Fluid Dispensing Capabilities for Assembly of MEMs

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Abstract

The assembly of MEMs devices may include a number of fluid dispensing processes. Uses for fluids include; bonding, coating for protective or optical functions, getter materials, electrical connections, and many other functions. The automated dispensing equipment that is used in electronics assembly and packaging is well suited for many MEMs devices. This paper does not focus on any specific device, but discusses the capabilities of dispensing equipment. Various technologies are discussed for making small dots of materials, small lines, and film coating. Conventions of specifying the requirements for automated dispensing processes are discussed. Matching up the fluids, the dispensing technology, and the capability of various combinations will be the key focus. Some examples of fluid dispensing for MEMs are given.

Dispensing Technologies

Three major categories of fluid dispensing technology include: Pin transfer, needle dispensing, jetting, and spraying.

Pin transfer uses pin that is dipped into a reservoir of fluid. The fluid is transferred to the part by touching the pin to surface of the part.

Needle dispensing is one of the more common methods used in automated fluid dispensing. Material is extruded through a needle that is held close to the surface of a part. As the needle is pulled away, the fluid is held to the board by gravity and surface tension. A variety of devices can be used to extrude the material through the needle: auger pumps, pneumatic pumps, or piston pumps. Needle dispensing devices may include valves to control the flow of very low viscosity fluids. Material viscosity from 1 cps (water) to over 1,000,000 cps (thick grease) can be dispensed with needles.

Jet dispensing energizes a specific quantity of fluid such that the kinetic energy of the fluid is used to break the fluid stream from the nozzle. Viscosities of 1 cps (water) to over 100,000 cps (surface mount adhesives) can be jetted with various mechanisms. Complex fluid rheology is an important factor in the suitability of a fluid for jetting.

Spraying, either atomized or non-atomized, can used to form coatings or films of materials. Fluid is extruded through a nozzle. The fluid is dispensed in a continuous curtain or becomes atomized depending on fluid rheology, material flow, and nozzle design.

Dot Dispensing

Large deposits of fluid can be made with relative ease, so the discussion here will focus on the practical lower limits available commercially.

With pin transfer, fluid deposits of <1 nanoliter and 100 µm in diameter are possible with many adhesives. The stability of the processes are difficult to control since the amount of fluid deposited can vary as fluid characteristics change. The process requires open containers of fluid. Evaporation, contamination, and moisture absorption can affect the Process. Pin contact with the part may not be acceptable for the assembly of some devices.

Needle dispensing performed by automated equipment for electronics assembly can produce deposits of materials as small as 3 nanoliters and 125 µm in diameter. Figure 1 shows solder paste dots 130 µm in diameter dispensed with a needle. Figure 2 is an example of 163 µm silver dots on a wafer level package. The diameter of the needle, the surface tension of the fluid, and the gap between the needle and part limit the size of the deposit. For fluids with solid particles, the size of the particles can put a minimum limit on the inside diameter of the needle. For low filler content, 10% or less by volume, the inside diameter of the needle should be at least 2 to 3 times the diameter of the particles to prevent plugging. For higher filler contents, up to 50% by volume, the inside diameter of the needle may need to be up to 7 times larger than the particle size. Dispensing materials with greater than 50% solid particles by volume can be problematic as it is difficult to get complete wetting of the particles.

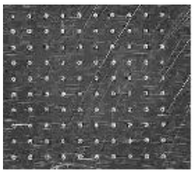

Figure 1. 130 µm solder paste dots

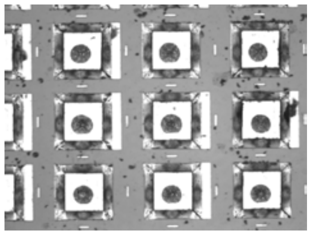

Figure 2. 163 µm silver epoxy dots on a wafer

Precise location of the needle above the part is critical to the repeatability. Surface tension of the fluid and its attraction to the part being dispensed upon are necessary to pull the material off the needle. Mechanical standoffs can be used to create precise dispensing gaps, but contact with delicate MEMs devices is not always feasible. Laser sensors are often used to help position the needle above the surface of the part so that only the fluid comes in contact with the part.

Jet dispensing picoliter volumes of low viscosity materials are widely used in printing technology, however, fluids used in these applications are generally limited to specially formulated inks. Jetting of materials likely to be used for MEMs assemblies, such as adhesives, find a practical limitation of approximately 3 nanoliters and larger. Diameters of approximately 250 µm are possible, as shown in figure 3. Many of the limitations of solid content and filler size of needle dispensing apply to jetting.

Jetting fluids can provide some unique advantages. The energy for breaking the fluid from the nozzle comes from the kinetic energy of the fluid. Jetting is less sensitive to the gap between the nozzle and the part. The fluid stream from a jet can be as small as 100 µm in diameter, allowing fluid to be deposited in areas that it is not possible to place a needle.

Requirements for dot dispensing can include criteria such as the volume, height , diameter, and position location of the dot. The diameter and position of a deposit can be measured with a variety of optical devices, but the height and volume of individual deposits are difficult to measure with sufficient precision. A common method of verifying process stability is to measure the average weight of a large quantity of deposits and divide the weight by the density to compute the volume. A correlation between volume and diameter can be used to get an indication of the accuracy and repeatability of the process. Pressing the fluid between two surfaces with a fixed gap and measuring the area can also be used.

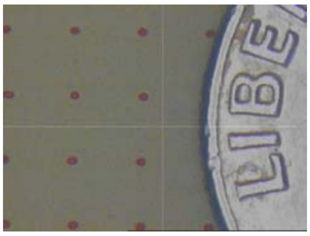

Figure 3. 250 µm jetted dots of adhesive

Line Dispensing

Lines or beads are formed with fluid for many applications, the most common being a gasket or a seal for a device. The cross section area and the width of the line are usually interest to the designer. In some applications, the width or height may be of primary importance.

Dispensing lines or beads of fluid with a needle is performed by extruding material in a continuous stream while move the needle relative to the part (or part relative to the needle). Line widths of as small as 100 µm are possible. Most commercially available dispensing equipment for electronics assembly is capable of 200 µm width lines. Figure 4 shows a 250 µm wide line of silicone used to form a lid seal for an MOEMs sensor that was dispensed with a needle. The height of the line is dependent on the fluid rheology. Fluid must be thixotropic if a height to width ratio of 0.5 or greater is desired. Limitations on filler content and particle size apply as they do to dot dispensing. The cross section area (volume per unit length) is limited by the cross section area of the needle. If the cross section area of the line is less than the cross section of the needle, the material will be stretched as it flows from the needle. Controlling width of the line can be very difficult in this case since the tension for stretching the fluid comes from the adhesion of the fluid to the part.

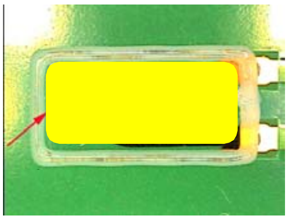

Figure 4. 250 µm silicone lid seal for MOEMs sensor

The profile of a line is dependent on the gap between the needle and the part. Non-contact laser devices can be used to set this gap, but part and tooling flatness help make the production process robust.

Jetting can be used to form lines of material. Discrete deposits of material are dispensed close together, allowing the deposits to flow together to form a line. The cross section area of the line is adjusted by the size of the deposits and the spacing between them. Line widths <350 µm are possible. Relative insensitivity the gap between the nozzle and the part make this process robust. The narrow fluid stream makes it possible to deposit fluid where a needle may not fit. Figure 5 shows a conductive line that was formed across a 3 dimensional surface of a MEMs sensor by jetting silver epoxy. Figure 6 shows a cavity wall that was formed by jetting silicone based material.

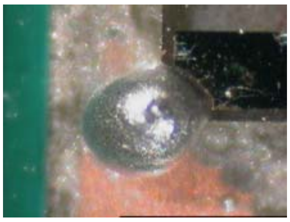

Figure 5. 3D line of conductive silver jetted on MEMs sensor.

Figure 6. Cavity wall formed by jetting silicone adhesive

Requirements for statistical process control vary for lines, but usually are focused on width, height, cross section area, and/or placement of the line of material. Width and placement are measured with relative ease, but height and cross section area can be difficult to measure with sufficient precision. If it is possible to cure the fluid to make it solid, the height and cross section can be measure mechanically. Laser scanning devices are often used for measuring height and cross section, but can be difficult for fluids that are transparent or translucent.

Dispensing of Films or Coatings

Applications that require a film of material to be dispensed over a specific area are most commonly sprayed. Jetting or needle dispensing can be used if the materials are very low viscosity and have sufficient wetting to achieve the desired thickness.

In non-atomized coating, the material is dispensed in a laminar flow fan of thin film that is moved across the area to be dispensed. The thickness of the film depends on many variables, but usually is in the range of 20 to 75 µm. The chief advantage to this method is the ability to control the edge definition.

In atomized spray, enough energy is put into the fluid stream to cause the fluid to break apart into small droplets. This can be done with pressurized fluid through special nozzles or with an air stream mixed with the fluid stream. A jetting device can be use to produce a partially atomized fluid stream. The advantage of atomization is that it can produce very thin coating as compared to non-atomized methods. <5 µm wet fluid thickness coatings are possible.

The dry thickness of the coating can be adjusted by the use of solvents. Adding solvent to a fluid reduces the dry thickness proportionally. Wetting characteristics of the fluid to the part for good coverage. The addition of a low energy, non-etching, plasma-cleaning process can be used to improve wetting.

If the coating thickness is to be controlled carefully, thought must be given to metrology. Wet film build gages can be used for checking specific points. If the entire surface must be controlled, mechanical and optical methods are available for many coatings.

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