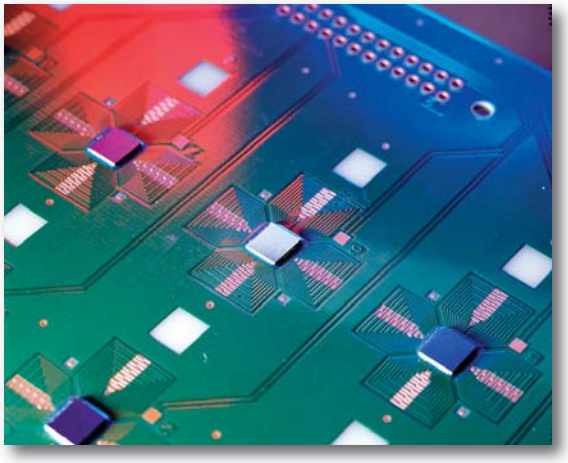
GPD Global Process

Capillary Underfill

Successful Application Method

APPLICATION

The Capillary Underfill process is used to encapsulate the bottom side of a silicon die. The word “encapsulation” typically means to cover a top surface where fragile interconnects are located, but in this case, the fragile interconnects are on the bottom side of the die. The device to be underfilled is either a “flip chip” or a BGA.



The reason for underfilling is to compensate for the differences in thermal expansion rates of two unlike materials: solder bumps and flex circuit or FR4, for example. Without underfill, the life expectancy of a product with a flip chip would be greatly reduced due to cracking of the interconnects. The underfill adds rigidity to the product; that is, underfill gives it the ability to survive high impact shock without fracturing or separating completely from the substrate.

A successful underfill process results in complete encapsulation of the bottom side of the die, free from air entrapment with an even meniscus on all 4 sides. If bubbles are present in the encapsulation, it could cause a defect during normal operating temperatures due to the expansion of the gas in the void.

EQUIPMENT

GPD Global® recommends the MiniMax™ II or DS Micro Series in either a stand-alone or inline configuration. All of these systems are equipped with work area heat to keep the substrate at operating temperature, typically 80 degrees C. The elevated temperature reduces the underfill viscosity to facilitate material flow. A lower viscosity material will flow quickly and easily below the die reducing the chances of voids. Additional features of these systems are optional pre- and post-heating, valve and needle heat, as well as closed loop process calibration.

MAX II Series

Heated, compact dispense platform. Shown with Pre- and Post-Heaters

DS Micro II

Heated dispense platform. Boards up to 15“ x 9“ (381 mm x 229 mm)

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GPD Global® utilizes proven auger technology that is easy to maintain and yields excellent process results. Valve maintenance is minimal and can be cleaned and rebuilt in 7 minutes. The dispense valve is attached to the system through the GPD Global® exclusive tool-less Taper-Lock™ mounting hardware.

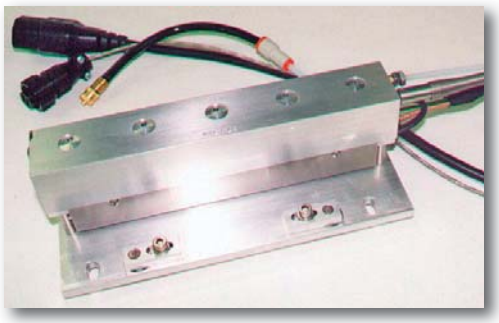
Toolless Taper-Lock™

PROCESS

The basic steps to an underfill process are:

1) Pre Heating from ambient to 80 degrees C
2) Vision alignment of die to be underfilled
3) Locate surface to dispense (z axis)
4) Dispense the *fill* pass – Multiple passes may be required
5) Dispense the *fillet* pass – May not be required depending on chip size or underfill material selection
6) Post-heating – Product dependent

Inline systems are recommended for underfill due to the ability to use pre- and post-heaters. Pre-heating is used to quickly ramp a product from ambient temperature to process temperature. Different methods of pre-heating are available. The most common method is a custom contact vacuum fixture. This offers the quickest and most uniform heat transfer.



Heated, Contact, Vacuum Fixture

A universal heating method utilizes forced air. Forced air allows any substrate to be heated no matter the geometry or size, but time to heat is longer versus contact heating. To ensure that the substrates are not overheated, a temperature monitoring system has been employed. If the substrate reaches the operating temperature, heat is removed and the substrate is transported to the work area. Post-heating is used after the dispense process to continue the flowing process. Depending on the application, the post-heater may be used to gel an underfill to hold it in place before the next step.

After preheating, the substrate is transported to the work area where alignment of each die will begin. The system scans all die first to determine which units will be processed and their orientation. Accurate alignment of each die is necessary to keep the dispensed material within the allowed wetted areas.

The alignment process can be very tricky when silicon dies are used as the surface texture and finish can vary from unit-to-unit or lot-to-lot. It is these variations that can make finding a die with a standard illumination system very difficult. By using FullView Illumination, which is a combination of a low angle dark field with an on-axis source, any die can be found.

FullView Illumination

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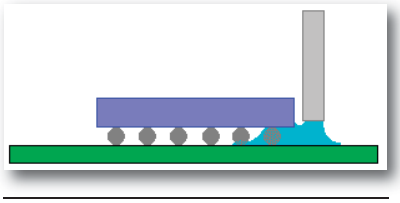
The dispense routine begins with a fill pass. The fill pass deposits the majority of the material that will flow under the die. The pattern



First Fill Pass

for dispensing the material is also key for a successful process. In most cases, the “L” pattern is the right choice. The “L” starts on the longest side of the die and turns the corner to the shorter side. Depending on the die size, this pass could be all the material required to complete the underfill. Once the material is dispensed it will flow under the flip chip via capillary action. If all the material disappears and there is no fillet or meniscus at the sides of the die, then either:

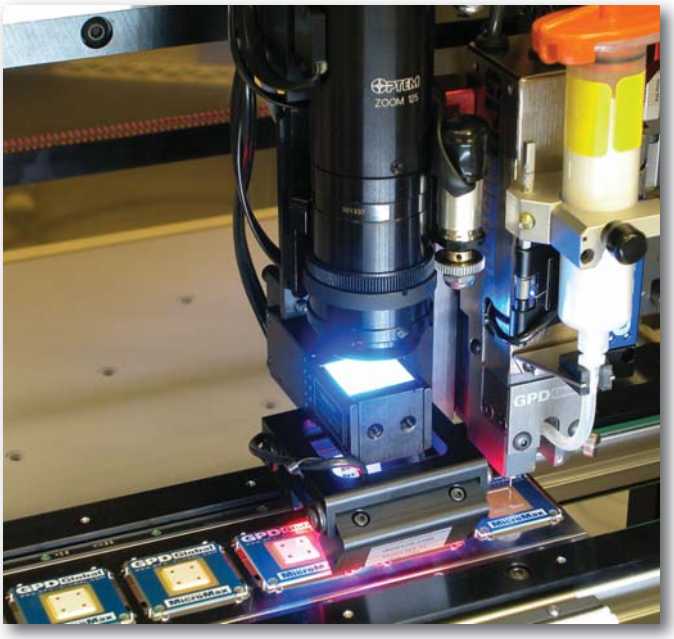
1) More material is required on first fill pass,

2) An additional fill pass is needed,

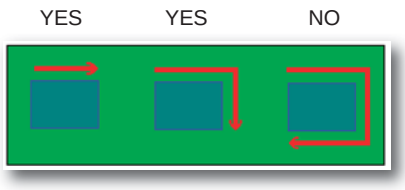
OR

3) A fillet pass is required.

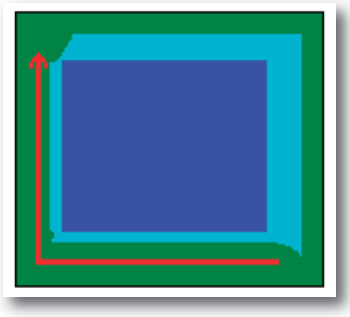
In many cases, the fillet pass is required. The fillet pass is used to “finish” the process by applying enough material to create the sealing joint. In an optimized process all the fill passes will be dispensed first, wait for the material to flow, followed by the fillet. The reason for doing all the fills first is to give the material enough time to flow under the die before applying the final amount of material. Note that a multiple fill pass process will take longer but the cosmetics of the finished product will be excellent. In some very high volume applications, a large quantity of material is dispensed in a single pass with no fillet. The cosmetics of this process will show a large wetted area to one side of the die but the functional results will be acceptable.



Additional process control is achieved through volumetric feedback that comes from an integrated weight scale. During the calibration process, the weight scale monitors the amount of material that is dispensed over a period of time. If the amount of material varies from what is expected, the system will make adjustment to the dispense parameters to ensure a consistent dispense quantity. The reason for this calibration routine is to compensate for material changes over time (pot life) and batch-to-batch variations.



Fill Pass Patterns



Fillet Pass

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EXCLUSIVE SYSTEM FEATURES

- ***Unibody Frame with MAX II Series*** – Extremely stable platform for precise dispensing.

- ***Clear Vu™ Vision*** – Programmable zoom and focus for accurate alignment of *small* features.

- ***FullView Illumination –*** Combination of on-axis with dark field illumination, individually controlled to view any surface.

- ***Illuminator Intensity Control*** – Controls illuminator brightness for hard to find fiducials. Intensity values are stored with the fiducial pattern and are automatically adjusted when a program is executed.

- ***Precision Laser Surface Sensing*** – Accurately locates substrate surfaces without contact.

- ***Taper-Lock™ Mounting Hardware*** – Allows valves and tools to be removed from the system without the need for allen wrenches or other tools.

- ***Toolless Valve Cleaning*** – Valves have been designed to be disassembled without tools, making for easy valve maintenance.

- ***NCM Dispense Technology –*** High speed non-contact dispensing.

- ***Automatic Needle Calibration*** – Standard feature that has the system automatically calibrate the position of a dispense tip. Complete process takes approximately 30 seconds.

- ***Auto Nozzle Cleaning*** – Cleans a needle or nozzle before dispensing. Ensures a good dispense process.

- ***FLOware® Software*** – Proprietary software that makes programming substrates and converting data a snap. Additional process monitoring features allow system and operator productivity to be monitored and saved for later recall.

- ***Temperature monitoring*** – Monitors the temperature of a substrate in the pre-heater for tight process control.

- ***Available Non Contact Work Area Heat*** – Allows one fixture to be used for a variety of substrates as long as the package dimensions don't change.

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