Injection Molding Large Current Circuit Board

1. INTRODUCTION

Electric Vehicles (EVs), Plug-in Hybrid Electric Vehicles (PHEVs) and Hybrid Electric Vehicles (HEVs) are expected to become the mainstream of the automobile market in the future. Those vehicles need voltage conversion devices which are applicable in a large current and high temperature environment inside the vehicles, such as inverter circuits which convert the battery voltage of several hundred volts for driving, and converter circuits which lower the battery voltage of several hundred volts for control. We have already commercialized a thick copper circuit board and a metal core circuit board, which are applicable to the power circuits stated above. This time, we have developed a large current circuit board using a technology called an injection molding technology. The technology is different from the existing manufacturing methods of circuit boards. We describe the developed large current circuit board in the following sections.

2. STRUCTURE

The injection molding large current circuit board is manufactured according to the following process: Blanking circuit conductors from a copper strip of equal to or thicker than 0.5 mm. Then, joint each conductor by arc welding, etc. if necessary. Finally, mold these conductors in block by injection molding. Figure 1 shows the manufacturing process, and Table 1 shows the main specifications.

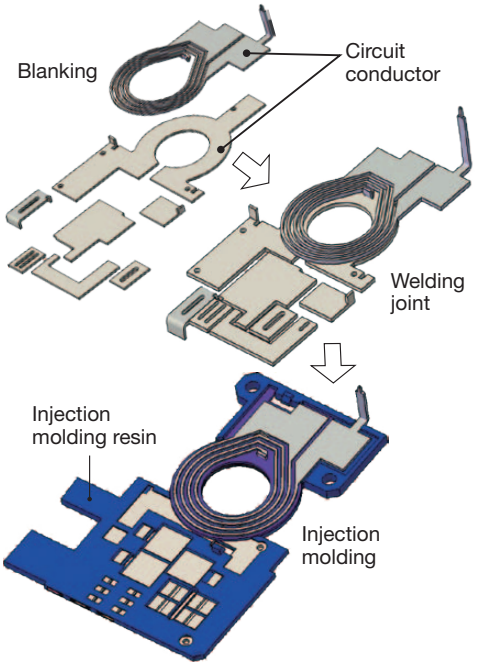


Figure 1 Manufacturing process.

Table 1 Main specification.

Material of circuit conductor	Copper system material (tinned on surface)
Thickness of circuit conductor	Equal to or thicker than 0.5 mm
Material of injection molding resin	Polyphenylene sulfide (PPS)
Thickness of injection molding resin	Equal to or thicker than 0.8 mm
Number of circuit layers	Can be set arbitrarily
Joint between circuit conductors	Weld

A high heat resistance PPS is used for the injection molding resin. The number and the location of the circuit layers can be set arbitrarily, which is different from the existing glass-epoxy circuit, etc. Each circuit conductor is jointed by welding. By using a welding method which joints each base material by melting (such as arc welding), a high joint reliability can be obtained.

3. FEATURES

3.1 Available for Surface Mounting

As Figure 2 shows, surface mounting parts such as diodes and ceramic condensers can be mounted on this product by lead free solder in a reflow oven. Surface mounting became available because the circuit board was able to be processed in a reflow oven by using a high resistance PPS, and also because the solderability of the circuit board became good by tinning the conductors. With respect to the solder joint reliability of the surface mounting parts, the level which is equivalent to the one of glass-epoxy circuit board was obtained in a vehicle installed condition (high temperature 120°C, low temperature -40°C) by a unique structure which absorbs linear expansion and contraction of the circuit board (Figure 3).

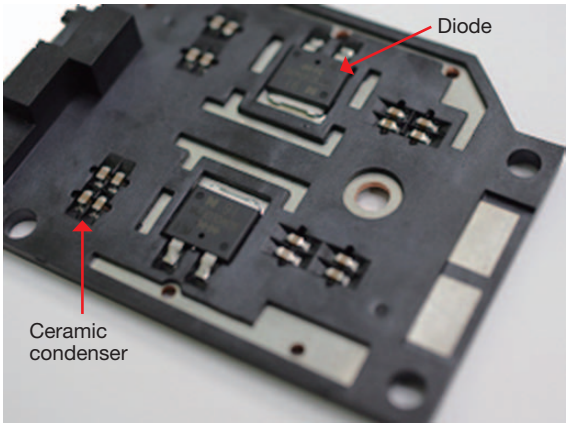
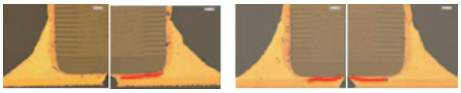
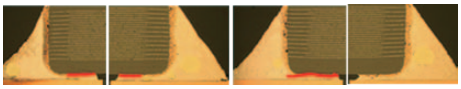
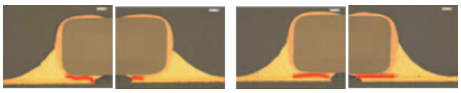
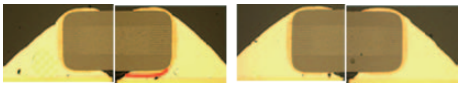


Figure 2 Surface mounting on injection molding large current circuit board.

After 1000 cycles of -40℃ /120℃ thermal shock test

Ceramic condenser C2012	
Glass-epoxy circuit board	
Injection molding circuit board	
Ceramic condenser C3216	
Glass-epoxy circuit board	
Injection molding circuit board	

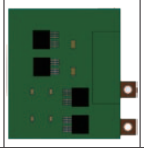
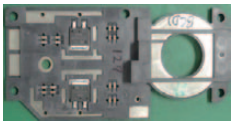
※ Red lines indicate welding cracks.

Figure 3 Solder joint reliability.

3.2 Example of Application Enabled by Jointing Parts

The circuit conductor parts, which are discrete in the existing products, can be jointed by injection molding in block. Table 2 shows the examples of the application for a converter circuit. A converter circuit basically consists of a trans-coil part and a circuit board part which is mounted with switching heater elements. Each part needed to be jointed by a terminal screw clamp, etc. before. However, as in this product, the technology of molding in block enabled the joint of the parts. This jointing method contributes to the reduction of the needed parts for jointing and to space-saving.

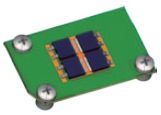
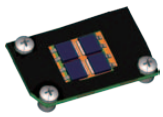
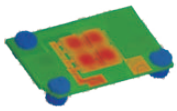
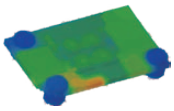
Table 2 Example of application to a converter circuit.

	Existing product		Developed product
Part	Circuit board	Trans	Circuit board jointed by injection molding
Shape			
Size	130 × 95 mm		105 × 77 mm
Component	Metal base circuit board, trans-coil, litz wire, screw		Circuit board only

3.3 Resistance to Large Current and High Heat Dissipation

In the existing circuit boards, the thicker the circuit conductors are, the longer the molding time becomes, because the circuit forming is processed by etching, etc. On the other hand, in this product, the circuit forming can be processed without problems even when the circuit conductors are thicker because of the conductors blanking. Therefore, it is optimal for the use in a large current and in a high heat dissipation. As Table 3 shows, this product's restraining effect for the rise in temperature is about 20% in ΔT compared with the aluminum-base circuit board. That is, this product has a superior heat dissipation performance.

Table 3 Comparison of heat dissipation.

	Existing product	Developed product
Part	Metal-base circuit board	Injection molding large current circuit board
Construction	 Thickness of circuit conductor : 70 μm Thickness of aluminum-base : 1 mm	 Thickness of conductor : 1 mm
Temperature Distribution		
Heating condition	Four diodes × 17.4 W Output 100 A	

4. CONCLUSION

This product is suitable for the heat dissipation of power elements which have large heat generated values, such as MOS-FETs (Metal-Oxide-Semiconductor Field-Effect Transistor) and diodes. Also, it can joint the parts, such as trans-coils, which can't be assembled or mounted on regular circuit boards. Other than the application to converter circuits stated in 3.2, it is applicable to inverter circuits, to switching supply circuits and to other various purposes which require a large current and a high heat dissipation.

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