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Jet Dispensing of Underfills

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Jet dispensing has become the preferred method for dispensing flip chip underfills. Jetting is a non-contact dispensing method that shoots drops of fluids from a stationary or moving nozzle. It has advantages in board density, fillet size, placement accuracy, dispense speed, and cost over the needle dispensing of underfills.

Needle Dispensing

The traditional method for dispensing underfill is by a pump-driven needle. Since the fluid must remain in contact with both the needle and the target during dispensing, the needle must be physically positioned close to both the chip and the substrate.

Horizontal spacing is governed by the needle diameter and the XY positioning tolerance required to prevent needle contact with the die. Vertical spacing is one-half the die height above the substrate. After dispensing, the needle is lifted vertically to break the fluid stream without excessive dripping.

Jet Dispensing [1]

The key element of a jet dispensing system is a valve that meters and ejects fluid droplets. As shown in Figure 1, air pressure retracts an internal spring-driven plunger, allowing a precise amount of fluid from the reservoir to enter the chamber under pressure. The spring-driven plunger then returns to its seat, ejecting the fluid as a droplet though the nozzle.

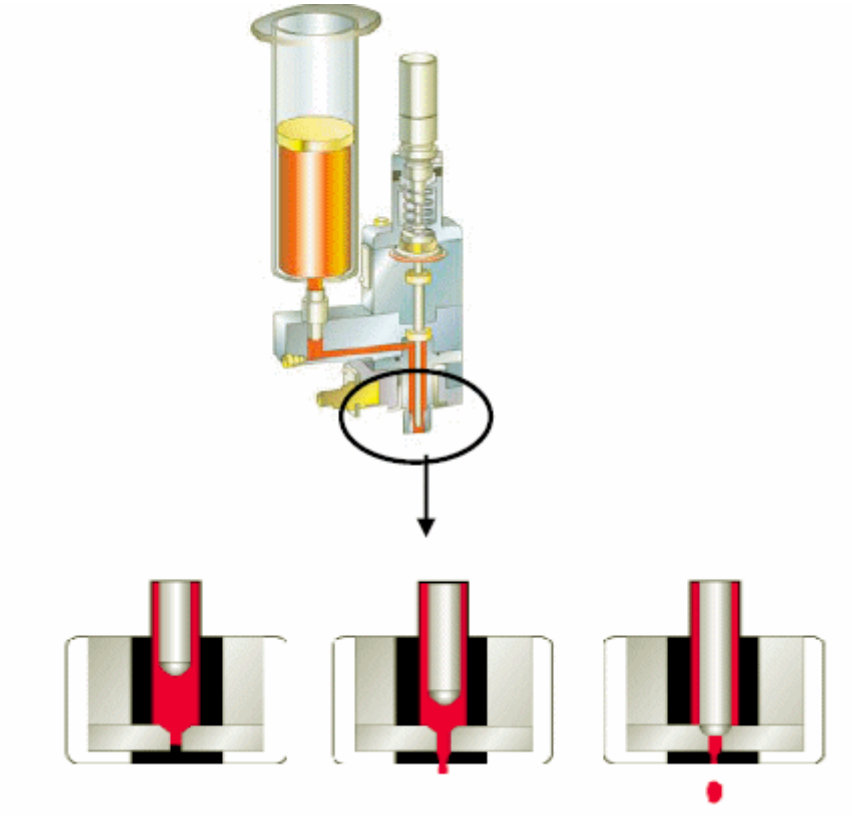

Figure 1. Jet dispensing valve, showing droplet forming and ejection. (Asymtek)

The dispense rate is 200 drops per second, with a typical drop diameter of 100 microns. The fluid temperature is controlled in the valve to maintain uniform flow and drop sizes. The valve is moved in the XY plane in pre-programmed patterns, guided by optical recognition equipment.

In jet dispensing, the jet nozzle is positioned 0.5 to 3 mm above the substrate, with a single height sensing per board. The vertical distance from the substrate is not critical, as the droplets leave the nozzle before contacting the substrate. XY positioning centers the nozzle 100 microns from the edge of the die.

Jetting Advantages

Component Density Placing a needle safely between components requires more space than jetting a small drop between them. As shown in Figure 2, a 20-gauge needle of 0.88 mm diameter generates a fluid edge (or run-out) 1.25 mm wide and requires a minimum component separation of 1.5 mm. [2] Jetting a standard 0.10 mm droplet gives a fluid edge of 0.25 mm, requiring a minimum component separation of 0.5 mm.

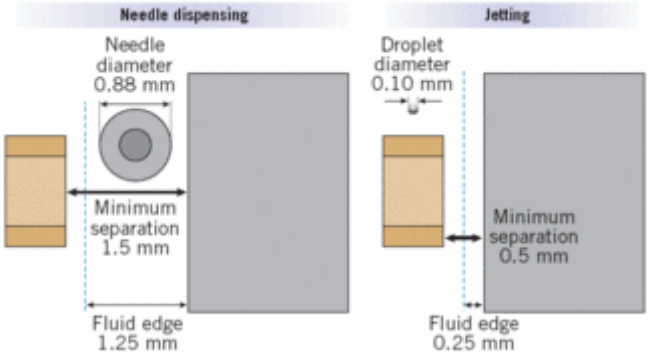

Figure 2. Needle and jet separation requirements. (SMT Magazine)

As shown in Figure 3, a 7 mm square die requires a 100 square mm $(7+1.5+1.5)^2$ board area for needle dispensing at 1.5 mm separation, versus a 64 square mm area for jetting at 0.5 mm separation, a 36% area reduction. [3]

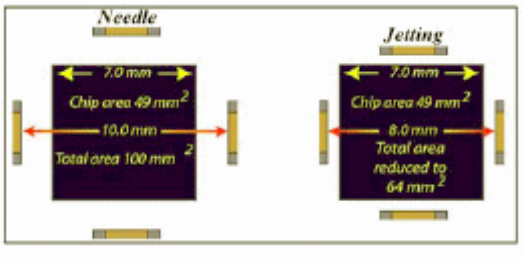

Figure 3. Comparative area required for needle and jet dispense. (Asymtek)

Fillets Because of the narrower fluid edge, the 100 micron droplet stream creates smaller fillets than needle dispensing, allowing die to be placed closer to a board edge or to bond pads.

Speed Jet dispensing is faster than needle dispensing because the needle must be lifted vertically away from the substrate between dispensed dots or lines, while the non-contact jet travels in the x-y plane without being lifted between dots or lines, and can dispense "on the fly" without stopping.

Contact-Free The jet nozzle is positioned well above any die. Needles may strike an adjacent chip, causing damage to the needle and possibly to the die. Die clipping creates a yield loss for needle dispensing. Jet dispensing eliminates that risk.

Lower Cost Jet dispensing of flip chip underfills allows denser component spacing, greater throughput, contact-free dispensing, and higher yields than needle dispensing, resulting in 50% to 66% lower operating costs than for needle dispensing. [4]

Die Stacking 3-D packaging with stacked, wire-bonded die requires minimum wetted area, to bring bond pads close to the die. Jetting stacked die underfill also eliminates the risk of needle contact with the bond wires.

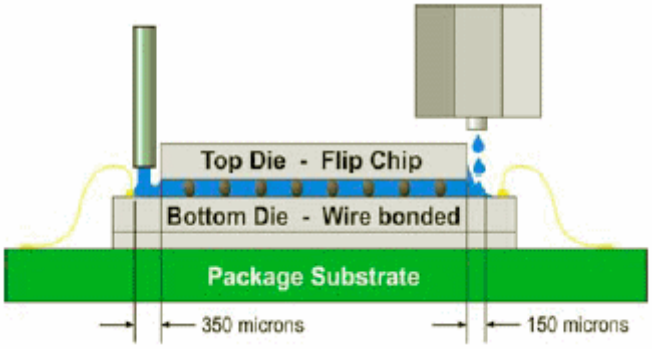

Figure 4. Jet advantage for stacked die dispense. (Asymtek)

Conclusion

The advantages listed above, continuing technical improvements, and growing demand for smaller, higher density boards will continue to favor jetting as the method of choice for underfill dispensing.

References

[1] "Jet dispensing underfills for stacked die applications," Steven J. Adamson, Proceedings SMTA International Symposium, 2004.

[2] "Successful jetting in SMT," Dan Ashley & Al Lewis, SMT Magazine, May 2007.

[3] "Enabling high density system in package (SiP) manufacturing and consumer electronic devices through the use of jetting technology to minimize substrate area for underfill," Michael Peterson & Steven J. Adamson, Proceedings SMTA International Symposium, 2006.

[4] " Jetting adhesives and other materials for semiconductor and electronic component packaging," Alec J. Babiarz, Proceedings SMTA Pan Pacific Conference, 2007.

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