

Electrical Connector And Manufacturing Method Thereof

The present invention relates to an electrical connector and in particular to a method for manufacturing same.

With the ongoing trend towards smaller, faster and higher performance electrical components, such as a processor used in computers, routers, switches, etc., it has become increasingly important for the electrical interfaces along the electrical path to also operate at higher frequencies and at higher densities with increased throughput.

In a traditional approach for interconnecting circuit boards, one circuit board serves as a backplane and the other as a daughter board. The backplane typically has a connector, commonly referred to as a header that includes a plurality of signal pins or contacts, which connect to conductive traces on the backplane. The daughter board connector, commonly referred to as a receptacle, also includes a plurality of contacts or pins. Typically, the receptacle is a right angle connector that interconnects the backplane with the daughter board so that signals can be routed between the two. The right angle connector typically includes a mating face that receives the plurality of signal pins from the header on the backplane and a mounting face that connect to the daughter board. Likewise, the header comprises a mating face adapted to mate with the mating face of the right angle connector and a mounting face that connects to the backplane board.

As the transmission frequencies of signals through these connectors increase, it becomes more desirable to maintain a desired impedance through the connector to minimize signal degradation. A ground shield is sometimes provided on the module to reduce interference or crosstalk. In addition, a ground shield may be added to the ground contacts on the header connector. Improving connector performance and increasing contact density to increase signal carrying capacity without increasing the size of the connectors is challenging.

Some older connectors, which are still in use today, operate at speeds of one gigabit per second or less. In contrast, many of today's high performance connectors are capable of operating at speeds of up to 10 gigabits or more per second. As would be expected, the higher performance connector also comes with a higher cost.

When trying to design an electrical connector having a reduced pitch between signal pins, so as to obtain an electrical connector with a reduced size or with an increased pin density, the signal pins are made thinner and are therefore more fragile and likely to be bent or broken. When these electrical connectors are implemented in high-speed applications involving high transmission data rates, it is crucial to guarantee a high degree of electrical performance. However, the impedance and other important electrical properties of an electrical connector are dependent on the geometrical arrangement of the signal pins with respect to one another. Hence, it is challenging to design an electrical connector having a smaller pitch between its contacts, while guaranteeing high electrical performance.

Another problem, which might occur in electrical connectors, is that the contacts in the housing of the electrical connector, in particular the resilient parts that are located at the end of the electrical contacts, may be inaccurately positioned. This inaccurate positioning is considered a failure mechanism according to the electrical connector qualification tests used for telecommunication connectors such as Telcordia GR-1217-Core in the American market. This inaccurate positioning of the resilient part of the electrical contacts within one electrical connector can occur during production, handling, insertion, board handling, mating, etc. Furthermore, interferences may result that cause deviations from the contact normal force that has been originally designed. Moreover, the contact normal force may also decay with time due to stress relaxation or deformations of the resilient parts of the electrical contacts or deformations of the plastic connector parts of the housing. If the contact normal force is reduced to low levels, any additional decrease could be unacceptable and the contact normal force may reach critical minimum values.

In a high-speed connector, which supports high data rates and high frequencies, the design of the dielectric material surrounding the electrical conductors is crucial. Indeed, in order to enable constant electrical properties along the path of signals carried by the electrical conductors in the electrical connector, the dielectric properties of the material surrounding the electrical conductors should be as continuous as possible, and irregularities within the dielectric material should be avoided. In particular, introducing cavities in the over-molded material, which are filled with air, that has different electrical properties than the over-molded material itself, should be avoided as they introduce differences in the electrical characteristics within the dielectric material, thereby

introducing irregularities within the electrical path of a signal, and therefore decreasing the electrical performance of the electrical connector.

An object of the invention is to provide a method for manufacturing an electrical contact module and a method for assembling an electrical connector, which allow to obtain an electrical connector having improved electrical characteristics.

This object is solved by the subject matter of the independent claims. Preferred embodiments are subject matter of the dependent claims.

An embodiment of the invention provides a method for manufacturing an electrical contact module, said method comprising forming a lead-frame of electrical conductors, wherein at least one supporting strip is formed in the lead-frame of electrical conductors in such a way as to maintain the electrical conductors in a predetermined position with respect to each other, over-molding the lead-frame of electrical conductors with a first dielectric material in a first over-molding step, thereby obtaining a first over-molded lead-frame, wherein at least one aperture is formed in the first over-molded lead-frame so that the at least one supporting strip is accessible for being removed, removing the at least one supporting strip in the first over-molded lead-frame after completion of the first over-molding step, and over-molding the first over-molded lead-frame with a second dielectric material in a second over-molding step in such manner as to fill the at least one aperture and a space left between the electrical conductors after removal of the at least one supporting strip.

The present invention will be described in detail in the following based on the figures enclosed with the application.

Figure 1 is a perspective view of a lead-frame of electrical conductors according to an embodiment of the invention;

Figure 2 is a perspective view of a first over-molded lead-frame of electrical conductors upon completion of a first over-molding step;

Figure 3 is a perspective view of the first over-molded lead-frame of electrical conductors shown in Figure 2 after removal of a first supporting strip from the lead-frame of electrical conductors;

Figure 4 is a perspective view of the first over-molded lead-frame of electrical conductors shown in Figure 3 after a further step of removal of a second supporting strip from the lead-frame of electrical conductors;

Figure 5 is a perspective view of the first over-molded lead-frame of electrical conductors shown in Figure 4 after a second over-molding step; and

Figure 6 is a perspective view of a finished electrical contact module after a removal of a third supporting strip arranged at the mating side of the electrical contact module.

Figure 1 is a perspective view of a lead-frame 10 of electrical conductors according to an embodiment of the invention. A lead-frame 10 comprises a plurality of electrical conductors, wherein each electrical conductor comprises a mating contact 2 and a mounting contact 4, which are respectively arranged at the respective ends of each electrical conductor. The plurality of mating contacts 2 of the electrical conductors of the lead-frame 10 define a mating edge and the plurality of mounting contacts 4 of the electrical conductors define a mounting edge.

A first supporting strip 1 is formed in the lead-frame 10 of electrical conductors in such a way as to hold the electrical conductors in a certain position with respect to each other. The supporting strip 1 is formed as a part of the lead-frame 10 of electrical conductors, preferentially as a strip made out of the same conductive material as that used to form the lead-frame 10 of electrical conductors. The first supporting strip 1 is formed as a strip that connects the electrical conductors to each other.

As shown in Figure 1, a second supporting strip 1' is formed in the lead-frame 10, wherein the second supporting strip 1' is arranged in the portion of the lead-frame 10 of electrical conductors comprised between the mounting edge and the first supporting strip 1. The second supporting strip 1' also allows to maintain the electrical conductors in a predetermined position with respect to each other.

Even though Fig. 1 represents the particular case where two supporting strips 1, 1' are formed in the lead-frame 10 of electrical conductors to maintain the electrical conductors in a certain position with respect to each other, it can also be envisaged to foresee only a single supporting strip in the lead-frame 10 of electrical conductors. However, the mechanical stability of the lead-frame 10 of electrical conductors can be enhanced when using two supporting strips 1, 1'. The supporting strips 1, 1' provide the advantage of

maintaining the lead-frame 10 of electrical conductors in a predetermined position during an over-molding of the lead-frame 10 of electrical conductors.

Furthermore, as also shown in Figure 1, a third supporting strip 1" is formed in the lead-frame 10 of electrical conductors at the mating side of the lead-frame 10. This additional supporting strip 1" allows to maintain the mating contacts 2 in a predetermined position with respect to each other during over-molding of the lead-frame 10.

Figure 2 represents the subsequent step of the method for manufacturing an electrical contact module according to the invention. It represents the lead-frame 10 of electrical conductors after a first over-molding step. Figure 2 thus shows a perspective view of an over-molded lead-frame 20 according to an embodiment of the invention.

The electrical conductors of the lead-frame 10 are maintained in a predetermined position with respect to each other by the supporting strips 1, 1', 1" during a first over-molding step, during which the lead-frame 10 of electrical conductors is over-molded with a first dielectric material 5. The lead-frame 10 of electrical conductors is over-molded with the first dielectric material 5 in such a way that the mounting contacts 4 protrude out of the over-mold, as well as the mounting contacts 2.

A first aperture 6 is formed in the over-mold 5, so that the first supporting strip 1 formed in the lead-frame 10 of electrical conductors is accessible for being removed at a later stage, in order to electrically insulate the electrical conductors from each other. A second aperture 6' is also formed in the over-mold 5, so as to render the second supporting strip 1' accessible for being removed at a later stage, in order to electrically insulate the electrical conductors from each other. The method used to remove the first and second supporting strips 1, 1' will be explained in the following.

Even though a plurality of apertures 6, 6' is represented in Fig. 2, it may also be considered, as already mentioned above, that only one supporting strip supports the lead-frame 10 of electrical conductors, in which case a single aperture 6 would be formed in the over-molded lead-frame 20.

The lead-frame 10 of electrical conductors is over-molded with a dielectric material 5, which is preferentially made out of a liquid crystal polymer, which can be easily over-molded, and provides outstanding mechanical properties at high temperatures, as well as excellent chemical resistance, while being relatively cheap.

The over-mold out of dielectric material 5 may also comprise one or a plurality of protrusions 5' as well as one or a plurality of cavities 5'', which allow for connecting thereto a second over-mold made out of a second dielectric material (not shown), which will be arranged on the first over-molded lead-frame 20 in a second over-molding step, which will be explained in the following.

Figure 3 shows a perspective view of the over-molded lead-frame 20 shown in Fig. 2, wherein the first supporting strip 1 is removed from the over-molded lead-frame 20 after completion of the first over-molding step. The removal of the supporting strip 1 comprises cutting away the connection points connecting the electrical conductors to each other, thereby electrically insulating the electrical connectors from each other. During this removal step, the conductive material comprised between the electrical conductors is removed. This therefore leaves a hole in the remaining dielectric material that has been over-molded in the space between the electrical conductors during the first over-molding step.

Figure 4 shows a perspective view of the over-molded lead-frame 20 shown in Fig. 3, wherein the first supporting strip 1' is removed from the over-molded lead-frame 20 after completion of the first over-molding step. The removal of the supporting strip 1' comprises cutting away the connection points connecting the electrical conductors to each other, thereby electrically insulating the electrical connectors from each other. During this removal step, the conductive material comprised between the electrical conductors is removed. This therefore leaves a hole in the remaining dielectric material that has been over-molded in the space between the electrical conductors during the first over-molding step.

Figure 5 shows a perspective view of the over-molded lead-frame 20 of Figure 4 after a second over-molding step, thereby forming an electrical contact module 30.

After removal of the supporting strips 1, 1' connecting the electrical conductors of the lead-frame 10 to each other, a second over-molding step is performed, wherein the first over-molded lead-frame 20 is over-molded with a second dielectric material 7.

The first aperture 6 and second aperture 6' foreseen in the over-mold made out of the first dielectric material 5 and the space left between the electrical conductors after removal of the respective supporting strips 1, 1' are filled during the second over-molding step with the second dielectric material 7, in order to prevent cavities filled with air

surrounding the electrical conductors of the lead-frame 10. In such a way, the cavities are filled with second dielectric material 7, thereby allowing to avoid discontinuities in the dielectric material surrounding the electrical conductors of the lead-frame 10.

The second dielectric material 7 can be preferably foreseen as a dielectric material identical to the first dielectric material 5, or, alternatively, as a dielectric material different from the first dielectric material 5, and having a melting point that is lower than the melting point of the first dielectric material 5.

When the first over-molded lead-frame 20 comprises protrusions 5' and cavities 5", the over-mold made out of the second dielectric material 7 comprises corresponding cavities and protrusions, respectively, in order to allow for connecting the over-mold made out of the second dielectric material 7 with the first over-molded lead-frame 20 more easily.

Figure 6 shows a perspective view of a finished electrical contact module 30 after a final step of removing the third supporting strip 1" between the mating contacts. The connection points between the electrical connectors at the mating edge are cut away, thereby electrical insulating the mating contacts 2 from each.

According to another embodiment of the invention, a method for assembling an electrical connector is provided, wherein a plurality of electrical contact modules 30 are inserted into an electrical connector housing. An electrical contact module 30 is also referred to in the art as a chicklet, a plurality of which may be foreseen into an electrical connector housing, thereby providing an electrical connector.

Since the second dielectric material 7 is over-molded on the first over-molded lead-frame 20 in such a way as to avoid any cavities filled with air from being present in the electrical contact module 30, high electrical performance of the electrical connector can be achieved.

LIST OF REFERENCE SIGNS

- 1 first supporting strip
- 1' second supporting strip
- 1'' third supporting strip
- 2 mating contacts
- 4 mounting contacts
- 5 first over-mold
- 5' protrusion of the first over-mold
- 5'' cavity of the first over-mold
- 6 first aperture of the first over-mold
- 6' second aperture of the first over-mold
- 7 second over-mold
- 10 lead-frame of electrical conductors
- 20 first over-molded lead-frame of electrical conductors
- 30 electrical contact module

CLAIMS

1. A method for manufacturing an electrical contact module (30), said method comprising the following steps:

forming a lead-frame (10) of electrical conductors, wherein at least one supporting strip (1, 1') is formed in the lead-frame (10) of electrical conductors in such a way as to maintain the electrical conductors in a predetermined position with respect to each other,

over-molding the lead-frame (10) of electrical conductors with a first dielectric material (5) in a first over-molding step, thereby obtaining a first over-molded lead-frame (20), wherein at least one aperture (6, 6') is formed in the first over-molded lead-frame (20) so that the at least one supporting strip (1, 1') is accessible for being removed,

removing the at least one supporting strip (1, 1') in the first over-molded lead-frame (20) after completion of the first over-molding step, and

over-molding the first over-molded lead-frame (20) with a second dielectric material (7) in a second over-molding step in such manner as to fill the at least one aperture (6, 6') and a space left between the electrical conductors after removal of the at least one supporting strip (1, 1').

2. The method according to claim 1, wherein said supporting strip (1, 1') is formed as a strip made out of a same conductive material as the conductive material used to form the lead-frame (10) of electrical conductors, wherein said strip connects the electrical connectors with each other.
3. The method according to claim 2, wherein said step of removing the at least one supporting strip (1, 1') comprises cutting away the connection points between the electrical connectors, thereby electrically insulating the electrical connectors from each other.
4. The method according to one of claims 1 to 3, wherein two supporting strips (1, 1') are formed in the lead-frame (10) of electrical conductors, and two corresponding apertures (6, 6') are formed in the first over-molded lead-frame (20) so that the two supporting strips (1, 1') are accessible for being removed.

5. The method according to one of claims 1 to 4, wherein a second supporting strip (2), that is different from the at least one supporting strip (1, 1'), is formed in the lead-frame (10) of electrical conductors at a mating side of the electrical conductors, and said method further comprises removing said second supporting strip (1") after completion of the second over-molding step, thereby electrically insulating the mating contacts from each other.
6. The method according to one of claims 1 to 5, wherein the first over-molded lead-frame (20) is over-molded in the second over-molding step with a second dielectric material (7) that is identical to the first dielectric material (5) used in the first over-molding step.
7. The method according to one of claims 1 to 5, wherein the first over-molded lead-frame (20) is over-molded in the second over-molding step with a second dielectric material (7) that is different from the first dielectric material (5) used in the first over-molding step and that has a lower melting point than the melting point of the first dielectric material (5).
8. A method for assembling an electrical connector, said method comprising inserting a plurality of electrical contact modules (30) manufactured according to the method according to one of claims 1 to 7 into an electrical connector housing.
9. An electrical contact module (30) manufactured according to the method according to one of claims 1 to 7.
10. An electrical connector comprising:

a plurality of electrical contact modules (30) according to claim 9, and

an electrical connector housing,

wherein the plurality of electrical contact modules (30) are inserted into the electrical connector housing.