DIRECT MOLDING SYSTEM AND PROCESS

Field of the Invention

[0001] The present invention relates to molding technology and, more particularly, to a direct molding system and process for molding a substrate with a molding material.

Background of the Invention

[0002] Electronic devices are usually encapsulated with a molding material so that they are insulated from external environment, resulting in minimized damages and longer use lives. For example, a LED usually comprises a transparent cover (called lens) that protects the LED from damages caused by external environments and at the same time permits the emission of the lights from the LED.

[0003] Historically, epoxy compounds have been favored for protective lens for semiconductor devices. However, epoxy compounds tend to stick to the surfaces of the cavities after it cures; as such, the surfaces of the lens will likely be affected when the leadframe is segregated from the mold plate. In addition, when the epoxy compounds are used for LEDs, it has been found that the epoxy lens degraded in optical properties (e.g., turning opaque or yellowish) if the lens are used for high power LEDS.

[0004] Silicone rubber materials are good alternative for the epoxy compounds because they have superior optical properties when used for high power LEDs. However, silicone rubber materials have a low solidification temperature and short curing time. Thus, a LED with a silicone lens is usually manufactured in a two-step procedure. The silicone lens is first molded, and then bonded onto the LED to form a LED assembly with a silicone lens. See, US 2006/0220049 A1. Apparently, this two-step procedure is cumbersome and time-consuming.

Summary of the Invention

[0005] One embodiment of the present invention provides a molding system for molding a substrate with a molding material. The molding system comprises a mold module, where the mold module comprises a cooling/dispensing station with a cooling mechanism, where the cooling/dispensing station conducts the heat away from a center cavity plate, and where the center cavity plate has a plurality of cavities and the molding material is dispensed into the cavities before molding; and a molding station, where the molding station comprises a top mold chase and a bottom mold chase so that the center cavity plate with the substrate can be disposed between them for molding at a predetermined period and temperature.

[0006] Another embodiment of the molding system, the cooling mechanism is one selected from the group consisting of an air-based cooling mechanism, a fluid-based cooling system, or a cooling system with one or more peltier modules.

[0007] Another embodiment of the molding system, the mold chases comprises a heater.

[0008] Another embodiment of the molding system, it further comprises an input gripper for transferring the substrate from an input module onto the center cavity plate disposed on the platform of the cooling/dispensing station; and an output gripper for transferring the molded substrate from the center cavity plate disposed on the platform of the cooling/dispensing station to an output module.

[0009] Another embodiment of the molding system, it further comprises a dispensing mechanism with a dispensing head, a container for holding the mold material, and an electro-mechanical transport mechanism for moving the dispensing head into/away the position where the dispensing mechanism can dispense the mold material into the cavities of the center cavity plate.

[0010] Another embodiment of the molding system, it further comprises an input module, where the input module comprises an onloader for transferring the substrate to an onload track; a track & gripper for picking and placing the substrate onto a lead-in plate; the lead-in plate for orientating the substrate; and a loading plate for maintaining the proper orientation of the substrate.

[0011] Another embodiment of the molding system, the loading plate comprises a heating mechanism for pre-heating the substrate to a predetermined temperature.

[0012] Another embodiment of the molding system, it further comprises an output module, where the output module comprises an unloading plate for receiving the molded substrate; a pick and place for picking the molded substrate from the unloading plate and places onto an offload track; the offload track for receiving the molded substrate; and an offloader for readying the molded substrate to be removed from the system. In further embodiment of the molding system, the offload track comprises a vision inspection device for inspecting the molded substrate.

[0013] Another embodiment of the molding system, the substrate is a leadframe. In a further embodiment of the molding system, the leadframe is populated with a plurality of electronic devices. In yet further embodiment of the molding system, the electronic devices are LED.

[0014] Another embodiment of the molding system, the molding material is a silicone rubber.

[0015] Another embodiment of the molding system, the cooling/dispensing station comprises a platform, where the cooling mechanism is so configured that it controls the temperature of the platform, and where the platform provides support for the center cavity plate during dispensing.

[0016] Another embodiment of the molding system, the cooling/dispensing station comprises a cooling plate of which the temperature is controlled by the cooling mechanism, and a supporting means for providing support to the center cavity plate during dispensing.

[0017] Another embodiment of the present invention provides a process for molding a substrate with a molding material. The process comprises the following steps of providing a center cavity plate with a plurality of cavities; placing the center cavity plate on a supporting plate; dispensing the molding material into the cavities; placing the substrate onto the center cavity plate, where the substrate is aligned with the cavities; transporting the substrate and center cavity plate into a mold; pressing and molding the substrate for a predetermined period at a predetermined temperature so as to allow the molding material be molded and cured; transporting the molded substrate and center cavity plate onto a cooling plate to allow the center cavity plate to cool; and picking the molded substrate out of the cavities of the center cavity plate.

[0018] Another embodiment of the process, the supporting plate and the cooling plate can be same.

[0019] Another embodiment of the process, the substrate is a leadframe. In a further embodiment of the process, the leadframe is populated with a plurality of electronic devices. In yet further embodiment of the process, the electronic devices are LED.

[0020] Another embodiment of the process, the molding material is a silicone rubber.

[0021] The above and other objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0022] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0023] FIG 1 shows a functional block diagram of the molding system in accordance with one embodiment of the present invention.

[0024] FIG 2 shows a functional block diagram of the mold module **20** in accordance with one embodiment of the present invention.

[0025] FIGS 3 (a)-(g) show more details of illustration of the processes carried out in the mold module in accordance with one embodiment of the present invention.

[0026] FIG 4 shows a functional block diagram of the input module and output module in accordance with one embodiment of the present invention.

[0027] FIG 5 shows a perspective view of the mold module in accordance with one embodiment of the present invention.

Detailed Description of the Invention

[0028] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention. However, it will be understood by those skilled in the relevant art that the present invention may be practiced

without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0029] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0030] As discussed above, it would be desirable to mold a silicone cover over an electronic device such as LEDs. However, the available silicone rubber materials (e.g., Dow Corning's resin based liquid silicone rubber SR-7010; GE-Toshiba's heat curable silicone material IVSM4500) are not suitable for traditional multi-cavity molding process because they usually have a very short curing time (e.g., 1-10 minutes) at relatively low temperature (e.g., 150°C). In addition, if the curing temperature is too high, the harden silicone rubber len does not bond properly with the die and leadframe.

[0031] The present invention provides a molding system and process that is capable of molding silicone-based covers onto electronic devices and leadframes directly, thus it eliminates the bonding of a pre-molded cover to an electronic device. In principle, the molding system of the present invention has a design that the dispensing and molding are carried out separately in two physical locations. It is to be noted that the following discussion will refer to the leadframe, LEDs, silicone rubber materials, but they are by no means intended to limit the scope of the application of the molding system and process to these specific examples.

[0032] Now referring to FIG 1, there is provided a functional block diagram of the molding system in accordance with one embodiment of the present invention. The molding system **1** comprises an input module **10**, a mold module **20**, an output module **30**, and a controller **60**. Briefly, the input module **10** receives substrates **50** (shown in FIG 3(c)) to be molded and orientates the substrates according to a user's requirement so that the substrates are ready for the process of the mold module; the mold module **20** is configured to have two stations so that the dispensing of molding materials and molding process are carried out separately; the output module **30** receives the molded substrates and performs post-molding processes including vision inspection; and the controller **60** is responsible for controlling the processes performed by three mentioned modules. It is to be noted that the modulation of the

system is for the sake of convenience of description; it is by no means intended to indicate or imply that the system has to be modulated for its function. A more detailed description of each module is provided hereinafter.

[0033] Now referring to FIG 2, there is provided a functional block diagram of the mold module **20** in accordance with one embodiment of the present invention. The mold module comprises a cooling/dispensing station **22** and a molding station **25**. In one embodiment, the cooling/dispensing station **22** comprises a platform that is configured to perform at least two functions, one is to provide support for a center cavity plate **40** with a plurality of cavities (shown in FIG 3(a)), and the other is to conduct the heat away from the center cavity plate **40** after the center cavity plate **40** has been molded with the substrates in the mold station **25**. The cooling/dispensing station **22** further comprises a cooling mechanism that is configured to control the temperature of the platform. For example, the cooling mechanism may be disposed directly beneath the platform so that the heat from the platform in turn from the center cavity plate can be conducted away efficiently. Any cooling system can be suitable if it is compatible with the operations of the system. For example, the cooling mechanism can be an air-based cooling mechanism or a fluid-based cooling system. Furthermore, the cooling mechanism may be comprised of one or more peltier modules, where each peltier module has a first surface and second surface. When in use, a voltage can be applied to the one or more peltier modules to achieve a temperature difference between the first surface and second surface of each peltier module. For example, the first surface can be hot and the second surface can be cold to achieve the heating mode; and by simply switching the polarity of the voltage applied to the peltier modules, a cooling mode can be achieved so that the first surface can be cold and the second surface can be hot. Thus, it is to be noted that the cooling mechanism used in the present invention may be used to pre-heat the center cavity plate if desired. In another embodiment, the cooling/dispensing station **22** comprises a cooling plate with a cooling mechanism for cooling the center cavity plate **40** and a supporting means (e.g., a rack) for supporting the center cavity plate (e.g., during dispensing), where the supporting means is so configured that the center cavity plate can be in direct contact with the cooling plate when desirable. It is to be noted that the cooling mechanism can be used to cool the center cavity plate so that it can get ready for another dispensing cycle.

[0034] The molding station **25** as shown in FIG 3(a) comprises a top mold chase **25a** and a bottom mold chase **25b** so that the center cavity plate with the substrates can be disposed between them; when the press is actuated, the two mold chases will be closed so as to mold the substrates. The molding station **25** further comprises a heating mechanism for heating the center cavity plate and substrates and molding materials. In one embodiment, the heating mechanism is a heater installed within the mold chase.

[0035] The mold module **20** further comprises an input gripper **21** that transfers the substrates from the input module **10** onto the center cavity plate **40** disposed on the platform of the cooling/dispensing station **22**, and an output gripper **23** that transfers the molded substrates from the center cavity plate disposed on the platform of the cooling/dispensing station **22** to the output module **30**. The design and configuration of the input gripper **21** and output gripper **23** may be very similar or identical since both are used to grip and carry the same substrates. However, the actual design and configuration of the grippers depend on the substrates.

[0036] The mold module **20** further comprises a dispensing mechanism **24** that can be positioned over the cooling/dispensing station **22** so that when the center cavity plate is positioned upon the platform, the dispensing mechanism **24** can dispense the mold material into the cavities of the center cavity plate. The dispensing mechanism **24** comprises a dispensing head, a container for holding the mold material, and an electro-mechanical transport mechanism for moving the dispensing head into/away the positions. The design and configuration of the dispensing head should be compatible with the mold materials. For example, when the mold material is in liquid form, the dispensing head should be able to dispense a desired volume of the liquid mold material into the mold cavities of the center cavity plate.

[0037] Now referring to FIGS 3 (a)-(g), there are provided more details of illustration of the processes carried out in the mold module in accordance with one embodiment of the present invention.

[0038] As shown in FIG 3(a), the center cavity plate **40** is disposed upon the platform of the cooling/dispensing station **22**, and the mold chases **25a**, **25b** are open. It is to be noted that more than one center cavity plate may be disposed upon the platform for dispensing of the

mold material, and more than one center cavity plate may be positioned within the mold station for the molding.

[0039] As shown in FIG 3(b), the cavities are filled with liquid mold material **41** dispensed by the dispensing head.

[0040] As shown in FIG 3 (c), a substrate **50** is positioned over the center cavity plate and is going to be overlaid onto the center cavity plate. The substrate as illustrated is a leadframe with a plurality of electronic devices, where the electric devices are LED. It is evident that the molding process and apparatus of the present invention is not so limited.

[0041] As shown in FIG 3(d), the leadframe with the LED is overlaid with the center cavity plate and the LED are immersed within the liquid mold material within the cavities.

[0042] As shown in FIG 3(e), the mold chases **25a, 25b** are closed, and the LEDs are molded with the mold material.

[0043] As shown in FIG 3(f), the molded LEDs and the center cavity plate are moved out of the mold station and disposed onto the platform of the cooling/dispensing station for cooling by the cooling mechanism as described above.

[0044] As shown in FIG 3(g), the cured LED frame is gripped by the output gripper **23** and moved to the output module.

[0045] Now referring to FIG 4, there is provided a functional block diagram of the input module and output module in accordance with one embodiment of the present invention. The mold module has been described above.

[0046] The input module **10** comprises an onloader **11**, a track & gripper **12**, a lead-in plate **13**, and a loading plate **14**. The following description of the input module will use leadframes as an example to illustrate the functions of each component. It is also apparent that individual functions can be combined and performed by fewer components. The onloader **11** holds the magazines of leadframes, and transfers the magazines containing the leadframes to the correct height of an onload track; and then an onloader dragger transfers the leadframe from the magazine onto the onload track. The track & gripper **12** is positioned over the onload track to pick and place the leadframe onto the lead-in plate **13**. The lead-in plate **13** comprises a rotary mechanism that orientates the leadframes so that the leadframes have the proper orientation for being transferred to the loading plate **14**. The loading plate **14** receives the

leadframes in their proper orientation so that they can be transferred onto the center cavity plate disposed on the cooling/dispensing station. The leadframes may be transferred onto the center cavity plate after the center cavity plate is disposed within the mold chases of the mold station. In addition, the loading plate **14** may further comprises a heating mechanism to pre-heat the leadframe to a desired temparature. The heating mechanism may be any controllable heating system including peltier system.

[0047] The output module **30** comprises an unloading plate **31**, a pick and place **32**, an offload track **33**, and an offloader **34**. Following the description of the input module, the following description will use the leadframes as an example to illustrate the functions of each component. It is also apparent that individual functions can be combined and performed by less of components. The molded leadframe is transferred from the platform of the cooling/dispensing station to the unloading plate **31**, and then shuttled to the offload track by the pick and place **32**. The offload track **33** may be incorporated with a vision inspection device to inspect the acceptance of the molded product. The completed molded products are placed and stored on the offloader station **34** to be removed from the system.

[0048] Now referring to FIG 5, there is provided a perspective view of the mold module in accordance with one embodiment of the present invention. Each component has been described above.

[0049] Now there is provided a brief description of the molding process in accordance with one embodiment of the present invention. The onloader **11** transfers leadframes from magazines onto the onload track; the track & gripper **12** picks leadframes and places them onto the lead-in plate **13** where the lead-in plate can hold one or more leadframes; and the leadframes are transported onto the loading plate **14**, where the loading plate can hold one or more leadframes and the leadframes may be pre-heated; at the same time, the dispensing head dispenses molding material into the cavities of the center cavity plate; then the input gripper **21** transports and places the leadframes onto the center cavity plate; then the aligned center cavity plate and the leadframe are transported into the mold station **25** when the mold is carried out; then the molded leadframe along with the center cavity plate is transported onto the cooling/dispensing platform for cooling; then the cooled molded leadframe is transported

by the output gripper **23** to the unloading plate **31**; then the pick and place **32** picks the molded leadframes and places them onto the offload track **33** and further to the offloader **34**.

[0050] With respect to the process of fabricating high power electronic devices such as LEDs with liquid silicone rubber resins or elastomers materials and with reference to the embodiment illustrated in FIG 5, the external dispensing of liquid silicone rubber delays the curing process of silicone rubber until the leadframe overlaid with LEDs is transferred to the molding station **25** as shown in FIG 3(e). Shortly after the curing temperature of the silicone rubber is reached, the embodiment of the present invention releases the top and bottom molds **25a, 25b** and transfers the molded and cured LEDs on leadframe to the cooling/dispensing station **22**. This cooling step obviates the adhesion problems encountered in the die and leadframe interface with silicone rubber when the latter is over-cured. It follows that the mass production of delicate electronic components such as high powered LEDs can achieve yields that are superior to processes that rely on discrete LED lens while reducing overall manufacturing costs.

[0051] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

Claims

What is claimed is:

1. A molding system for molding a substrate with a molding material, said molding system comprising:

a mold module comprising:

a cooling/dispensing station with a cooling mechanism, where the cooling/dispensing station conducts the heat away from a center cavity plate, and where the center cavity plate has a plurality of cavities and the molding material is dispensed into the cavities before molding; and

a molding station, where the molding station comprises a top mold chase and a bottom mold chase so that the center cavity plate with the substrate can be disposed between them for molding at a predetermined period and temperature.

2. The molding system of claim 1, wherein the cooling mechanism is one selected from the group consisting of an air-based cooling mechanism, a fluid-based cooling system, or a cooling system with one or more peltier modules.

3. The molding system of claim 1, wherein the mold chases comprises a heater.

4. The molding system of claim 1, further comprising:

an input gripper for transferring the substrate from an input module onto the center cavity plate disposed on the platform of the cooling/dispensing station; and

an output gripper for transferring the molded substrate from the center cavity plate disposed on the platform of the cooling/dispensing station to an output module.

5. The molding system of claim 1, further comprising:

a dispensing mechanism with a dispensing head, a container for holding the mold material, and an electro-mechanical transport mechanism for moving the dispensing head into/away the position where the dispensing mechanism can dispense the mold material into the cavities of the center cavity plate.

6. The molding system of claim 1, further comprising:

an input module comprising:

an onloader for transferring the substrate to an onload track;

a track & gripper for picking and placing the substrate onto a lead-in plate;

the lead-in plate for orientating the substrate; and

a loading plate for maintaining the proper orientation of the substrate.

7. The molding system of claim 6, wherein the loading plate comprises a heating mechanism for pre-heating the substrate to a predetermined temperature.

8. The molding system of claim 1, further comprising:

an output module comprising:

an unloading plate for receiving the molded substrate;

a pick and place for picking the molded substrate from the unloading plate and places onto an offload track;

the offload track for receiving the molded substrate; and

an offloader for readying the molded substrate to be removed from the system.

9. The molding system of claim 8, wherein the offload track comprises a vision inspection device for inspecting the molded substrate.

10. The molding system of claim 1, wherein the substrate is a leadframe.

11. The molding system of claim 10, wherein the leadframe is populated with a plurality of electronic devices.

12. The molding system of claim 11, wherein the electronic devices are LED.

13. The molding system of claim 1, wherein the molding material is a silicone rubber.

14. The molding system of claim 1, wherein the cooling/dispensing station comprises a platform, where the cooling mechanism is so configured that it controls the temperature of the platform, and where the platform provides support for the center cavity plate during dispensing.

15. The molding system of claim 1, wherein the cooling/dispensing station comprises a cooling plate of which the temperature is controlled by the cooling mechanism, and a supporting means for providing support to the center cavity plate during dispensing.

16. A process for molding a substrate with a molding material, said process comprising the following steps of:

providing a center cavity plate with a plurality of cavities;

placing the center cavity plate on a supporting plate;

dispensing the molding material into the cavities;

placing the substrate onto the center cavity plate, where the substrate is aligned with the cavities;

transporting the substrate and center cavity plate into a mold;

pressing and molding the substrate for a predetermined period at a predetermined temperature so as to allow the molding material be molded and cured;

transporting the mold substrate and center cavity plate onto a cooling plate to allow the center cavity to cool; and

picking the molded substrate out of the cavities of the center cavity plate.

17. The process of claim 16, wherein the supporting plate and the cooling plate can be same.

18. The process of claim 16, wherein the substrate is a leadframe.

19. The process of claim 18, wherein the leadframe is populated with a plurality of electronic devices.

20. The process of claim 19, wherein the electronic devices are LED.

21. The process of claim 16, wherein the molding material is a silicone rubber.