High-Throughput Precise Dotting in Electronics Assembly

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Abstract

In Electro-Mechanical Module Assembly (EMMA), adhesive and encapsulation materials are applied to protect electronic components from physical stress, contamination, and electrical bridging. Assembly processes have evolved dramatically in recent years due to cost saving efforts, increasingly smaller form factors, and mass customization. These changes have resulted in advanced and dynamic standards for equipment manufacturers in terms of speed, precision, and flexibility. For automated fluid dispensing, challenges include maintaining high-throughput to keep pace with upstream pick-and-place processes, enabling precise fluid delivery into narrow gaps between components, and avoiding keep out zones (KOZs).

Nordson ASYMTEK has developed a high-throughput, precise fluid dispensing process to match the production rate of 15,000 to 50,000 chips per hour (CPH), a typical speed for pick-and-place systems. The process meets EMMA requirements by delivering a narrow fluid stream with a placement accuracy range of 0.025 – 0.065mm and an adhesive wet-out zone of 0.2 – 1.0mm. The process includes a new jetting technique, new dispensing system, and the use of unique software features. The paper will discuss the following application examples: optical lens encapsulation, camera module image sensor attach, and the placement of a non-conductive adhesive boundary around a hard disk drive piezo actuator.

Key words: dispense, high throughput, precise dotting, narrow fluid stream, jetting, electronics assembly, electro-mechanical module assembly

I. Introduction

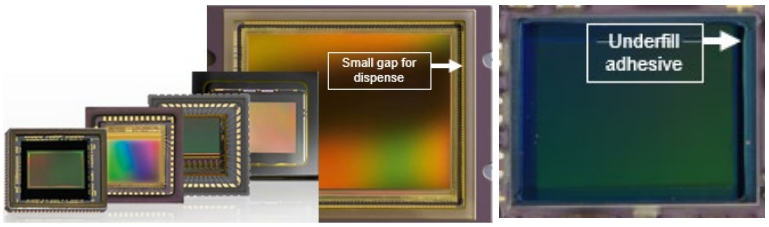
Encapsulation materials and surface mount adhesives are broadly used in electronics applications to assemble components and protect devices and sensitive components. These materials and adhesives provide electrical, mechanical, and thermal support properties along with protection from physical stress, contamination, and electrical bridging.

In recent years, Electro-Mechanical Module Assembly (EMMA) has become an increasingly important area of focus for consumer electronics, medical device, and automotive manufacturers. The focus on EMMA is the result of an ongoing effort to modularize independent sub-functions for streamlined component testing and simplified component replacement. Individual modules continue to decrease in size and offer more functionality. These changes have led to more complex production processes and increased consumer demand for new products. Manufacturers must accommodate these complex production challenges and increase UPH to meet customer demand and remain successful. Automated dispensing systems that run at high speed with high accuracy can provide the UPH and quality outcomes that manufacturers need.

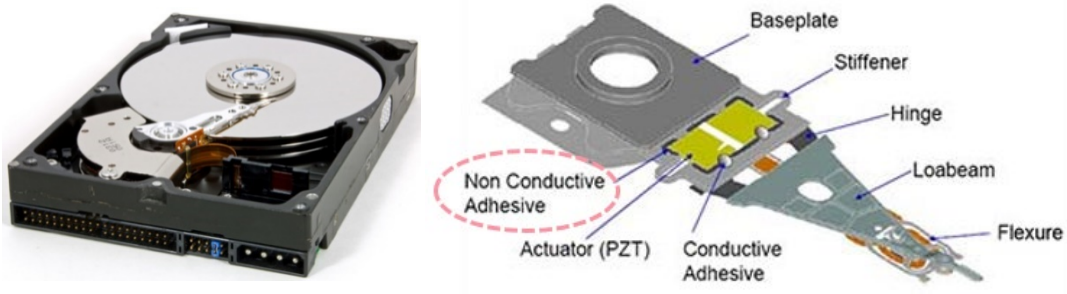
To meet high-volume manufacturing requirements, an automated dispensing system must deliver (1) throughput that accommodates high speed pick-and-place processes; (2) a dot dimension in the range of 200-650µm to precisely cover small components; and (3) added benefits including the flexibility to accommodate application changes at any stage of the design or assembly process and the ability to jet thick adhesives in micro-grams with high repeatability.

This paper discusses Nordson ASYMTEK's advanced dispensing technologies and unique process development results that have been applied in consumer electronics, medical device, and automotive assembly processes. The applications include: optical lens encapsulation at 180,000 lenses per hour and positioned at 2mm intervals, camera module image sensor attach with a 0.2mm gap-fill requirement, and the placement of a 0.2mm non-conductive adhesive boundary around a hard disk drive piezo actuator. See Figure 1.

(a) Encapsulation



(b) Surface Mount and Underfill



(c) Non-Conductive Adhesive Mounting

Figure 1: (a) LED light or optical lens encapsulation (b) Camera module image sensor mounted on supporting frame with underfill (c) Hard drive piezo actuator mounted with non-conductive adhesive.

II. Dispensing Process Development

Nordson ASYMTEK's Vantage® Series and Spectrum® II Premier fluid dispensing systems were selected and equipped with the IntelliJet® Jetting System to test and develop three precise high-throughput fluid dispensing processes. See Figure 2. In addition, the Jet-on-the-Fly feature in Fluidmove® software was also used.

(a) Spectrum II Series

(b) Vantage Series

(c) IntelliJet Jetting System

(d) Narrow Dot Stream

Figure 2: Dispensing setup (a) Spectrum ll (b) Vantage Series and (c) the IntelliJet Jetting System for narrow dot streaming.

Advanced high-volume production applications require accurate and narrow fluid streams to fill gaps as small as 200-500µm. The Vantage and Spectrum ll Series dispensing platforms are specifically designed to support underfill, cavity fill, die attach, and encapsulation processes that require increasingly smaller dispense target, line width, and KOZ requirements. The Spectrum ll has long been established as a premier scalable dispensing platform for a wide variety of applications. The Vantage Series offers premium advanced dispensing capabilities to support increasingly complex microelectronics applications.

When combined with a dispensing platform, the IntelliJet Jetting System delivers small dot sizes and narrow jetted stream widths quickly and cleanly, increasing UPH and avoiding contamination on top of chips or neighboring components. The IntelliJet Jetting System can jet thick fluid in very small dot sizes with high dimension uniformity, a challenging requirement that is difficult to achieve with any valve.

The Jet-on-the-Fly software feature enables the valve to jet fluid as it flies over the dispensing locations. With Jet-on-the-Fly, dot dispensing throughput is largely increased because the jet does not decelerate, stop, dispense, and accelerate between the dispense locations. This feature can increase throughput by 2-6 times compared to jetting with a full stop at each dispensing location.

III. Results

The Vantage Series and Spectrum II Premier with the IntelliJet Jetting System significantly increased productivity and yield compared to prior solutions in all three applications. The combination of advanced jetting techniques, new hardware, and software features successfully increased precision and throughput in three dot jetting examples.

Application: Optical Lens Encapsulation

The optical lens encapsulation application is a high-speed dotting application designed to encapsulate optical lenses in an array with a 2mm interval. See Figure 3. This is a simple potting application and dispensing takes 95% of the total cycle time. In this case, the application required a throughput improvement from 8Hz (8 dots per second) to 13.6Hz. The goal of 13.6 Hz was accomplished and further enhanced using the Jet-on-the-Fly software feature. After employing Jet-on-the-Fly, the application throughput improvement increased to 50Hz and a line speed of 150mm per second. Overall, the new process is 6.2 times faster with a placement accuracy of 50-60um per dot which is maintained consistently across thousands of dots.

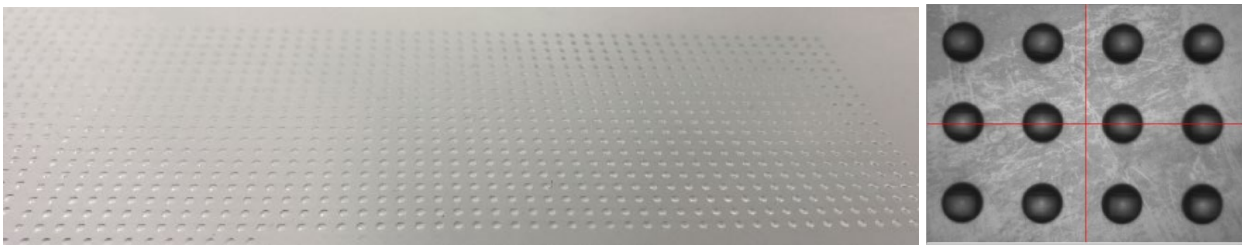


Figure 3: Optical lens encapsulation at 50Hz with a dot-to-dot interval of 2mm.

Application: Camera Module Image Sensor Attach and Small Gap Underfill

The second application involved the jetting of adhesive material through a small gap between an image sensor and the supporting frame. See Figure 1(b). This is a typical underfill and mounting process, that involves dispensing adhesive onto the frame and allowing it to flow into and fill a gap under the image sensor. However, in this challenging application the requirement involved jetting the fluid cleanly through a narrow gap without contaminating the image sensor. The customer's product featured a gap of 350µm and they planned to release a next-generation version of the product with a reduced gap of 200µm and an increased chip distribution on each board. Simulation parts were built in house with a chip-to-chip gap of 0.2mm. See Figure 4. In the new application, the fluid was repeatedly dispensed per the requirements, through the small gap with complete underfill results under each chip. No contamination was observed on the chip surface after dispensing a 5mg line a total of 15 times. These results demonstrate the system's high placement accuracy and volume repeatability with adhesive materials.

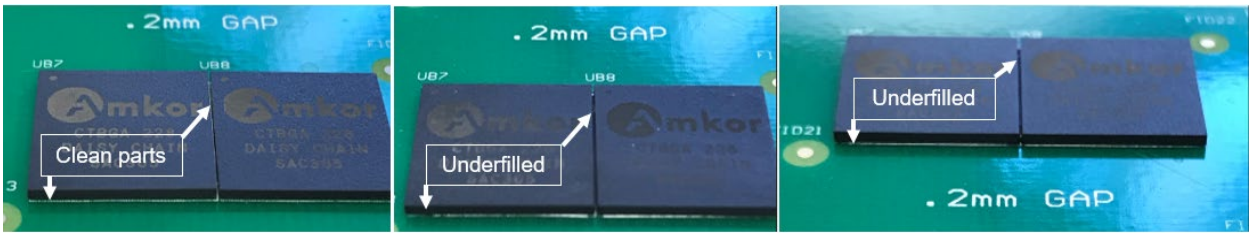


Figure 4: Camera module small gap underfill adhesive jetting, without surface contamination.

Application: Hard Drive Piezo Actuator Non-conductive Adhesive Boundary

The final application involved placing a small dot of non-conductive adhesive in an array to bound a piezo actuator and support precise movement in the hard disk drive. The IntelliJet Jetting System was used with the Spectrum II to jet 6,000 SMA dots in a single test. See Figure 5. The customer's existing application was designed to achieve a uniform distribution of the surface mount adhesive along the periphery of the actuator resulting in a 4x3 array of 350µm dots. In the newly developed process, precision was increased and the dot size was reduced from 350µm to below 275 µm. The dot diameter was measured using an offline precision tool (Mitutoyo) and an image processing technique to detect the dot's edge as a circle and then calculate the diameter. In Table 1 below, the statistical data analysis shows the dot diameter to be 239µm with an 11% variance in three sigma.

Table 1: Statistics for 6,000 SMA dot diameters measured with a high precision tool (Mitutoyo).

Average (µm)	Standard Deviation (µm)	3σ (µm)	3σ (%)	Range (µm)
238.73	8.73	26..21	10.98	[187.5, 268.5]

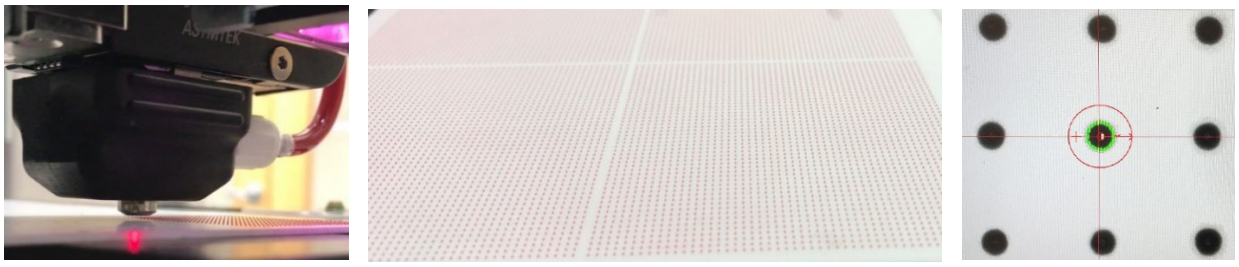


Figure 5: Hard drive actuator non-conductive adhesive boundary: 6,000 small dots jetted and inspected.

IV. Conclusion

We have presented three module assembly applications using our current solutions for high-speed dotting. Each application increased throughput and maintained accuracy and flexibility. The Vantage and Spectrum II Series, IntelliJet Jetting System, jetting techniques, and unique software features successfully met customer requirements. Nordson ASYMTEK's high-speed dotting process is applicable for larger dimensions. In this paper, we focused on three module assembly applications that featured smaller dimensions of 200-1000µm. Through these application examples, we have demonstrated our ability to develop dispensing applications for adhesive materials in small volumes on high-density circuits. Our high-throughput, high-precision and flexible technologies provide the manufacturing industry with capable solutions for module assembly, delivering dispensing speeds as fast at 180,000 chips per hour and precise component clearance as small as 200µm.