Liquid Encapsulation Protects Electronic Components

Complex Dispensing Process Requires Precise Control of Many Variables

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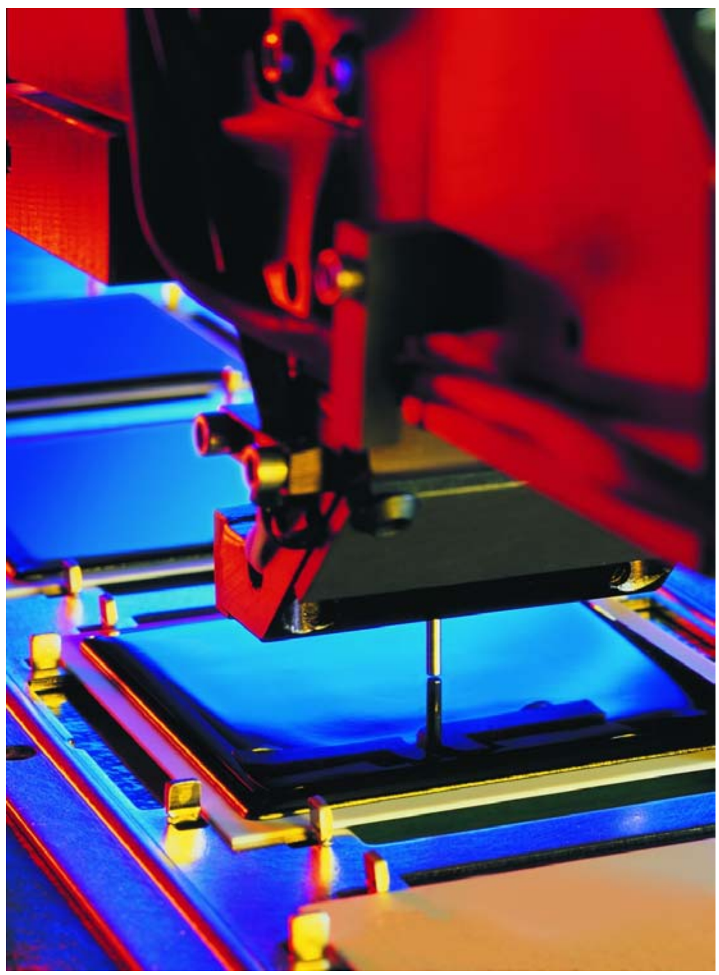
Shock and moisture are serious threats to delicate electronic components. To protect them, some manufacturers use an overmolding process that encapsulates the components in a plastic shell. But other manufacturers turn to liquid encapsulation. Thanks to automated dispensing equipment, liquid encapsulation is an attractive alternative to molding in high-volume manufacturing operations.



There are two types of liquid encapsulation: glob top and dam-and-fill. In glob top encapsulation, a volume of material is deposited on top of a component. The material flows downward, covering the component. There's no border around the material, so it can flow to the area immediately around the component.

Not so for dam-and-fill. This technique is a two-step process (see Figure 1). First, a dam of high-viscosity encapsulant is dispensed around the component. Then the dam is filled with a lower-viscosity fill material, which flows quickly and evenly, lessening the chances of air entrapment.

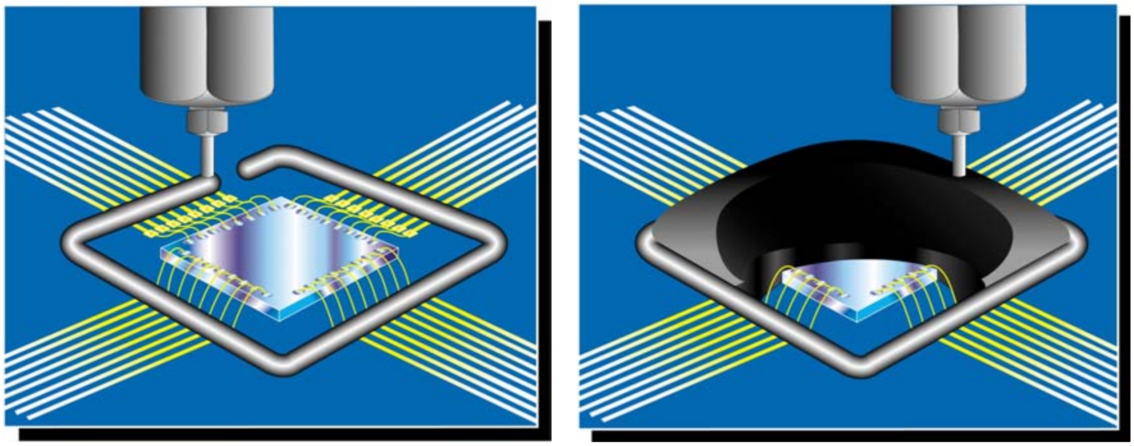


Figure 1. Dam-and-fill encapsulation is a two-step process. First, a high-viscosity encapsulant is dispensed around the component (see above left). Then the dam is filled with a lower viscosity fill material (see above right).

For a better understanding of the encapsulation process, consider a ball grid array component with wire bonds that make the die connection to the substrate. For protection, the wire-bonded die must be encapsulated.

Single- and multi-chip modules come in cavity-up and cavity-down configurations. For cavity-up configurations, manufacturers use the two-step dam-and-fill technique (See Figure 2). First, a needle dispenses a dam of high-viscosity encapsulant around the wire bonded die. The dam is usually square in shape so that stress is evenly distributed after the material is cured. Dam height should be at least 0.010 inch higher than the highest wire bond.

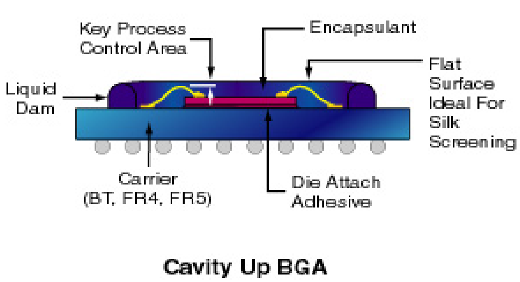


Figure 2. Cavity up configurations require two-step-and-fill encapsulation, with a dam of at least 0.010 inches higher than the highest wire bond.

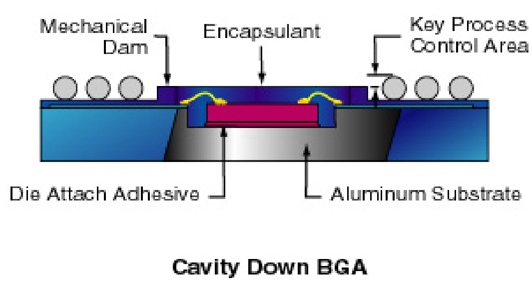
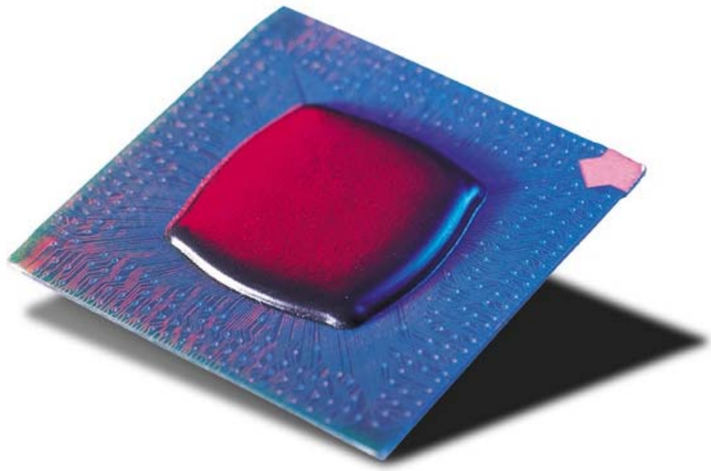


Figure 3. Cavity down configurations typically require only fill encapsulants, as the cavity walls can provide material containment.

Once the dam is in place, a second needle fills within the dam perimeter to the top of the dam with a lower-viscosity encapsulant. The needle dispenses encapsulant in a spiral pattern as it moves toward the center of the fill area. Both circular and rectangular spirals are popular filling patterns.



In cavity-down configurations, the cavity walls can provide containment, so a dispensed dam may not be required (see Figure 3). Fill encapsulant is dispensed in the same manner as in cavity-up applications.

Precise Dispensing Equipment

Liquid encapsulation requires precise dispensing equipment. If too little material is dispensed on the component, there will be voids in its protective coating. If too much encapsulant is dispensed, the component may not fit in its allocated space or the encapsulant may flow over the dam.

For precise dispensing, encapsulants are delivered by a fully programmable platform, equipped with dual auger pump assembly. Air pressure maintains a steady flow of encapsulant into the pump cartridge. At the same time, a high torque dc motor drives a precision auger that rotates in the cartridge. As the auger turns, it pushes encapsulant out of the cartridge and into a needle, which dispenses the material onto the electronic component.

To prevent dripping of the encapsulants, the valve includes a positive shutoff that stops material flow out of the needle. Valves are also equipped with a low material sensor to warn the operator in advance of material supply problems.

To minimize wear on the auger screw because of the abrasive encapsulant, both the auger and the cartridge liner are made of carbide steel. This carbide-in-carbide arrangement results in almost frictionless pumping of the encapsulant.

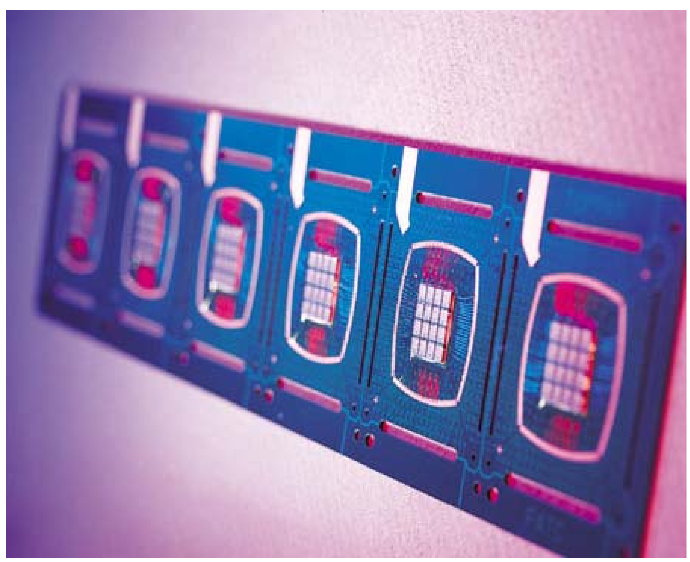
Software in Control

In encapsulant dispensing, there's virtually no room for error. Dispensing the dam is particularly challenging because the start and stop times must be precisely controlled to maintain the proper amount of dispensed material. To achieve this, the dispensing system must feature precise software control with the ability to adjust the dispense height, gantry speed, start dispense delays, valve shut-off control, and the location of the start/stop overlap.

Automated systems turn this demanding process over to a QNX operating system developed specifically for precise machine control. QNX is true multi-tasking software that provides process control of +/- 1 ms.

For faster setup and throughput, dispensing software should be versatile enough to allow easy parameter modifications. QNX lets operators program changes while the system is running without affecting system performance. The software's Windows-type interface makes it easy for engineers to develop programs for a variety of applications.

Needle position control and accurate X, Y, Z gantry movement are also major considerations in dispensing encapsulants. Contour mapping® software maps each gantry position and automatically adjusts the system to correct inaccuracies in the needle position. This positional control is crucial when dam material is dispensed as close as .005" from the wire bond or component area, and the dispenser must be positioned at less than half of the clearance (.0025"). This ability to dispense closer to the wire bonds or component area reduces dispense time and increases throughput, thereby reducing the material consumption and manufacturing cost.



The Role of Heat

To a large extent, successful encapsulation depends on heating. During the process, both the encapsulation material and the component are heated a number of times using both convection and conduction heating methods.

Encapsulant material is stored at a temperature of –40ºC. Before the heating process begins, the material thaws out during 30 to 45 minutes' exposure to ambient temperature.

For faster flow through the pump, a material heater is mounted to the valve, bringing the material temperature up to between 55º and 60ºC before entering the auger assembly.

The heater is controlled using a RTD probe in the material path to monitor material temperature. Constant material temperature is necessary to ensure that the material viscosity stays constant and the material volume is repeatable. The needle heater also aids in keeping the needle tip clean.

Components Take the Heat

While the encapsulants are being heated, components are heated as well. A heated substrate maintains the thinner viscosity material, resulting in faster material flow.

First comes hot air convection pre-heating, which brings components up to 40º to 60ºC. Pre-heating shortens heating time at the dispensing station, eliminates thermal shock, and removes moisture from the component wire bonded areas.

The component is then transferred to the dispensing nest. Mounted on a lifter plate, a precision staging fixture equipped with heaters and vacuum makes contact with the bottom of an incoming component. The vacuum holds the component level and firmly in place, while heat from the fixture warms the substrate to between 80º and 100ºC using contact heat. This allows trapped air to escape from the dispensed area, thereby eliminating coverage imperfections and improving material flow for a level encapsulation.

Next is hot-air convection post-heating, which maintains the component temperatures to between 60º and 80ºC. Post-heating brings trapped air to the surface of the encapsulant, preventing the formation of pinholes. It also gels the material before the components are moved to the curing oven to reduce height variation caused by handling errors.

In all, components are heated three different times during the encapsulation process: hot-air convection pre-heating; contact heating at the nest area; and hot-air convection post-heating. All heating stations along with needle and material heaters are consistently monitored for temperature. If any of the heated items are not up to temperature the system pauses until the proper temperature is achieved.

Encapsulation is necessary to protect sensitive electronic components from the hazards they'll encounter during their lifetimes. Dam and fill encapsulation is a complex, multi-step process that depends on precise control of many variables. Fortunately for manufacturers, automated dispensing systems can monitor, adjust, and manage the variables in concert to produce the optimal encapsulation process.

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