

Compression molding solutions for various high end Package and Cost savings for standard Package applications

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Introduction

There have been substantial changes on sensitive IC such as 2.5D, 3D and MEMS packages to prevent breakage of silicon chips by packing pressure and high density IC packages.

Packages are becoming smaller, thinner and weaker with more numbers of chips installed and stacked. Bump height for flip chip is trending smaller and wires are becoming longer and finer.

Towa has been providing mold technology solutions for IC packages based on their original innovative Multi-Plunger molding technology.

Recently, transfer molding technology has been challenged to mold advanced packages that has multi-stack die in 2.5D, 3D or MEMS structures and finer wire bonding.

Transfer molding applies high injection pressure on melted thermoset compound and requires resin flow path to fill up the cavities. Fact is these advanced packages have limited space for resin flow and high number of longer and finer wires.

Also, it has become more difficult to mold large wafer and large area size substrate (Panel Mold) with the current transfer mold technology.

To solve these issues, Compression Molding^{Pat.P} was developed and introduced by Towa which has become new Defacto standard.

Compression Molding Technology

Basic process is as below:

1. Supply substrate on top mold.
After release film is sucked in flat by vacuum action onto bottom mold, substrate loads onto top mold by mechanical handler-
2. Supply granular compound
After scanning the substrate for number of chips attached, weight of granular compound is prepared accordingly in the box and transfer to be spread over onto cavities in bottom Mold Chase.
3. Clamp substrate and vacuum starts
After supplying the granular mold compound, mold is close and vacuum turn on to suck out air, gas and moisture coming out from the compound.

4. Close mold and cure starts

Mold is completely closed by applying required pressure and compound starts the curing process.

5. Mold open and release

After cure is complete, mold starts to open and molded substrate is released by ejecting release film.

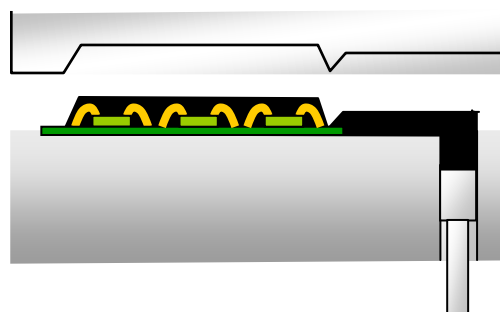


Figure 1: Transfer Molding

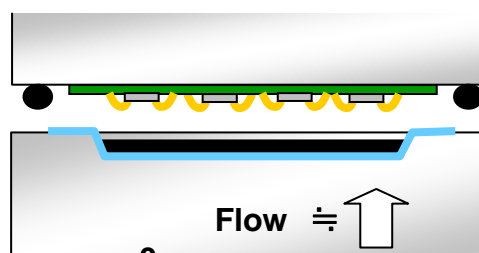


Figure 2: Compression Molding

Towa's Compression Mold Technology was developed to mold packages with minimum compound flow. And Towa's unique high vacuum method "FM (fine mold)" helps to fill in any open area and very small gaps.

The release film helps to release the molded part from the mold and do away with cleaning after each shot.

After scanning for the number of chips attached on actual substrate a precise correct amount of

compound is supplied and loaded into the mold cavity.

We have found that there are significant advantages by Compression Molding.

1. No mold cleaning

After every shot, no mold cleaning process is required because compound never touches mold cavity surface. Melamine mold cleaning is not required. This reduces scheduled down time and minimize cleaning material costs.

2. High effective usage of mold compound

There is no waste of mold compound as the precise required amount of compound is supplied and molded without any cull and runners. It is also eco-friendly.

3. High quality molding

Towa's compression molding technology produces high quality molding that enables molding of the following advanced packages without any internal defects:

a. 2.5D, 3D(TSV), MEMS package

Thinner and weaker chips (smaller than 28-nano process) in thin packages. These packages failed with transfer molding because of high packing pressure (minimum 70kg/cm) required to eliminate voids.

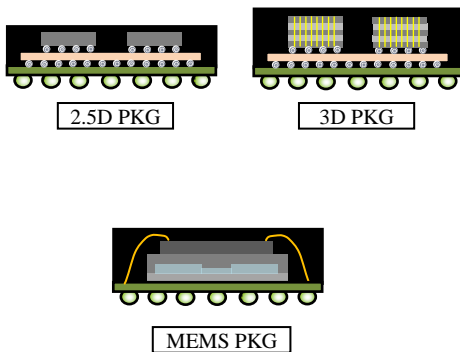


Figure 3: 2.5D, 3D (TSV) and MEMS Package

b. Multi-stack die package

When chips are stacked in thin package, there is limited space between top surface of package and top of chip. But, compression mold can make sure that the limited space can be filled with molding compound.

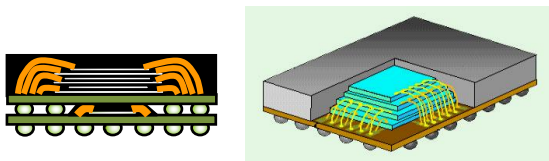
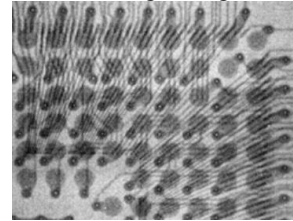


Figure 4: Stacked die Package

c. Long or fine wire bonded package

Compression mold with minimum flow in X or Y direction will eliminate wire sweep. Picture2 shows an evaluation of 15um ϕ by 5mm long wire with no wire sweep.

In transfer molding, wire sweep is a concern with long and very thin wires because of injection pressure and velocity of melted mold compound flow through the gate is very high.



Picture2: Package after molding

d. Low-K die package

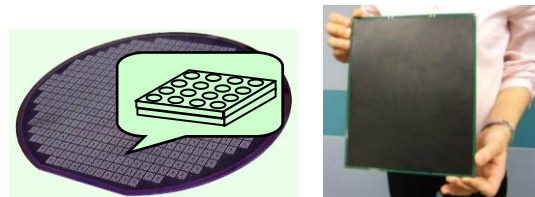
With Towa's soft close and no resin flow, high pressure is not needed to eliminate voids. Damage to low-K die can be avoided.

e. Wafer molding

Compression mold enables wafer molding of 8-inch and 12-inch (future size 18-inch) diameter wafer without creating any internal defects such as voids and delamination.

f. Large area substrate (Panel) Molding

Compression mold can make sure the symmetric mold condition on any place of the substrate. Compression mold can also keep the resin temperature changes equally on any place of the substrate. Transfer molding may create different filler distribution and air may be trapped due to long resin flow by injection pressure.



Picture3: Wafer Level & Panel Mold Package

4. Common use of Mold

Compression molding has the capability of molding up to 0.3 mm range in package thickness with a single set up. It is not necessary to change mold cavity for each unique package type.

In cases where different thickness of molding is required same mold cavity can be used. Only variation is the amount of mold compound dispense. Advantage includes reduce down time as conversion to different mold cavity is not needed.

Package cost reduction with high productivity

Definitely compression mold technology allows significant cost reduction in current standard package assembly process.

1. Gold wire saving

It is possible to mold finer wires of 15 μm diameter. This is approx. a 64 % reduction of gold consumption from $\phi 25 \mu\text{m}$ diameter wires. As we all know gold is one of the most expensive materials in package assembly.

2. CMP process elimination

There is no limitation between the top surface of package and top of IC Chip for Compression Molding. Transfer molding needs minimum mold gap for resin compound flow but not compression molding which has no flow. Therefore, thicker chip which reduces CMP or back grinding process can be used without increasing total package height.

3. Large size substrate (Panel) with larger number of packages

Transfer mold faces unbalanced mold injection flow which results in possible yield loss. But, Compression Mold has no such limitation. Therefore, larger area size substrate can be designed and molded which increases number of packages per strip resulting in higher productivity.

4. Lower Cost of Ownership (CoO)

As described earlier, advantages in compression mold technology includes reduction of compound usage, scheduled down time, and system conversion time and same mold set up for packages within 0.3 mm thick contributes substantially to a lower CoO.

Compression molding technology is now receiving high attention in the molding market as an important method of CoO reduction.

Mass Production System PMC for Semiconductor,

In 2008, Towa finished the development and started selling the PMC for mass-production in response to high market demand.

This system adopts the unique "Hold Frame" press structure which reduces system depth to 1,250 mm which in turn helps to reduce floor space in the clean room.

Main features are as below:

1. Maximum 4 press

Press Module Unit can be added (up to 4 modules) on site when the production volume is increased.

2. Modular design

Towa's patented Modular Press design makes sure that each press is independently controlled and possibility to skip the disable press.

3. Small foot print

The hold frame press design makes it possible to reduce the machine depth.

4. Pre-cut release film method reduces film usage

On Transfer Molding System the release film advances after every shot. The used film is continuously pulled into a used film roller. By advancing continuously there is a large unused area of release film. This process certainly contributes to higher operating cost.

But, Towa has invented and applied the "pre-cut" method which reduces film usage by 30%.

5. Cleaner working environment

By separating supply of substrate and compound and with the compound on the film the littering of granular compound and contamination are greatly reduced.

6. Accurate granular compound control

By scanning the actual number of attached chip on the substrate on every shot, the required amount of compound is accurately dispense for each shot into the mold cavity.

7. Max.100 x 260 mm substrate

Current maximum substrate size meets existing substrate and L/F market requirement. However in an effort to further reduce CoO bigger size material (100 x 300mm or larger) is being developed.

8. Possible to detect number of stacked die

A special laser scan sensor is installed to detect number of stacked die on each position on the substrate. Each scan is then analyzed and volume of compound is adjusted accordingly to maintain accuracy of package thickness.



Picture 3: PMC for Auto Molding System

Various applications

There are various possible applications for compression molding. One of the best applications is for LED lens manufacturing.

LED application

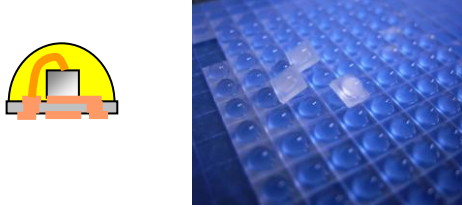


Figure5: LED Package by Compression mold

Basic process is the same as IC packages.

More and more, compression molding is now becoming most popular because of the following advantages:

1. Lens shape can be molded by high precision mold tooling capability.
2. LED package size can be significantly reduced.
3. Silicone liquid resin can be molded by 1-liquid or 2-liquid mix type dispenser.
4. High yields.
5. Fragile ceramic substrate can be molded without any crack.
6. Wider light emitting scope can be achieved.

Towa has also developed and started selling LCM auto-molding system for mass production of LED.

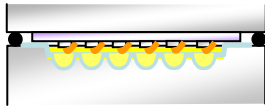


Figure6: Compression Mold for LED



Picture 4: LCM Auto Molding System

Other possible applications

1. Solar Cell protection

Various kind of plastic is used to protect solar cell. The solar cell needs to guarantee its life for more than 30 years. Compression mold receives high interests to encapsulate the cell.



Picture 5: Solar panel

2. Power IC and Electric Component module

Lately, compression mold technology has been used to encapsulate the Power Module for inverter control of motors given its high reliability and cost effectiveness.



Picture 6: Electric Component module

Conclusion

Great progress has been made on Compression Molding Technology and Equipment. It has been applied not only for most advanced semiconductor packages but also to molding MAP for regular BGA and QFN packages to further reduce CoO.

Each component has proven to achieve excellent required reliability primarily due to no resin flow.

As mentioned there is wide range of applications including LED production. The system is fully developed, is selling and ready to support high volume mass production.

Compression molding by Towa has shown that it has become the next Defacto standard technology in the mold industry.