Managing Stringing or Tailing in Adhesive Deposition

by Steven R. Marongelli
Application Specialist/GSM Dispensing Platform Product Team
Universal Instruments

Abstract

Dispensing equipment must be able to administer a precise, consistent dot shape and height of adhesive at varying volumes for different-sized surface mount devices (SMDs). After the SMD is placed, the wet adhesive must have sufficient "wet" or "green" strength to hold the device in position, even on the bottomside of a printed circuit board (PCB), until the board is cured during wave soldering.

One of the most common problems encountered with adhesives in surface mount manufacturing is "stringing" or "tailing." Stringing or tailing in this sense means the peak of the dispensed material falls away from the center of the dot when the nozzle finishes dispensing – see Figure 1.

Stringing can be attributed to several factors, including poor thixotropic properties within an adhesive (the ability of the material to bounce back into a well-defined shape after it has been dispensed), incorrect machine set-up parameters, inadequate surface condition of the PCB/solder resist, and/or utilization of the wrong dispense nozzle.

This article focuses on the phenomenon of adhesive stringing that can be attributed to various characteristics of the dispense nozzle:

- The inside diameter of the nozzle, called the nozzle ID. This dictates the smallest dot dispensed from that nozzle. A good rule of thumb is that the smallest possible dot that can be dispensed is typically twice the nozzle ID.
- The distance between the nozzle and the board, called the nozzle stand-off. The nozzle stand-off usually dictates the height of the dispensed material.
- The correct volume of adhesive represents the amount of material dispensed through the nozzle at a given time. The volume of material dispensed is controlled by the stroke of the piston when utilizing a Piston Positive Displacement style pump, or by the amount of revolutions of the screw when utilizing an Archimedes Metering Valve style pump.

Introduction

Adhesives are typically used in printed circuit board (PCB) assemblies to hold passive (and sometimes active) surface mount devices (SMDs) to the bottomside of the board during wave soldering. The adhesive bonds the SMD to the PCB, forming a joint between the body of the device and the solder resist or bare FR-4 board between the solder pads. This is necessary to avoid displacement of the SMDs from their sites during high-speed placement.

Dispensing equipment must be able to administer a precise, consistent dot shape and height of adhesive at varying volumes for different-sized SMDs. After the SMD is placed, the wet adhesive must have sufficient "wet" or "green" strength to hold the SMD in position until the PCB is cured.

The distance between the bottom of the component and the surface of the PCB is typically 0.0762mm to 0.127mm (0.003" to 0.005"), see Figure 2. To assure a good bond or "wetting" of the adhesive to the bottom of the component as it is placed on the PCB, a good rule of thumb is to use a dot height that is twice this distance, see Figure 3.

Stringing

One of the most common problems encountered with adhesives used in surface mount manufacturing is "stringing" or "tailing," see Figure 1. Stringing or tailing of adhesive means the peak of the dispensed material falls away from the center of the dot when the nozzle finishes dispensing. This can be attributed to a number of factors. These include poor thixotropic properties within an adhesive (the ability of the material to bounce back into a well-defined shape after it has been dispensed), incorrect machine setup parameters, inadequate surface condition of the PCB/solder resist, and/or utilization of the wrong dispense nozzle.

When selecting a nozzle for use in dispensing adhesives, the main parameters for determining the correct nozzle are dot diameter, nozzle stand-off, and nozzle ID. A relationship exists among the nozzle ID, the nozzle stand-off, and the adhesive diameter, see Figures 4 and 5. When the correct adhesive volume is dispensed, the surface tension of the adhesive on the board should be twice that of the surface area of the adhesive at the nozzle tip. If this condition exists, as the nozzle retracts, the adhesive will snap off clean from the nozzle and leave a well-defined dot of constant volume on the board.

Dot Size Diameter Requirement and Pad Spacing

Any given dot size requires a nozzle that meets those specifications. The dot size requirements can be derived from the board design being used, specifically, the pad spacing of components, see Figure 6.

It is not uncommon for a PCB manufacturer's engineering personnel to ask about recommended adhesive dot diameter for a particular component type. Much has been written about recommended SMD pad designs and layouts for bottomside applications. However, these guidelines are rarely used. Most often, topside pad designs are used with bottomside PCB fabrication.

Why is that an issue? Because PCBs are manufactured one of two ways, and each way is dependent on how the solder will be placed on the board. If the PCB is designed to go through a wave solder bath after component placement (typically the case when adhesive is used), then the pad spacing of each component is relatively large. If the PCB is not designed to go through a wave solder bath, then the pad spacing is relatively small and the solder paste is screen-printed onto the PCB component pads prior to component placement. The challenge is that manufacturers will have PCBs that incorporate pad spacing intended to be used with screen printers, but they will need adhesive placed between the pads. In other words, they now want both processes on one board — screen printing of solder paste ***and*** deposition of adhesive between pads with solder paste on them.

The pad spacing for a particular component in any individual manufacturer's product is unique. And, because the pad spacing for most typical surface mount components is not standardized from

one product to another, it is virtually impossible to generalize recommendations for specific tooling to satisfy the adhesive deposition requirement for any particular component.

To address this challenge, Universal's Advanced Process/Surface Mount Technology Laboratory has developed component pad spacing guidelines for use when designing PCBs for adhesive application.

Typically, surface mount component pads for a particular circuit board are designed for either adhesive deposition or screening of solder paste. The pad spacing is generally smaller for solder paste application. For example, the component pad spacing for 0603 chip cap/resistors is typically 0.508mm (0.020") if the board is designed to be screen-printed with solder paste. The pad spacing for the same board could be as large as 1.016mm (0.040") if the board is intended for adhesive deposition.

A 0.762mm (0.030") diameter dot of adhesive would easily be recommended for use if the component pads on the board were indeed designed for adhesive deposition. However, if the pad design for the same board was originally designed for solder paste, a 0.762mm (0.030") diameter dot of adhesive would be too large, as the spacing between the pads is now 0.508mm (0.020"). A diameter dot in the range of 0.381mm to 0.457mm (0.015" to 0.018") would be required for this particular application, see Figure 7.

Therefore, since all pad designs and component spacings vary from one PCB to another, the actual spacing between the pads for any particular component must be known.

Note that the volume of adhesive needed to keep the component in place during high-speed placement or wave solder may be larger than possible for some specific pad designs.

Nozzle Stand-Off

Nozzle stand-off is the distance from the tip of the dispensing surface to the end of the mechanical stand-off, in other words, how far the surgical tube portion of the nozzle that actually dispenses the material is from the surface of the PCB. Nozzle stand-off is used to maintain the distance between the PCB and the dispensing tip of the nozzle. Most dispensers in use today use some sort of mechanical stand-off with the nozzles. The stand-off usually dictates, to some degree, the height of the dispensed dot.

If the stand-off is too large, the adhesive may never contact the board and the adhesive will build up on the bottomside of the nozzle. This usually leads to poor dot shapes, inconsistent volume, stringing, and missing dots. The typical stand-off is 0.2032mm to 0.254mm (0.008" to 0.010"). This distance, along with the nozzle ID, represents an imaginary amount of volume between the nozzle tip and the top of the PCB. If the amount of material exceeds this amount of volume, there will be material contamination on the nozzle tip, the board, or both, which leads to stringing, tailing, or inconsistent dots.

Nozzle ID

The nozzle ID is the inside diameter of the surgical tube portion of the dispensing nozzle, through which the material passes, contacting the board. The only rule of thumb that applies to choosing the correct nozzle ID is that it should be one half of the required dot diameter, see Figure 8.

As the nozzle ID and nozzle stand-off decrease, the dot diameter range also diminishes, see Figure 9. Note the recommended stand-off for an 8 mil ID nozzle is the same as a 10 mil nozzle. It is recommended not to go below the 5 mil stand-off due to tolerancing of PCB fabrication. Two methods of building the component pads onto a PCB are “cold rolled” and “hot air leveling.” In either method, the goal is to keep the pad height at approximately 0.0762mm to 0.127mm (0.003"-0.005") above the top surface of the board.

Dot diameters smaller than 16 mil require special care from board manufacturing. Slight variations of pad heights and solder mask on the PCB add up to large variations in actual mechanical stand-off while dispensing.

When too much adhesive volume is dispensed, the surface tension of the adhesive on the nozzle tip is greater than that on the board. If this exists, excessive adhesive is forced to migrate throughout the inside of the outer nozzle stand-off. As the nozzle retracts, the excess adhesive stays with the nozzle and a very small, irregular dot is left on the board. The excess adhesive left on the nozzle tip will be added to the next dispensed dot. The final result is inconsistent dot volume and poor dot shape, see Figure 10.

Conclusion

The volume of the dispensed adhesive dot should possess enough wet (green) strength to hold passive and active components on the PCB during placement. Too much adhesive can lead to pad contamination or stringing of adhesive, causing faulty solder joints and potential clogging of the nozzles on high-speed chip placement machines. Too little adhesive can lead to components falling from the PCB. Pad spacing dictates the volume of adhesive used. PCBs designed for deposition of adhesive have adequate space between the pads. The correct volume of adhesive dispensed, along with the correct nozzle type, help reduce the effects of adhesive stringing, see Figure 11.

Nozzle selection depends on recommended dot diameter and dot height. The ID of the nozzle generally dictates the volume of adhesive dispensed. The nozzle stand-off dictates the height of the dispensed dot. When all these variables are understood, the process of eliminating adhesive stringing should be a simple one.

Figure 1

Figure 2

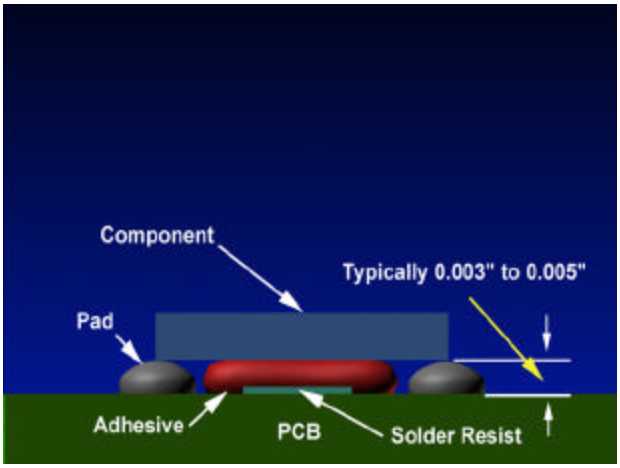


Figure 3

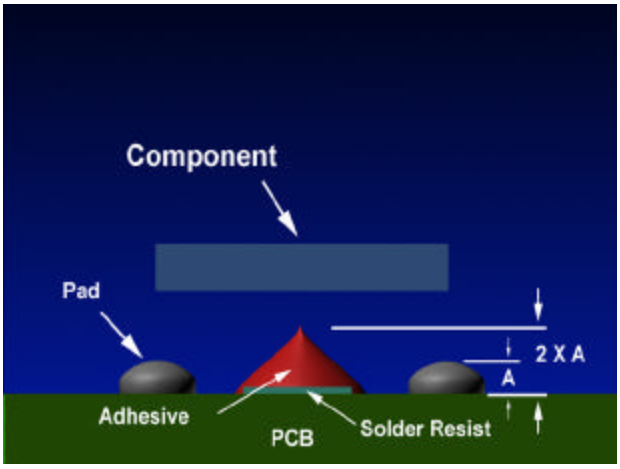


Figure 4

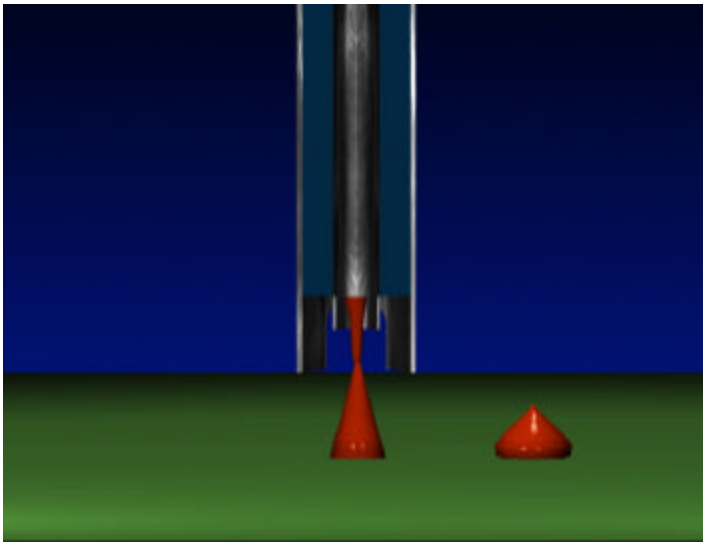


Figure 5

Correct Relationship Between Nozzle ID, Nozzle Stand-Off and Adhesive Dot Diameter

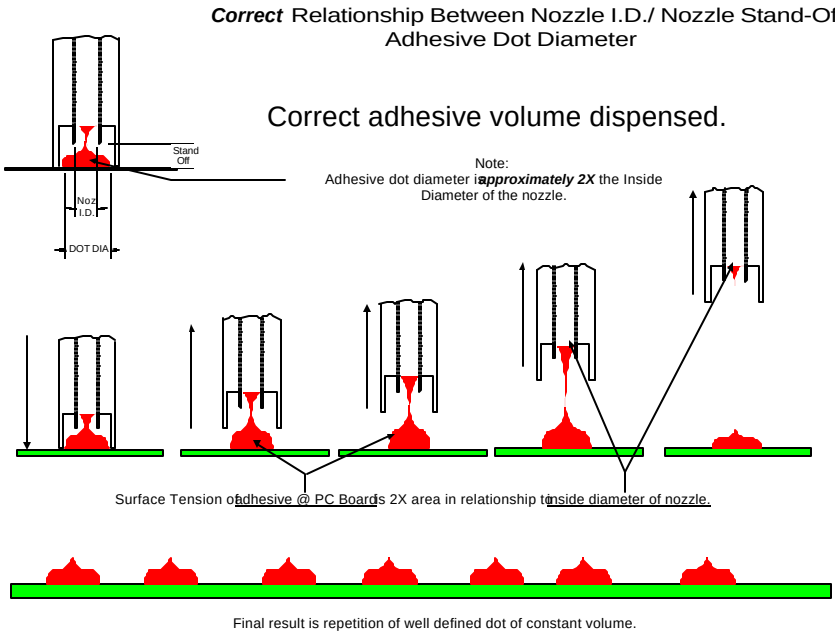
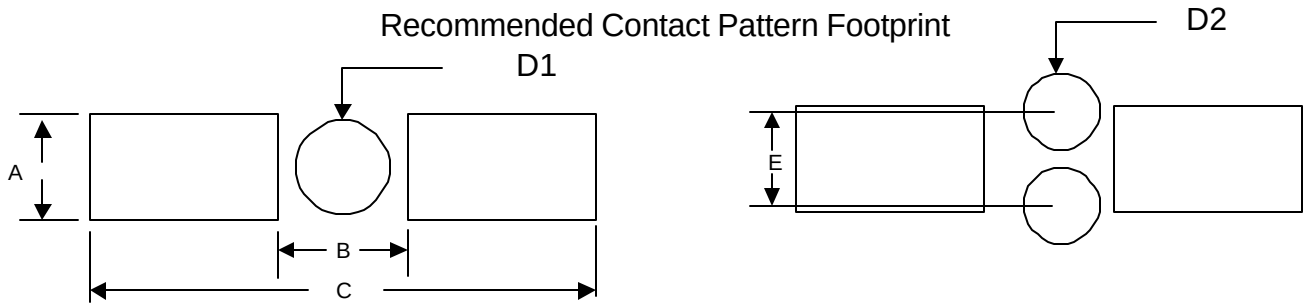


Figure 6



	0402	0603	0805	1206	1210
A	0.013"	0.020"	0.035"	0.040"	0.060"
B	0.025"	0.040"	0.040"	0.070"	0.070"
C	0.121"	0.140"	0.140"	0.205"	0.205"
D1	0.010"-0.015"	0.020"-0.025"			
D2			0.020"-0.035"	0.020"-0.035"	0.020"-0.035"
E			0.035"	0.035"	0.035"

Figure 7

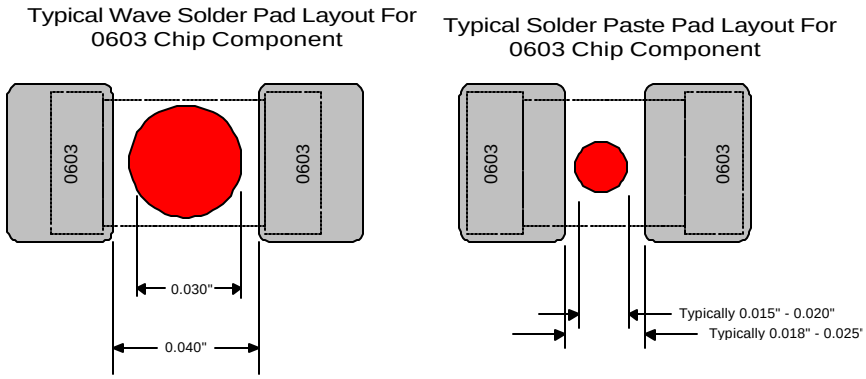


Figure 8

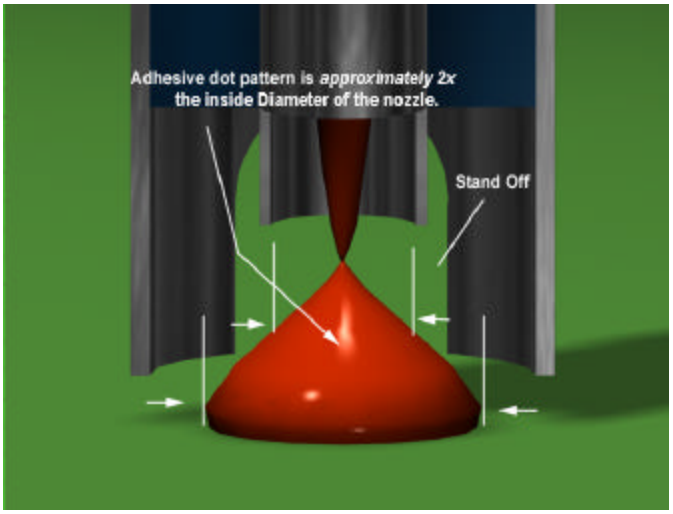


Figure 9

Nozzle ID	Nozzle Standoff	Dot Diameter Range	Optimal Dot Diameter
8	5	16-20	18
10	5	18-22	20
12	8	24-35	28
16	10	28-45	35
23	15	40-60+	45
33	20	50-100+	60

Figure 10

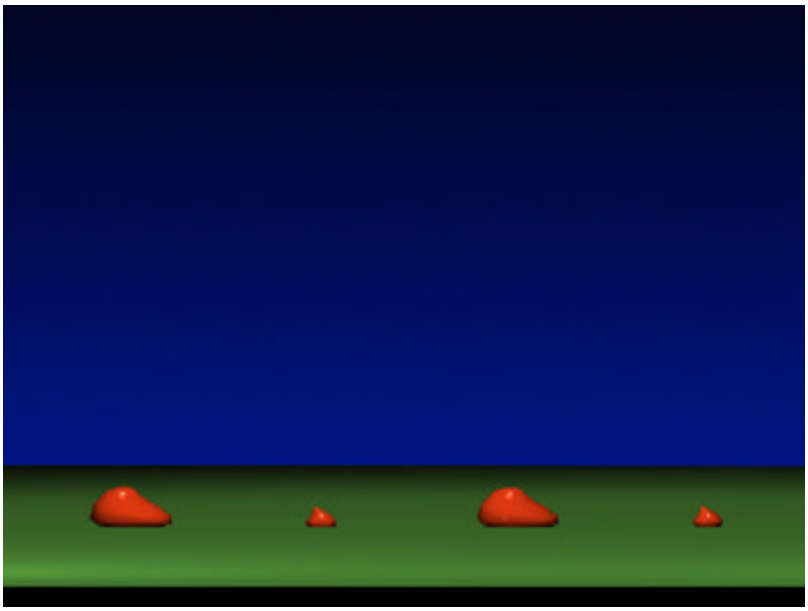


Figure 11