Adhesive Deposition

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When choosing whether to dispense adhesives with high-speed dispensing equipment or a stencil printer, a number of factors must be taken into consideration.

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Dispensing epoxy for bottomside chip attach before wave soldering can be accomplished with a wide variety of processes, including the use of a screen printer or dispensing equipment. In many cases, surface mount adhesives are being deposited with high-speed dispensing systems that primarily use a single tip for each dot or area of epoxy being placed. When using high-speed dispensing equipment, a number of factors contribute to maintaining a consistent dot placement.

Adhesive

The liquid properties of adhesives play a major role in both dispensing and printing. Viscosity of the material can determine air pressure and time set-points for nozzle systems and print speed settings for screen printing. Finding the correct combination of liquid properties can be the most important part of setting up a repeatable adhesive dispensing system.

Dispensable epoxies can be printed easily, but additional factors must be considered (Table 1). These factors include drying out, moisture absorption, contamination from cleaner solvents and others. For these reasons, adhesive chemistries have been specially formulated to the environment in which they are to be used.

Machine

Screen printing machine considerations can be considerably less than those for high-speed dispensers. Typically, the print pressure is set for cleaning off the stencil, as in solder paste printing. The print gap is set for contact printing, again as in solder paste printing.

The main parameter of concern is the print speed. For the most part, epoxy viscosity limits print speed. Because of the normally lower viscosity, epoxy printing can run at higher print speeds. As a result, throughput can normally be kept below 30 seconds. In comparison with high-speed dispensing equipment, there is a definite advantage to screen printing as the number of components or deposition locations increases.

Tooling

Tooling primarily consists of the stencil and aperture design. Stencil design is largely dependent on the components being placed. Design limitations such as aperture size vs. stencil thickness come into effect for smaller components - this causes problems when placing small components at the same time as large components with higher standoffs. This experiment is directed at finding a solution to screen printing epoxy for both small and large components at the same time, using the same stencil. It requires some nonstandard aperture designs to help achieve a large variation of deposit thicknesses.

Another tooling consideration for screen printing epoxy is the squeegee. A metal squeegee at a 45° angle has proven to print consistently, as determined by prior studies.

The major tooling consideration for high-speed dispensing is the nozzle. Factors such as the inner and outer diameters of the nozzle must be determined, as well as the standoff distance and location in relationship to the nozzle.

Another factor to consider is whether to dispense single or double dots to achieve the best adhesive strength and centering characteristics. Nozzle standoff wear can be a major problem with controlling adhesive dispensing. Constant hammering of the nozzle onto the printed circuit board (PCB) has a large impact on nozzle life.

Board Design

Board design plays a significant role in consistent adhesive deposition. Trace and via locations can get in the way of the nozzle standoffs. Inconsistencies in the mask thickness and solder pad height abnormalities, as seen with hot-air solder leveled (HASL) boards, can cause trouble for both nozzle dispensing and screen printing.

Metal-mask stencils offer an economical method for the deposition of adhesives onto the secondary (solder) side of a PCB. They also offer a flexible method for controlling adhesive volume, height and spread:

Adhesive volume. As in all printing processes, volume is a critical consideration for adhesive deposition. If there is insufficient volume, the component will skew or detach during placement and processing. If there is too much volume, the adhesive will intrude on the land patterns, causing opens and increasing cost through waste. With metal-mask stencil applications, the volume of material deposited on the substrate is controlled by three factors: length, width and thickness of the stencil aperture opening. Adhesive deposition, however, deviates slightly from normal practices.

Component standoff dictates the required adhesive height. This leaves the task of volume control to the length and width of the stencil aperture opening.

Adhesive height. Height is critical because insufficient height will prevent the component from contacting the adhesive and defeat the gluing process. Excess height can cause the adhesive to spread erratically, possibly intruding on the surface mount land patterns and causing opens.

As stated earlier, individual component standoff dictates the required material deposition height. This becomes more complicated when there are components with varying standoffs on the board. Material deposit height is controlled through a combination of stencil thickness and printing techniques (Figure 1).

Adhesive spread. Proper adhesive spread results in sufficient wicking of the glue onto the component. This ensures that the component is held in place during placement and processing, preventing detachment or skewing. Improper spread may cause the adhesive to intrude on the surface mount land pattern, causing opens. It may also result in insufficient adhesive wicking, allowing the component to skew or detach during placement or processing. This critical element of adhesive printing is controlled by aperture design - with the appropriate design, the adhesive will spread in the directions desired to achieve proper wicking, and prevent surface mount land-pattern intrusion.

It is convenient to separate adhesive deposition with a metal-mask stencil into three main categories:

1. The gluing of standard chip components with standoffs between 0.002 and 0.005".

2. The gluing of standard chip components, small-outline integrated circuits (SOIC) and plastic leaded chip carriers (PLCC) where the standoffs can be between 0.002 and 0.030".

3. The application of adhesive where there are intrusions on the board that require clearance on the board side of the stencil to achieve proper gasketing.

The design and printing techniques for each application will be discussed, taking into account adhesive volume, height and spread (Figure 2).

Gluing Standard Chip Components

Generally, the standoffs for these types of components will be between 0.002 and 0.005", requiring only minor modifications to the normal stencil design. Volume is controlled by controlling aperture size, which is generally noncritical for these types of components; a tolerance of ±0.001" should be sufficient. Tighter tolerances are easily achieved.

Because of the relatively short standoff, the stencil thickness should be sufficient to control material deposit height. A stencil of 0.006 to 0.010" will provide the height required, ensuring that the component contacts the adhesive. Adhesive spread is controlled by aperture design. By looking at the relationship between the width of the surface mount aperture and the gap between the pads, the appropriate aperture size can be determined. A simple design guide for chip component glue apertures is 33 percent of the gap (G) between pads and 110 percent of the chip component width (W). The glue is placed in the center of the gap. The shape of the aperture should be obround (Figure 3).

Gluing PCBs with Standard Chip Components and PLCCs

With the addition of PLCCs and SOICs to the equation, stencil design becomes slightly more complicated. PLCCs and SOICs have standoffs of up to 0.030" thick. A simple answer would be to produce a stencil with a thickness of 0.035" to ensure that the appropriate adhesive height is achieved. This does, however, bring up the question of aspect ratio, especially on smaller chip components.

If the adhesive that filled the stencil aperture for a 0.030" thick stencil were to release, it would exceed the requirement for 0402 components. However, adhesive does not exhibit the same characteristics as solder paste. Interestingly, aperture sizes of 0.015 to 0.020" in width for a 0.030" thick stencil do not release all of the adhesive to the substrate. This results in adhesive heights of 0.004 to 0.009", depending on the aperture size. Above 0.020" in width, the adhesive begins to release more freely from the stencil, resulting in higher material deposition.

However, a stencil of 0.035" requires extra processing and may not be the best solution. Through a combination of aperture design and printing techniques, a much thinner stencil can be used to achieve the same, if not a better, result. A stencil of 0.015" can be used to deposit adhesive on components with standoffs ranging from 0.002 to 0.030" and higher. A print-flood technique is used to achieve this result.

In this technique, adhesive is printed using a normal flood print mode. However, before the board is released from the stencil, an additional flood-only print mode that places an additional 0.015" thick layer of adhesive on the stencil is employed. The board is then allowed to separate from the reservoir created by the flood print mode. In this manner, large apertures can provide thick adhesive deposits (0.035") while the small apertures are still restricted and deposit only 0.006 to 0.009" high adhesive.

Controlling the length and width of the aperture controls volume. The obround shape is again the preferred shape. Spread is controlled through aperture design and shape, and height is controlled through the printing technique. Generally, there should be one glue aperture for each chip component being glued. When the chip components are arrayed linearly, one continuous aperture can be used to cover all of them - no adjustment in aperture width is necessary. When gluing PLCCs and SOICs, more than one aperture should be used. The goal is to cover 30 percent of the open area under the component (Figure 4).

Clearance on the Board Side of the Stencil

There are several occasions when an existing component or other intrusion requires clearance on the board side of the stencil. Standard stencil solutions do not address this situation.

As discussed earlier, a 0.035" thick stencil can be used to deposit adhesive onto a PCB. If a pocket is etched on the board side of the same stencil, it will allow for the intrusion and provide proper gasketing. Controlling the length and width of the aperture opening in the stencil can still control volume; height is dictated by the clearance needed by the intrusion. Fortunately, as stated earlier, aperture sizes between 0.015 and 0.020" do not release all of the adhesive material, resulting in the appropriate deposit height for the smaller chip components. Aperture design and shape control adhesive spread - again, obround is the preferred shape (Figure 5).

Why Stencil Printing?

Consider a dot placement rate of 30,000 to 40,000 dots per hour for the dispensing equipment; throughput can be com- pared using Table 2. It should be noted that dispensing equipment placement rates are based on ideal situations with programs at maximum optimization (Figure 6).

Deposition Flexibility

Because of the unlimited aperture designs available with chemical or laser etching processes, adhesives can be deposited in a wide variety of shapes and patterns (Figure 7). For this reason, the deposition can be customized to the device being placed. Aperture design can be manipulated to maximize the adhesive properties, both before and after cure. For some larger mass devices, the contact area must supply enough wet strength to hold the component through subsequent placement processes. This is easily accomplished with stencils because of the design flexibility.

Conclusion

The combination of throughput times, aperture design and equipment utilization make screen printing adhesive for bottomside chip attach an attractive alternative to standard deposition methods.

With an average dispense time of 0.5 minutes, screen printing offers re-duced cycle time, especially as the number of depositions increase. Using a screen printer for adhesive deposition also enables increased equipment utilization. No longer does a line sit idle waiting for a dispensing machine to complete its task. With advances in stencil manufacturing techniques, apertures of any shape can be used for adhesive deposition - this translates to great design flexibility. Considered in combination, these elements make screen printing adhesive an attractive alternative to traditional adhesive deposition methods.

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TABLE 1

Factors to Consider When Dispensing Adhesives

Dispensing	Screen Printing
Adhesive	
Viscosity	Viscosity
Wetting ability	Wetting ability
Temperature stability	Temperature stability
Machine	
Pressure	Print pressure
Time	Print speed
Temperature stability	Print gap
Support tooling	Support tooling
Throughput	Throughput
Tooling	
Nozzle design (Standoff height, diameter, etc.)	Aperture design (area vs. thickness, etc.)
Nozzle clogging	Aperture clogging
Nozzle wear	Squeegee type
Nozzle cleaning	Squeegee wear
	Stencil cleaning
Board Design	
Pad design (HASL, etc.)	Pad design (HASL, etc.)
Mask design	Mask design
Trace locations	Trace locations
Via locations	Via locations

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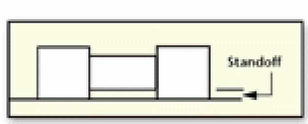

Figure 1. Material deposition height is often dictated by individual component standoff.

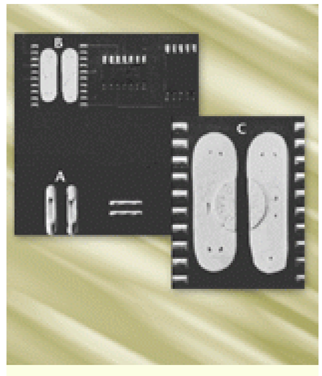

Figure 2. Adhesive before (a) and after (b) component placement, with a close-up view of the adhesive after placement (c).

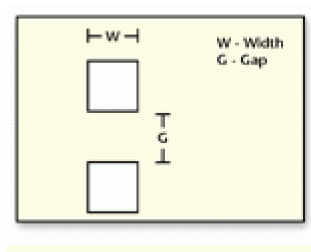

Figure 3. The appropriate aperture size can be determined by examining the relationship between surface mount aperture width and the gap between pads.

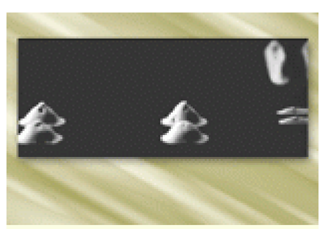

Figure 4. Adhesive height before component placement.

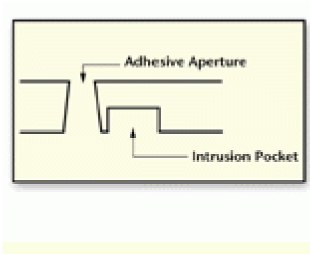

Figure 5. Controlling the length and width of a stencil`s aperture opening controls volume; height is affected by the clearance needed by the intrusion.

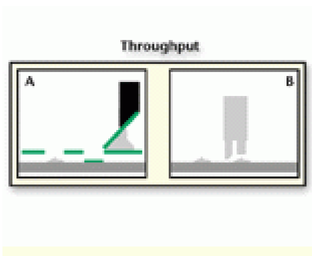

Figure 6. A comparison of throughput using a screen printer (a) vs. a dispensing machine (b).

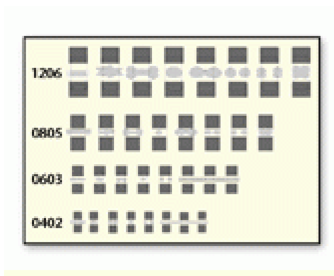

Figure 7. Just a few examples of the many shapes and patterns in which an adhesive can be deposited.