TECHtips

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Electronics Manufacturing Insights from ACI Technologies, Inc.

# Die Attach Dispensing Methods

Die attach material selection and process implementation play crucial roles in any microelectronic assembly. The chosen attach methods ultimately affect die stress, functionality, thermal management, and reliability of the assembly. Die attach applications are designed to optimize mechanical attachment of the die to the substrate, to create a thermal path from the die to the substrate, and to create an electrical path for a ground plane connection. Some of the more commonly used die attach materials in the microelectronics industry today are epoxies, polyimides, thermoplastics, silicones, solders, and special low outgassing, low stress, anisotropic adhesives.

Most fluid adhesives exhibit characteristics which adversely affect the dispensing process. These characteristics include Thixotropy, Viscosity (5,000 cps to 100,000 cps; sensitive to temperature and moisture) and Tailing.

Adhesive selection is very application specific and dependent on factors listed in Table 1.

The following are the manufacturing process steps to attach a die to the substrate.

- The die attach adhesive is dispensed on the die pad in a pattern to optimize attachment material coverage between the backside of the die and the substrate.
- The die is placed on the substrate with a pick and place machine. As the die is placed, the adhesive spreads to cover the die attach pad.
- The adhesive is cured, typically with heat.
- In wire bonded applications, encapsulation and sealing takes place to complete the assembly process.

The most common systems used in dispensing adhesives use a time-pressure dispensing valve, auger pump, positive displacement pump, or a jetting valve. Each technique has its unique advantages and disadvantages.

**Time-Pressure Dispensing Valve:** The time-pressure dispensing valve (Figure 1) consists of a syringe containing adhesive which is directly attached to the dispensing tip. Adhesive is fed from the syringe using pressure in a time-controlled manner. Pressure is removed to stop material flow. Fluid flow is proportional to the amount and duration of the applied pressure. Since the air pressure is kept constant over time, as the syringe is emptied, dot sizes decrease because the plunger does not advance as far with each air shot. This variability can be adjusted by increasing the air shot size, but is often operator-dependent and can lower throughput. Time-pressure systems are the most economical dispensing solutions, but have a lot of variation in their results, and are limited in the minimum dot size they can produce.

| Dispenser Unit | Dispensing Parameters | Adhesive | Production Area | Training |
|---|---|---|---|---|
| X, Y, Z gantries | Pressure | Viscosity thixotrophy | Dust and dirt | Knowledge |
| Nozzle type | Time | Thermal conductivity | Air circulation | Awareness |
| Nozzle temperature | Standoff | Filler type | Temperature fluctuation | Authority |
| Vision system | Auger rotation | Cure schedule | Humidity control | Safety |
| Dispensing repeatability | Temperature | Pot life | | |
| | | Shelf life | | |

*Table 1: Factors influencing adhesive selection.*

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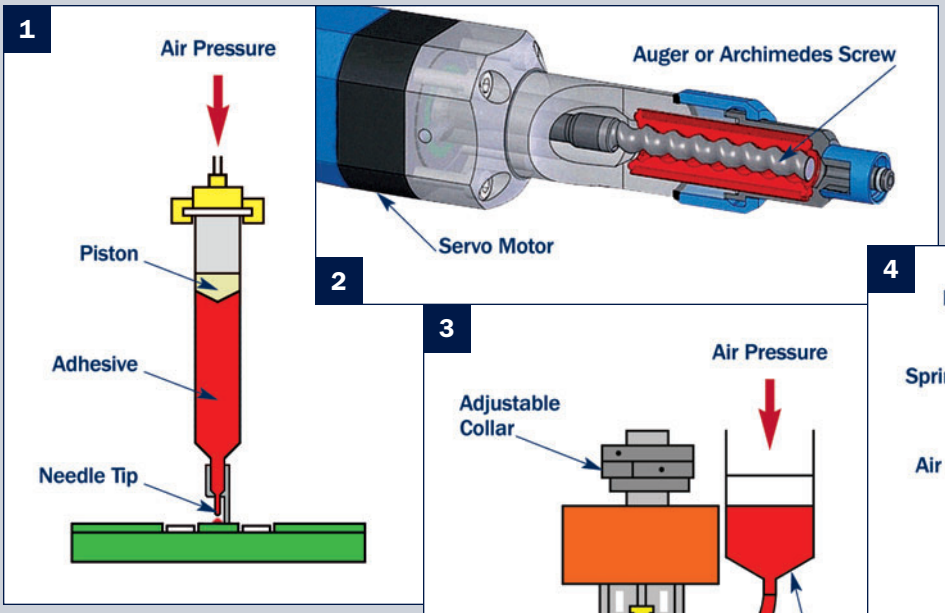


*Figure 1: Time-Pressure Valve. Courtesy of EFD, Inc.*

*Figure 2: Auger Pump. Courtesy of Fluid Research Corp.*

*Figure 3: Positive Displacement Pump. Courtesy of Universal Instruments.*

*Figure 4: Jetting Valve. Courtesy of Asymtek.*

**Auger Pump:** Rotary auger pumps (Figure 2) use an Archimedean screw turning in a cartridge to push the material through the pump. In some cases, the pump uses an electromagnetic clutch to engage and disengage the constant-speed DC screw motor. Low-pressure air maintains a steady flow of the material into the pump. A precision-controlled auger pump is programmable, and uses a DC servo motor with an encoder to precisely control rotation. A programmed dispense signal provides a direct and specific point-to-point indexed rotation of the auger while regulating speed, thus precisely controlling the quantity dispensed. When auger pumps are used to dispense adhesives with fillers, filler size and properties should be taken into consideration. If the filler is abrasive, suitable auger screw material like tungsten carbide should be selected. Needle size and auger screw clearance should be twice the filler size for easy flow of the adhesive. If this size is too small, filler material will clog the needle or the auger resulting in inconsistent dispensing.

**Positive Displacement Pump:** Positive displacement pumps (Figure 3) use a piston to force material through a needle. The piston motion inside the dispensing system is controlled by a DC servo motor with precision encoder. The displacement of the piston in the chamber results in an equivalent positive displacement of fluid through the pump. The deposition time is extremely fast and is solely dependent on the piston size and the length of piston stroke inside the chamber. A change in viscosity does not affect the amount of material dispensed through the pump. If the piston is not seated well, adhesive leaks through the sides of the chamber. Constant pressure is critical for filling the chamber; a drop in pressure results in an insufficient amount of adhesive in the chamber resulting in a smaller amount of material being dispensed. Higher pressures may lead to adhesive leaking.

**Jetting Valve:** Jet dispensing (Figure 4) – also called non-contact dispensing – provides the highest speed, delivering adhesive dots from a height between 1mm and 3mm above the board. In addition, it minimizes problems with adhesive tailing. Different sized dots can be applied by simply programming the valve to jet multiple shots into the same location. This allows tight process control, better repeatability, and better dot consistency.

- Eliminates Z-axis motion during dispensing.
- Positive shutoff prevents tailing.
- Dispensing speeds as high as 1000 dots/min.
- Fluid stream can be placed in areas where needle will not fit allowing tighter spacing.
- Reduced chances of damaging die.

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| Advantages | | | |
|---|---|---|---|
| **Time/Pressure Valve** | **Auger Pump** | **Positive Displacement Pump** | **Jetting Pump** |
| Low maintenance. | Used for filled and unfilled adhesives. | Used for filled and unfilled adhesives. | Used for filled and unfilled adhesives. |
| Low cost. Minimal operator training required. | Closed loop system guarantees accurate adhesive dispensing. | Adhesive flow rates of 5000mg/sec with 1% accuracy can be dispensed. | Very repeatable dots/line. Can dispense wide viscosity range without any process issues. |
| Quick change over. | Cartridge change over is quick and easy. | Easy to clean. | Relatively easy to clean. Does not use needle tips. |
| Used for large die application and low production volume. | Very good for small die attach application. | Application range from very large BGA to small flip chip attachment. | Application which requires non contact Z, no space for needle to dispense adhesive, very high throughput. |
| 0.01 inch minimum dot and line size can be dispensed. | Useful to dispense very small dots 0.006 inch very accurately. | 0.008 inch dot or line size can be dispensed accurately. | Useful to dispense very small dots 0.006 inch very accurately. |
| **Disadvantages** | | | |
| **Time/Pressure Valve** | **Auger Pump** | **Positive Displacement Pump** | **Jetting Pump** |
| Need constant adjustment of timing/pressure. | Special operator training required to use the system. | Special operator training required to use the system. | Special operator training required to use the system. |
| Not useful for small dot application. | Expensive, need extra auger cartridge to quickly change over. | Expensive, pump is available in fully automated dispensing system. | Very expensive. |
| Not useful for solder paste and high viscosity adhesives. | Cleaning takes time and training. | Quick change over not possible without proper cleaning. | |
| | Need special auger cartridge for abrasive fillers as they will wear the auger screw. | | |

*Table 2: Advantages and disadvantages of dispensing methods.*

The advantages and disadvantages of each dispensing method are shown in Table 2.

The desirable qualities of cured adhesive after die is placed are:

- A thin bond line to reduce electrical and thermal resistance.
- Cured adhesive after the die is placed should not squeeze out and touch the adjacent bond pads. This will create an electrical short if the adhesive used is electrically conductive. Subsequent wire bonding operation will be affected if adhesive is smeared on the bonding pads.
- Void free to maximize strength, thermal conductivity, and electrical conductivity.

A thorough design and process review, including definition of production needs, should be considered before selecting a suitable dispensing system for a given application.

For more information on the selection of an appropriate dispensing system for a specific application, or any dispensing issues or concerns, please contact ACI Technologies by phone at 610.362.1320 or via email at helpline@aciusa.org.

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