disengage the screw. A low pressure air supply maintains a steady flow of the material into the pump.

Solder paste or adhesive is forced through the cartridge by the auger in precise amounts. Heating of the material does not occur, as it does with pulsed air systems. Because the material's temperature is stable, its viscosity remains constant. In addition, unlike other types of dispensers, including the piston pump, the paste or adhesive is not compressed to the point where its density and homogeneity are altered.

The rotary auger pump is good for mounting of components where dot diameters are above 0.014 mils. However, the rotary auger pump has a serious drawback for microdispensing. In initiating a dispense cycle, the pump motor must ramp up and, at the end of the cycle, the motor must ramp down. In these two actions, slight delays occur as the motor reaches its maximum rpm and as it slows down to zero.

Some manufacturers have pumps where the motor runs constantly, using the clutch to control rotation. Despite this feature, slight delays in starting and stopping are an inherent aspect of the design, and precise rotation of the auger is impossible. Accordingly, exact amounts of material cannot be dispensed, a fact that becomes more critical as volumes and dot diameters diminish.

Microvolume Pumps

Given the unsuitability of time/pressure and piston pumps for microdispensing, the technology of an auger rotating in a cartridge offers the potential for achieving the required accuracy. However, the key to successfully dispensing material with dot diameters of 10 mils or less is in precisely controlling the auger's rotation.

A new type of pump overcomes the limitations of conventional rotary auger dispensing, while retaining the basic screw technique of pushing material through the pump (Figure 1). The pump is programmable and has a brushless DC servo motor with an encoder that precisely controls the auger's rotation. The encoder provides 57,000 counts per revolution, which means that a single 360° turn of the auger can be segmented into 57,000 portions of a revolution for accuracy and repeatability. No ramping up or down is needed; instead, a programmed dispense signal creates a direct, specific rotation of the auger.

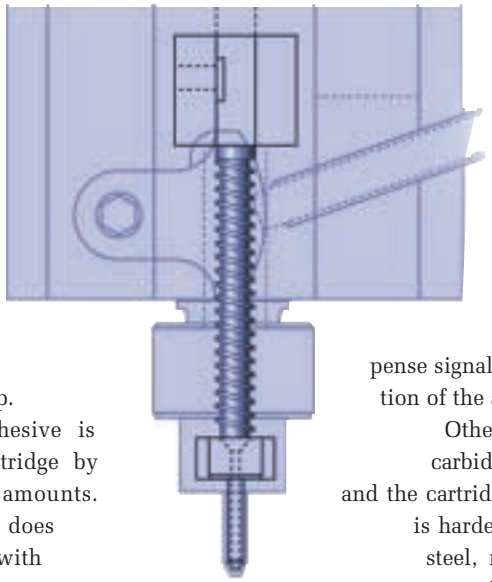


FIGURE 1: Cross-section of microvolume pump.

Other useful distinctions include carbide construction of the auger and the cartridge liner in the pump. Carbide is harder and smoother than stainless steel, resulting in near friction-free operation. In addition, the microvolume pump can introduce material to the auger at an angle, thereby lessening the material's tendency to retard the auger. In contrast, a conventional auger pump feeds material at a 90° angle to the axial line of the auger.

The microvolume pump also has a soft-mounted syringe to reduce the settling or compacting of material that can occur during repeated up and down Z-axis movement of the dispensing head. While the soft-mounted syringe converts the shock of the head into vibration, hard-mounted syringes on conventional pumps absorb the shock entirely, thereby compressing the solder paste or adhesive.

In dispensing small volumes of material, clogging of the needle can be a significant problem. The microvolume pump uses highly polished stainless steel needles with a chamfered tip,

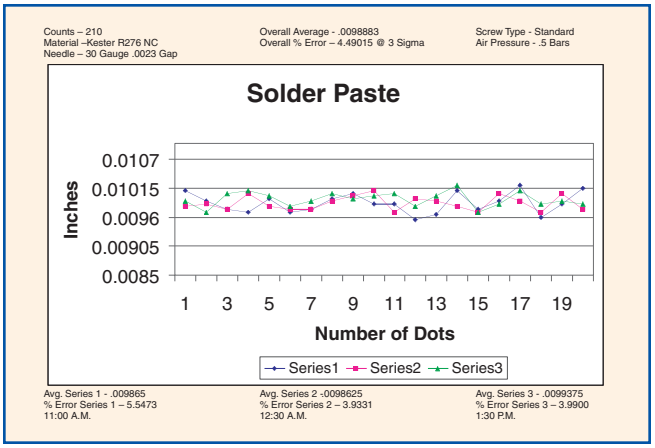


FIGURE 2: Performance tests of dispensed solder paste with microvolume pump.

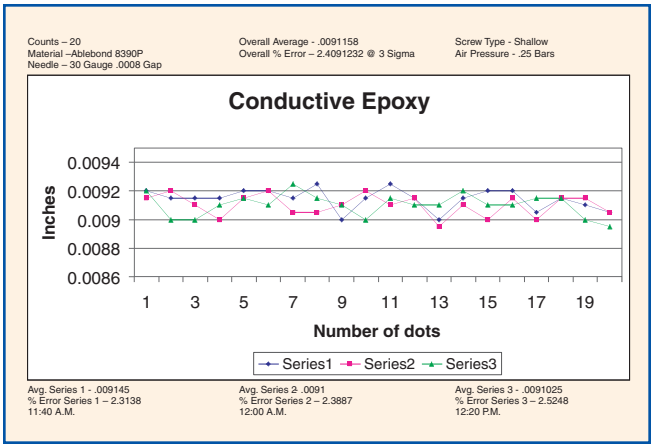


FIGURE 3: Performance tests of dispensed adhesive with microvolume pump.

which reduces the surface tension between the needle and the material. As a result, the solder paste or adhesive is less likely to stick to the tip, thus reducing tailing or bridging as the needle lifts up from the dispensed dot. The polished interior surface and the fact that the needle is constructed of a single piece extrusion ensure the least amount of surface interference as the material flows through the needle.

In contrast, most needles in other dispensing systems are of two-piece construction using rolled tubing. As a result, the needle's irregular interior surface can catch the material and lead to build-up over time, thereby degrading the quality and consistency of the dots being dispensed.

Microvolume Pump Performance

As dot sizes for solder paste and adhesives shrink to 10 mils and less, the challenge for dispensing systems increases. A conventional rotary auger pump cannot consistently dispense 10-mil dots. However, the microvolume pump is consistent for microdispensing.

Figure 2 shows the results of dispensing solder paste with a microvolume pump. The pump was equipped with a 30-gauge needle with a gap of 0.0023-inch. The objective was to dispense 10-mil dots. As shown, three separate series of tests were run, with a minimum dot size of 9.6 mils and a maximum dot size of 10.2 mils over all test points for all three tests.

Figure 3 shows the results of dispensing adhesive with a microvolume pump. In these tests, the pump was also equipped with a 30-gauge needle, except the gap was 0.0012-inch. Again, the objective was to dispense 10-mil dots. Three tests were run, with a minimum dot size of 9.0 mils and maximum dot size of 9.7 mils over all test points for all three tests.

Conclusion

With assembly densities continuing to increase as microcomponents become the norm, precise dispensing of small volumes of solder paste and adhesives has become a challenge for existing equipment and, in particular, traditional types of pumps. The need to dispense dot sizes as small as 10 mils with high repeatability has led to the development of a programmable microvolume pump, in which an encoder ensures exact rotation of the auger screw and, thereby, consistent dot sizes. Performance tests conducted on the microvolume pump demonstrated its ability to precisely and repeatably dispense solder paste and adhesives. ■

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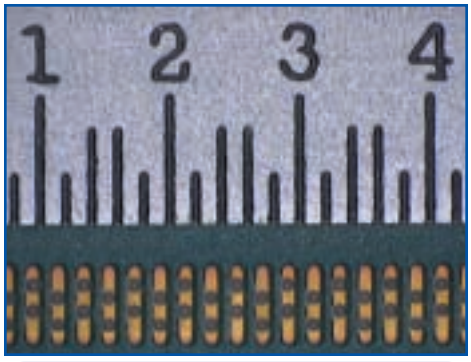
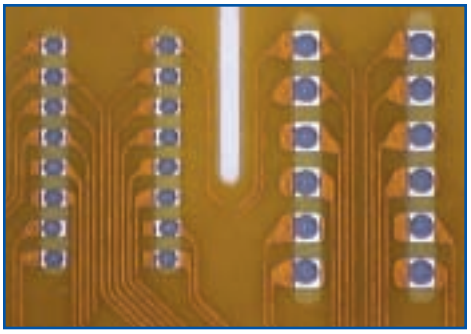


Applications for CSPs and direct chip attach components require dispensed solder in volumes as small as 10 mils; the smallest increment in the scale shown above represents 0.02 in. or 508 µm.



Dispensing needles and pumps are required to dispense a variety of solder paste volumes. Dual pump configurations can be used to dispense two different dot sizes on the same substrate simultaneously.

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