Speedline technologies

# Non-Contact Streaming Technology Enhances the Dispense Process

## INTRODUCTION

The dispensing industry within electronics manufacturing represents a very diverse marketplace indeed; many different materials can be applied in many different ways. One high-growth area in this market is underfill, driven by the explosive demand for hand-held devices (HHDs). This segment is comprised of popular consumer goods, such as cell phones, mp3 players, GPS navigators, PDAs, portable games and ultra-mobile PCs. A new, non-contact dispense technology, known as Streaming, has recently been introduced to specifically address the incumbent needs associated with underfill.

While Streaming has some attributes that are similar to current jetting technology, it offers some innovative differences that provide advantages, particularly with underfill. This new technique has been proven under extensive testing and stands to be a major factor in improving throughput and yields in underfill applications. Consumer demand and component miniaturization continues to shape this emerging segment, the technology and functionality of the individual HHDs are now converging into a single device known as the "smartphone." The additional capability of digital TV is undergoing implementation now, and what tomorrow holds is anyone's guess. The bottom line is that underfill is an important step in manufacturing these products, so improving speed and accuracy in this process is clearly welcomed by the industry.

## DESIGN DRIVERS FOR STREAMING

Prior to development, interviews were conducted with current and potential users of dispense systems to determine their needs. Speed enhancement, while maintaining high yields, was the most common response. This is highlighted by the 2007 iNEMI Technology Roadmap (figure 1). The underfill section of this report was compiled with feedback from both PCB and capital equipment manufacturers. Four key metrics relating to underfill dispensing are identified as well as current and future production capabilities from an equipment perspective. Green denotes current dispense technology capabilities and red highlights where research and development is needed. A shortfall in 2007 is already evident from a throughput standpoint, and that is likely to only increase. Equipment manufacturers must focus platform and dispense technology development on this requirement while simultaneously improving capability in control of volume, keep-out zones and process management.

***UNDERFILL DISPENSE CATEOGORY***

| Parameter | Comments | 2005 | 2007 | 2009 | 2011 | 2017 |
|---|---|---|---|---|---|---|
| UPH | 10 X10mm CSP single pass 200µ bump height | 2000 | 4000 | 5000 | 6000 | >10000 |
| Volume Control | As a % on 15mg dispense weight | 5% | 3% | 2% | 2% | 1% |
| Keep Out Zone Control | Best Case Scenario for controlling wet out areas for no contamination | 500µ | 250µ | 200µ | 175µ | 150µ |
| Process Control | Closed Loop Methodology for Volume ocntrol | Weight Scale | Weight Scale | Laser Scan | Laser Scan | Laser Scan |

Figure 1

STREAMING PUMP TECHNOLOGY

Streaming is accomplished by means of new, patent-pending pump technology. What differentiates streaming from other non-contact technologies, like jetting, is that striking of a piston to a seat or nozzle is eliminated in this unique process. This significantly increases longevity of the related parts since wear is reduced, and it results in very quiet operation. Carbide and sapphire are important materials used in the pump design. Underfill can have a filler powder blended into the material; commonly this is silica, but other materials such as alumina, carbon or aluminum nitride are also used. The primary use of the filler is to reduce the coefficient of thermal expansion (CTE) mismatch between substrate and device and reduce stress on solder joints. Unfortunately, the filler is abrasive and can cause most metal contact surfaces to wear. Carbide, however, is extremely resistant to abrasion from silica, so it is used for the piston and barrel assembly. The piston’s action expels the material through a nozzle, so this must also be wear-resistant. The nozzle orifice may be one of several different small diameters (typically the I/D is 200 microns), and would be cost-prohibitive if made of carbide.


Figure 2

Instead, an industrial sapphire orifice is bonded and roll-swaged into a steel holder (figure 2). Sapphire has a hardness rating of 9 on the Moh's scale (diamond is 10), so it is highly resistant to abrasion from the filler. Although sapphire has a connotation of being expensive, nozzles are actually comparably priced with needles, making them a cost-effective solution.

In operation, each cycle of the pump displaces more of a column of material, rather than a single sphere. The unit cycles at a frequency that creates a "stream" which can deliver increased flow rates, up to 70 µl/sec. The carbide displacement piston is driven by a linear motor/encoder assembly that precisely controls its upstroke to regulate the charge level. Following this, the piston is accelerated to a high speed on the down stroke with its bottom position governed by an external collar. Combining advantages associated with both positive displacement and jetting technologies allows streaming to deliver precise volumes from a preferred distance above the substrate.

Design of the pump unit enables easy removal and cleaning of the fluidic module that contains all wetted parts. Only three o-rings need to be replaced, so downtime and associated costs are minimal, with average consumables expense of less than $1 per day.

THE TECHNOLOGICAL DIFFERENCE

There are two major dispense methods available today; needle and non-contact based technologies. The latter has been documented in recent years as offering significant throughput advantages over needle-based processes. This advantage is most apparent in applications that involve dispensing into tight gaps, or have restrictions on the wet-out area of the material. When addressed with needle-based equipment, a small I/D (<0.010") is mandated which will restrict flow and, consequently, decrease UPH.

In some cases, the dispense rates of application vary by the speed of the capillary action after the material has been applied. For example, the material or process may have slow capillary action due to the underfill viscosity and/or a small stand-off gap underneath the component. Applying the underfill too quickly may cause material to build up and wet to the top, or wet out to the side, contaminating adjacent components. In this case, the pump, be it needle or non-contact based, would be tuned to accommodate the capillary action.

For many underfill applications, however, non-contact technology does not necessarily dispense material at higher flow rates than a needle. It is the process steps in and around the dispense step to which we can attribute the increased productivity.

In these applications, throughput improvements as a result of streaming come from two areas:

- Z-travel of the dispense head is virtually eliminated as non-contact dispensing expels the material from a nozzle 2-3mm above the substrate. Needles, on the other hand, must be approximately 0.25 mm above the surface to ensure wetting. Z-motion is required to move down to the dispense position, and then move upward after dispensing to "snap off" the material from the tip. The needle is also raised to physically clear components when moving to the next location.
- Height senses are used to reference the distance at the dispense area from substrate to dispense nozzle/needle. This measurement is taken either by

mechanical probe or by laser. With needle-based technology, height above the substrate is a critical parameter in maintaining a reliable process. Typically, height sensing is performed once per component (flip chip, CSP or BGA), or at least once per circuit. Dispense height, however, is less critical for non-contact processes, since the technology is much more forgiving and requires only a single height measurement per panel.

To better understand and quantify UPH improvements, applications trials were run using non-contact and needle-based techniques. The intent of these tests was to highlight the difference between technologies when operating at identical flow rates. Needle-based trials were conducted using a positive displacement, multi-piston pump, and the non-contact tests utilized the new streaming pump. In both cases, the pumps were installed on a commercially available, standard dispensing system.

A time comparison study was run on three different applications; a cell phone, a high-end mp3 device, and a GPS navigator.

| XyflexPro+ | Cell Phone | | MP3 | | GPS | |
|---|---|---|---|---|---|---|
| | Stream | Needle | Stream | Needle | Stream | Needle |
| Underfill devices per circuit | 3 | | 5 | | 7 | |
| Circuits per panel | 4 | | 4 | | 6 | |
| Dispenses or Z moves/panel | 12 | | 20 | | 42 | |
| Z - sense time | 0.5 | 1.5 | 0.5 | 2 | 0.5 | 3 |
| Dispense time/panel | 6 | 7 | 10.5 | 12.5 | 33 | 42.5 |
| Total | 6.5 | 8.5 | 11 | 14.5 | 33.5 | 45.5 |
| Stream improvement | **23.5%** | | **24.1%** | | **26.4%** | |
| Needle based trials used 1 z-sense per circuit, Stream trials used 1 z-sense per panel | | | | | | |
| Fiducial & transfer time not included as these are constant | | | | | | |

Figure 3

Both pumps were set to run with identical material flow rates (45 µl/second). With the needle-based trials, all programs used the same lift height between dispense commands, thus accurately identifying the differences in Z-operation and height sensing. A typical cell phone application was emulated with underfill dispensing through a hole in the RF shield.

The mp3 device dispense pattern used a combination of single lines, "L" passes and dots around the components. A combination of both through-shield and single line dispenses was used on the GPS navigator. For all three devices, each component dispense operation was done in a single pass. See the table (figure 3) for product details.

Results from the trials show conclusively that each product/application benefits from the use of streaming. The more dispense positions, the greater the difference between the two technologies. Additional improvements are realized as less height sensing is required. On average, streaming showed a 25% time reduction over the needle-based method relative to the Z-height and sensing operations. This figure can be considered fairly representative for these types of applications and should correspond to savings achievable in typical production environments. Speed advantages in addition to those outlined may also be obtained. For example is needle dispensing may require use of parameters that are not needed with the streaming approach. "On-delay," or "dwell" both pause the needle at either the beginning or end of a dispense line or dot and add to the cycle time. Again, the more required commands of this type, the more significant the time savings with streaming.

## CONCLUSION

The demand for higher throughput dispense solutions, that also improve process yields, is ever-increasing. Streaming is a new technology that succeeds in both of these areas. Continued focus and development in underfill applications is fundamental to keeping pace with the explosive growth of hand-held consumer devices.

## Acknowledgements

iNEMI 2007 Technology Roadmap