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METHOD FOR PROTECTING ELECTRONIC CIRCUIT COMPONENTS AND ASSEMBLIES USING A METALLIZED FLEXIBLE ENCLOSURE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates, in general, to an assembly using an enclosure for providing long-term environmental protection of and electromagnetic interference shielding capability for electronic devices.

2. Related Art

It is well known to those skilled in the art that the contents of a package can be protected from the environment by packaging the contents within an enclosure comprising multiple layer polymeric sheets with at least one metallized layer. Many examples of protecting the contents of the package can be found in the food processing industry, the medical industry, the construction industry, and the like. Basically, protecting products from atmospheric gases, water vapor or radiation to prevent spoilage or corrosion of the contents is universally employed for a wide range of products. As a result, the materials used for the multiple layer construction and composition of the package have been well developed.

Similarly, a printed circuit board (PCB) including components such as integrated circuits (ICs) is subject to degradation from environmental factors such as corrosive gases, water vapor and particulate matter. Electronic products using PCBs have primarily been located and used in controlled environments where the degree of environmental degradation to the PCB is minimal. However, electronic products are increasingly being deployed in uncontrolled environments, such as in the automotive and telecommunications industries. Furthermore, electronic products are increasingly penetrating the consumer market

where the ability to produce reliable devices using low-cost and high volume manufacturing methods is of paramount importance. Thus, there is a need to derive methods for providing environmental protection for electronic products using low-cost and high volume manufacturing methods.

Conventional methods for protecting electronic products from degradation due to environmental factors include rigid enclosures and encapsulation. Rigid enclosures may be fabricated from metal or plastic and are gasketed to minimize ingress of corrosive gases, dust and water vapor, as well as, to provide an electromagnetic interference (EMI) shielding capability. While effective to a certain extent, diffusion of these species is difficult to prevent and under certain conditions even exacerbated. Expensive gaskets and other sealing methods are required to provide adequate environmental protection. Thus, rigid enclosures are generally adequate for protecting powered electronic products over the period of several years only when properly designed and when expensive precautions are taken.

Encapsulation of electronic components in terms of electronic packaging is a foundation of the semiconductor industry. However, conformal coating of the PCB or sub-assembly with, for example, a urethane or silicone compound is not capable of providing long-term environmental protection. Polymeric material compounds can provide a diffusion barrier to chemical species. In practice, however, cracking, incomplete coverage, environmental impact, and cost are issues impacting environmental protection of electronic components using urethane or silicon compounds. Also, the expense required for specific component and fixture design for large electronic products that rapidly change can negatively effect high production volume encapsulation production.

In addition to environmental protection, many electronic products that are deployed in aggressive outside environments require EMI shielding. Not only must the electronic product not be influenced by external EMI radiation, but the electronic product must not radiate excessive amounts of EMI radiation. For many electronic products, particularly in the wireless domain, EMI shielding must be provided not only at the component level of a sub-assembly, such as between certain regions of a PCB, but also at the sub-assembly (circuit board) and electronic product level. To accomplish effective EMI shielding of an electronic product or between sub-assemblies within the product, it is necessary to provide shielding plates, separate devices and ensure that all joints of an enclosure are conductively sealed. Generally, the most cost effective EMI shielding and environmental protection of electronic products has been to house the product within a metal or metallized enclosure (for example, a conductively coated plastic enclosure). However, conventional methods for imparting conductivity to the surface of plastic parts, for example, electrochemical plating, metal sputtering, and the like, are often economically prohibitive. There is a need to provide EMI shielding capability for electronic products in a manner that is both low-cost and amenable to high volume production.

Conventionally, multiple layer enclosures consisting of a metal foil or a metallized polymer sheet can be used to provide EMI shielding of electronic products. Such multi-layered enclosures are disclosed in U.S. Patents Nos. 4,965,408 and 5,005,106 and incorporated herein by reference. A multiple layer enclosure including conductive fibers is disclosed in U.S. Patent No. 5,436,803 and herein incorporated by reference. Related constructs of multiple layer enclosures for the purposes of providing static protection of electronic devices are disclosed in, for

example, U.S. Patents Nos. 5,180,615, 5,175,033, 5,091,229 and 5,043,195 and incorporated herein by reference. Thus, the construction and composition of enclosures for providing both environmental protection and EMI shielding capability are well known to those skilled in the art.

Furthermore, the application of enclosures formed from sheets of material consisting of polymeric and metallized layers, to impart EMI shielding capability, is known in the art. Application of these enclosures for EMI shielding of printed circuit board products is disclosed, for example, in U.S. Patents Nos. 5,436,803 and 5,005,106 and incorporated herein by reference.

However, it is evident from the examination of these disclosures, that the method of sealing and providing for electrical interconnection is specific to the design of the electronic product, and in particular, to the design of the connector. Thus, the related art is directed toward enabling assembly to printed circuit boards with extended wires or to printed circuit boards with edge-card or connectors that extend across an entire dimension of the printed circuit board edge.

Moreover, in both U.S. Patents Nos. 5,436,803 and 5,005,106, for example, the purpose of the enclosure is to provide EMI shielding in a flexible structure does not accommodate separable connectors. Furthermore, the related art does not address providing a hermetic seal to ensure long-term environmental protection of the electronic product, does not address the design of the flexible enclosure and does not address an appropriate sealing method to provide the hermetic seal. Typically, hermeticity is defined as a helium leak rate of not more than 1×10^{-8} cm^2/sec. Here, we use the term to generally define very low permeability. In addition, the metallized layer of the enclosure is usually exposed on either the inner or outer surfaces of the enclosure to effect grounding or enhance

conduction. However, in harsh environments, exposed metal surfaces will corrode.

Thus, it would be advantageous to provide a metallized flexible enclosure and a method for providing both long-term environmental protection and EMI shielding of electronic products that is cost effective, amenable to high volume production and is suitable for use with separable connectors.

SUMMARY OF THE INVENTION

An object of the invention is to provide a metallized flexible enclosure for long-term environmental protection and EMI shielding of an electronic product.

Another object of the invention is to provide a metallized flexible enclosure for an electronic product including a multiple layer sheet of material with at least one metallic layer.

Another object of the invention is to provide a method for long-term environmental protection and EMI shielding of an electronic product that is both cost effective and amenable to high volume production.

Still another object of the invention is to provide a method for assembly of a multiple layer flexible enclosure to an electronic product that incorporates separable connectors.

Another object of the invention is to connect the metallized layer directly to the electrical ground of the PCB circuit.

To achieve these and other objects, the invention is directed to a metallized flexible enclosure made from a multiple layer sheet of material. The multiple layer sheet of material includes at least one polymeric layer forming an outer surface of the enclosure for providing diffusion barrier properties, at least one metallic layer adjacent to the polymeric layer for providing electromagnetic radiation

shielding properties and an electronically insulating adhesive layer forming an inner surface of the enclosure for bonding the enclosure to the electronic device. The enclosure is hermetically sealed to the electronic product, assembly or PCB to provide long-term environmental protection. The enclosure also connects the metallic layer of the multiple layer sheet of material to the electrical ground of the electronic product or assembly. Thus, environmental protection and EMI shielding of the electronic components of the PCB is performed while enabling access to the PCB's separable connectors.

The invention is also directed to a method for providing long-term environmental protection and electromagnetic interference shielding of an electronic device having electronic components and separable connectors. The method can include the steps of (1) providing a multiple layer sheet of material having at least one metallic layer, (2) forming the sheet of material into a tubular structure, (3) inserting a PCB having electronic components into the tubular structure formed from the sheet of material, (4) indexing and positioning the PCB such that the separable connectors are positioned under openings in the sheet of material, (5) exposing the separable connectors through the openings in the sheet of material, (6) compressing the tubular structure against the PCB to form an adhesive bond between the sheet of material and the PCB, (7) connecting the metallic layer of the enclosure to the electrical ground of the PCB, (8) crimping or connecting the edges of the sheet of material to form a metallized flexible enclosure, and (9) hermetically sealing the enclosure.

Using the above-described method, an assembly using the metallized flexible enclosure provides long-term environmental protection and EMI shielding while surrounding the electronic components and maintaining access to the separable connectors.

These and other aspects and advantages of the invention are described or apparent from the following detailed description taken in conjunction with the annexed drawings, which disclose preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the following drawings in which like reference numerals refer to like elements and wherein:

FIGURE 1 shows the metallized flexible enclosure and an electronic device according to a preferred embodiment of the invention;

FIGURE 2 is a cross sectional view along plane II-II of Figure 1;

FIGURE 3 is a cross sectional view along plane III-III of Figure 1;

FIGURE 4 is a planar view of the multiple layer sheet of material according to an embodiment of the invention;

FIGURE 5 is a cross sectional view of the multiple layer sheet of material of Figure 4;

FIGURE 6 is a cross sectional view of the multiple layer sheet of material of Figure 4; and

FIGURE 7 is a cross sectional view of the metallized flexible enclosure and an electronic device after assembly using the preferred method of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Generally, the invention is directed to an assembly including a metallized flexible enclosure that surrounds and attaches to an electronic product to provide long-term environmental protection and EMI shielding capability. Figures 1, 2 and 3 show the assembly 5 according to a preferred embodiment of the invention.

In Figure 1, the assembly **5** includes an electronic assembly including a printed circuit board (PCB) **10** having detachable or separable connectors **20**. Separable connectors **20** include, for example, press-fit pin insertion and threadedly engaged male/female connectors. Non-separable connectors are permanently attached connectors, for example, soldered wire leads or adhesively joined connectors to a circuit board. Further, the PCB **10** can be fabricated using conventional methods. A metallized flexible enclosure **50** is sealed both around a perimeter area **30** and to a PCB area **60** surrounding the separable connectors **20** to form a substantially hermetic seal. The perimeter area **30** and the PCB area **60** are such that a metallic layer **52** (Figure 5) within the multiple layer enclosure **50** forms an electrical connection at the perimeter area **30** and the PCB area **60**. A provision is made for an electrical connection to an exposed grounding pad **40** on the PCB area **60**. Openings **70** in the metallized flexible enclosure **50** enable the separable connectors **20** to extend through the metallized flexible enclosure **50** to facilitate interconnection access.

The metallized flexible enclosure **50** is bonded to the PCB **10** at bonding areas **75** immediately surrounding the separable connectors **20** or over the entire PCB area **60** to provide an environmental and hermetic seal. To enhance EMI shielding capability, the bond surrounding the separable connectors **20** can be made such that an electrical connection is made between the metallic layer **52** (Figure 5) within the metallized flexible enclosure **50** and the bonding areas **75** that surround the separable connectors **20**. This can be accomplished by a conductive adhesive as explained below or the like. Alternatively, other adhesive materials and composites can be used that are laminated or printed onto the multiple layer metallized flexible enclosure **50**.

Likewise, mechanical fasteners or other metal bonding methods can be employed.

Figure 2 shows a cross-sectional view of the enclosed PCB **10** across the plane II-II through the assembly **5** as shown in Figure 1. In this embodiment, the metallized flexible enclosure **50** surrounds the PCB **10** and fits loosely over the internal components **11**. As discussed below, the enclosure **50** can also be assembled to conform to the topography of the internal components **11**.

Figure 3 shows a cross-sectional view of the assembly **5** across the plane III-III intersecting the separable connectors **20**. The metallized flexible enclosure **50** is shown to be bonded to the PCB **10**, both in the location immediately adjacent to connectors **61**, and also over the PCB area **60** extending the width of the PCB **10**.

The detailed structure of the metallized flexible enclosure **50** is shown in Figures 4, 5 and 6. The enclosure **50** is formed, preferably by laminating multiple layers **53** and **54** of polymeric materials selected for various desired barrier properties to the pertinent environmental threats, such as corrosive gases and water vapor. Polymeric materials such as polyethylene, ionomers such as SURLYN®, polyvinylidene chloride, and polyethylene terepthalate (PET), can be used. Further, one skilled in the art can appreciate that additional layers such as **56** and **57** of polymeric materials can be incorporated to address specific environmental threats, physical integrity or for manufacturing efficiency. The inner polymeric layer **54** preferably is an electrically insulating thermoplastic material such as polyethylene that can also be heat sealable. Other appropriate materials well known to those skilled in the art can also be used. This prevents inadvertent electrical connection of components within the sealed enclosure.

In addition to the polymeric layers **53, 54, 56** and **57,** the metallized flexible enclosure **50** includes at least one metallic layer **52** disposed within the metallized flexible enclosure **50**. The metallic layer **52** provides both a barrier to diffusion of the environmental threats, such as corrosive gases and water vapor, and it also enables EMI shielding for the PCB **10** and internal components **11** (Figure 2). To provide adequate diffusion barrier properties, the metallic layer **52** should be substantially free of pin holes and provide a substantially impermeable diffusion barrier. For this reason, the metallic layer **52** is preferably a laminated foil with a thickness greater than 0.35 mils. Alternatively, a metal film can be deposited on the surface of the polymer layers by, for example, evaporation methods and other means known to those skilled in the art. For this application, the quality of the metal layer with respect to the diffusion barrier properties is more important than the absolute thickness of the metal layer. For reference, a 1.5 mil thick foil of aluminum is considered to provide a substantially impermeable diffusion barrier.

To provide additional diffusion barrier and EMI protection, more than one metallic layer may be incorporated into the metallized flexible enclosure **50.** The metallic layer **52** preferably is made from aluminum because of its low cost and wide availability. However, it should be understood that other electrically conductive metals such as copper, nickel, or the like, can also be used.

In Figures 4, 5 and 6, the outer polymeric layer **53** adjacent to the metallic layer **52** can be patterned to expose specific areas of the metallic layer **52**. Exposing areas of the metallic layer **52** enables formation of a metal-to-metal contact for providing both enhanced diffusion barrier properties and EMI shielding capabilities of the metallized flexible enclosure **50**. It is envisioned that the

metallic layer **52** can be exposed in the following locations: 1) opposed sides **58** of the metallized flexible enclosure **50**, 2) in a region **71** adjacent to the separable connectors **20**, 3) in intermittent or continuous areas **59** along opposed sides of the metallized flexible enclosure **50**, and 4) at the location of the grounding pad **42** on the PCB **10**. However, one skilled in the art can appreciate that the invention is not limited to exposing the metallic layer **52** in only the regions mentioned above and that the invention can be practiced by exposing the metallic layer **52** at other locations.

The locations for exposing separable connectors **20** can be formed by, for example, punching out the openings **70** in the polymeric layers **53, 54, 56** and **57** and metallic layer **52** and subsequently laminating the patterned polymeric layers **53, 54, 56** and **57** against the metallic layer **52** of the metallized flexible enclosure **50**. Also, the openings **70** can be formed by cutting appropriate holes with a die prior to formation of the metallized flexible enclosure **50** into a tubular structure. Alternatively, the polymeric surface film can be printed onto the appropriate locations using a liquid adhesive that is subsequently dried or cured in a well known manner.

Although Figure 4 shows a single metallized flexible enclosure **50**, it is possible that the method for assembling the metallized flexible enclosure **50** can be an economical semi-continuous process. Specific methods for fabrication of the metallized flexible enclosure **50** and expedients for providing the openings **70** in a semi-continuous process are well known to those skilled in the art.

A method for providing the assembly **5** according to the preferred embodiment of the invention will now be described.

Referring now to Fig. 7, the metallized flexible enclosure **50** is first formed as a tube and the electronic device including the PCB **10** and the separable connectors **20** is inserted into the tube. As shown, the metallized flexible enclosure **50** comprises three layers: 1) the inner polymer layer **54,** 2) the embedded metallic layer **52,** and 3) the outer polymer layer **53.** As previously described, the polymer layers **53, 54** include polymeric material that can be formed into a seal at the perimeter area **30** and the PCB area **60.** For example, the inner polymer layer **54** and the outer polymer layer **53** can both be made of a thermoplastic or other material that is heat sealable. Alternatively, the adhesive may be printed onto the surface of the multiple layer sheet. The polymer layers **53, 54** can also be electrically insulating, thereby preventing the metallized layer **52** from forming an unwanted electrical connection to external or internal parts, for example, the active electronic circuitry on the PCB **10.**

Next, the layers **52, 53** and **54** of the metallized flexible enclosure **50** are directly bonded along seam **80** by thermal bonding to form both a metallic bond and a polymeric seal to provide a complete EMI shielding capability and a hermetic seal. Alternatively, the metallic bond at the seam **80** can be formed by thermal or ultrasonic bonding with compression. The polymeric seal can also be formed by thermal compression. In addition, corrugation can be incorporated to enhance the metallic bond strength and the metal-to-metal contact of the seam **80.** The width of the seam **80** is selected to provide the desired performance. One skilled in the art can appreciate that alternative bonding locations and schemes can be used.

Then, seals in the perimeter area **30** (Figure 1) at the ends of the metallized flexible enclosure **50** are also formed by similar methods to those described above for the

seam **80**. Electrical contact of the metallic layer **52** can be performed by mechanically connecting the metallic layer **52** during the bonding process or by exposing openings in the sides **58** and the areas **59**, for example, in the surface of the inner polymeric layer **54**. The spacing and dimensions of the openings in the sides **58** and the areas **59** are determined by the EMI shielding capability requirements. To enhance EMI shielding capability, it is desirable to have a continuous metal-to-metal seal around the perimeter of the flexible enclosure. Also, electrical contact between the metallic layer **52** and the PCB electrical grounding pad **40** is provided by the region (opening) **42** in the inner polymeric layer **54** within the flexible enclosure **50**.

Next, the electronic device is indexed and positioned such that the separable connectors **20** are situated under the respective openings **70** in the metallized flexible enclosure **50**. In the preferred embodiment of the invention, the sides of the tubular structure are then pulled outward to cause the connectors **20** to extend through the openings **70** in the metallized flexible enclosure **50**. A heated platen (not shown) with cavities enabling recession of the separable connectors **20** presses against the metallized flexible enclosure **50**, and compresses the metallized flexible enclosure **50** against the PCB **10** to form the adhesive bond. At the same time, the electrical connection between the metallic layer **52** and the grounding pad **40** can be made by thermal compression bonding, mechanical fastening, by using a conductive adhesive or the like. Then, the ends of the tube are crimped and sealed, as previously described, to form the metallized flexible enclosure **50**.

Rather than have the metallized flexible enclosure **50** fit loosely around the electronic product, it may be desirable to have the metallized flexible enclosure **50**

conform to the shape of the internal components **11**. Vacuum lamination with a heated bladder or compressible material can cause the metallized flexible enclosure **50** to press against the internal components **11**. During the sealing process, the metallized flexible enclosure **50** can also be backfilled with an inert gas, such as nitrogen gas, or with dry air to provide non-corrosive atmospheric conditions for the internal components **11**. It may also be desirable to remove ambient air using a vacuum to vacuum pack the components and/or outgassing the electronic product prior to sealing the metallized flexible enclosure.

In Figure 7, the inner polymer layer **54** of the metallized flexible enclosure **50** is thermally bonded to cause the inner polymer layer **54** to melt directly to the PCB **10** at the PCB area **60** (Figure 1) along the edge of the PCB **10**. However, it is envisioned that other adhesive systems and methods can be employed. For example, a heat sensitive adhesive material can be applied either to the metallized flexible enclosure **50** on top of the inner polymer layer **54**, or an adhesive can be applied to the PCB **10** at the appropriate bonding location. Alternatively, it may be preferable to bond the metallized flexible enclosure **50** to the PCB **10** at locations adjacent to the connectors **61** rather than over the entire PCB area **60**. Furthermore, one skilled in the art can appreciate that the metallized flexible enclosure **50** can be bonded to the PCB **10** at other locations not discussed above.

The heat generated by the electronic product can be essentially contained within the metallized flexible enclosure **50**. As a result, the ambient temperature within the metallized flexible enclosure **50** will increase. The temperature within the metallized flexible enclosure **50** can be controlled to prevent adversely affecting the electronic components. In addition, the thermal gradient between the

inside and outside of the flexible enclosure **50** can serve as an additional positive impediment to the ingress of contaminants, such as water vapor. In situations where excessive heat is a concern, mechanisms for efficiently removing the heat can be used. For example, a heat sink (not shown) situated external to the metallized flexible enclosure **50** can be attached to and compressed against a heat generating component on the PCB **10**. Alternatively, the metallized layer **52** can be exposed as previously discussed to facilitate heat transfer either with or without a heat sink. Thus, the metallized flexible enclosure **50** provides a substantially permanent and inviolable containment for the PCB **10** and internal components **11** of assembly **5**. As such, the metallized flexible enclosure **50** provides long-term or product lifetime environmental and physical protection for the PCB **10** where the only access to the PCB **10** and the internal components **11** is the separable connectors **20**.

While the metallized flexible enclosure **50** can be removed for repair or end-of-life processing, it is not recommended because removal of the metallized flexible enclosure **50** can compromise the long-term environmental and physical protection of the PCB **10** and the internal components **11**. Furthermore, to ensure the integrity of the environmental seal, it is recommended that mounting methods for the assembly **5** that can puncture the metallized flexible enclosure **50** should be avoided. Instead, sliding mounts or compressive mechanisms (not shown) are preferred methods for securing the assembly **5** to the electrical system (not shown).

While this invention has been described in conjunction with specific embodiments, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, the preferred embodiments of this invention as set forth herein

are intended to be illustrative, rather than limiting. Various changes may be made without departing from the spirit and scope of the invention as defined in the following claims.

WE CLAIM:

1. An electronic assembly, comprising:

a printed circuit board (PCB) including components, an electrical ground and separable connectors; and

a metallized flexible enclosure for containing the PCB, the metallized flexible enclosure comprising,

layers of polymeric material,

at least one metallic layer electrically connected to the electrical ground of the PCB, and

openings that allow the separable connectors of the PCB to extend through the metallized flexible enclosure,

wherein the metallized flexible enclosure is hermetically sealed, the metallized flexible enclosure including an environmental protection capability and an electromagnetic interference shielding capability while enabling mechanical access to the separable connectors.

2. The assembly according to claim 1, wherein the metallic layer is disposed between an electrically insulating inner polymeric layer and an outer polymeric layer of the metallized flexible enclosure.

3. The assembly according to claim 2, wherein the inner polymeric layer adjacent the metallic layer is patterned to form a hermetic seal and to expose the metallic layer, which enables the metallic layer to electrically contact the electrical ground.

4. The assembly according to claim 1, wherein the metallic layer is substantially free of pin holes and provides a substantially impermeable diffusion barrier.

5. A metallized flexible enclosure providing environmental protection and electromagnetic interference shielding of an electronic circuit having electronic components and separable connectors, the metallized flexible enclosure comprising:

a plurality of layers of polymeric material for providing diffusion barrier properties to the metallized flexible enclosure, wherein the metallized flexible enclosure is hermetically sealed by at least one of the plurality of layers of polymeric material;

at least one metallic layer disposed between the plurality of polymeric layers for providing diffusion barrier properties and electromagnetic interference shielding capabilities to the metallized flexible enclosure;

wherein the metallized flexible enclosure provides environmental protection and electromagnetic interference shielding to the electrical components while enabling mechanical access to the separable connectors.

6. The metallized flexible enclosure according to claim 5, further comprising openings for exposing the separable connectors.

7. The metallized flexible enclosure according to claim 5, wherein the metallic layer is substantially free of pin holes and provides a substantially impermeable diffusion barrier.

8. The metallized flexible enclosure according to claim 5, wherein the metallic layer is made of aluminum.

9. The metallized flexible enclosure according to claim 5, wherein one of the plurality of layers comprises an electrically insulating inner layer capable of being

adhesively bonded to the electronic device and exposing the at least one metallic layer.

10. The metallized flexible enclosure according to claim 5, wherein the layers of polymeric material are made of at least one member of the group consisting of polyethylene, ionomers, polyvinylidene chloride and polyethylene terepthalate.

11. A method for protecting an electric assembly including a printed circuit board (PCB) having electronic components and separable connectors, comprising the steps of:

forming a sheet of material into a tubular structure the sheet of material including at least a metallic layer;

inserting the PCB into the tubular structure;

indexing and positioning the PCB such that the separable connectors are positioned under openings in the tubular structure;

exposing the separable connectors through the openings in the tubular structure;

compressing the tubular structure against the PCB to form an adhesive bond between the tubular structure and the PCB;

connecting the metallic layer to a circuit ground of the PCB;

forming a metallized flexible enclosure by crimping or connecting the sheet of material; and

sealing the metallized flexible enclosure to form a hermetic seal,

whereby the metallized flexible enclosure provides environmental protection and electromagnetic interference shielding to the electronic components while providing access to the separable connectors.

12. The method of claim 11, further comprising the step of vacuum laminating the tubular structure to press the tubular structure against the electronic components.

13. The method of claim 11, further comprising the step of backfilling the flexible enclosure with a gas during the sealing step.

14. The method of claim 11, wherein the metallic layer is connected in the connecting step by using a conductive adhesive.

15. The method of claim 11, wherein the tubular structure is sealed in the sealing step by using a corrugated tool.

16. The method of claim 11, wherein the tubular structure is sealed in the sealing step by using heat.

17. The method of claim 11, wherein the tubular structure is sealed in the sealing step by using ultrasonics.

18. The method of claim 11, wherein the metallic layer is connected in the connecting step by using ultrasonic bonding.

19. The method of claim 11, further comprising the step of folding the sheet of material over the PCB prior to the sealing step.