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(54) MANUFACTURING METHOD FOR OVER-CURRENT PROTECTION DEVICE

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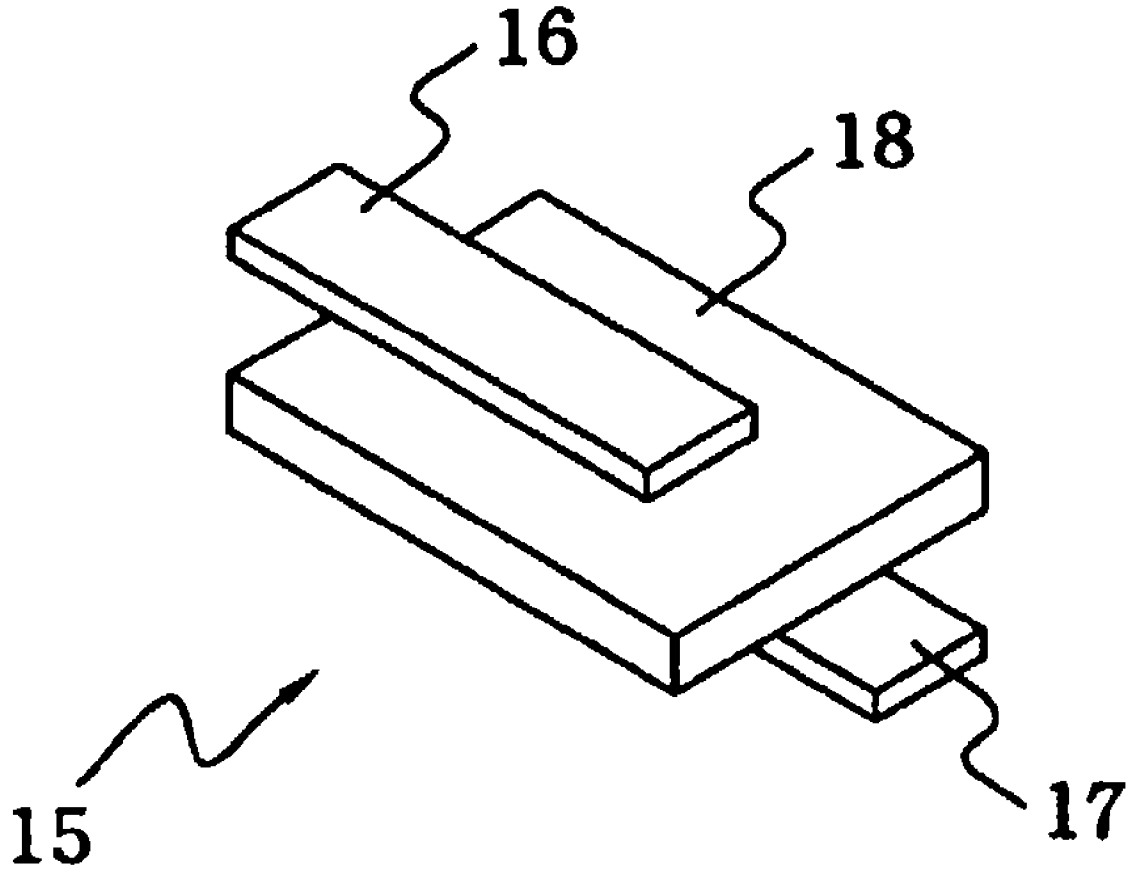
(57) **ABSTRACT**

The present invention reveals a manufacturing method for over-current protection devices. A current-sensitive material strip is combined with the first and the second electrode strips, and then they are punched to produce over-current protection devices, where each over-current protection device includes a first electrode, a second electrode and a current-sensitive material layer. The combination of the current-sensitive material strip with the first electrode strip and the second electrode strip can be employed by re-flowing soldering or hot pressing followed by tin-lead solder electroplating or solder spotting, so as to facilitate automation applications, and to enhance the throughput.



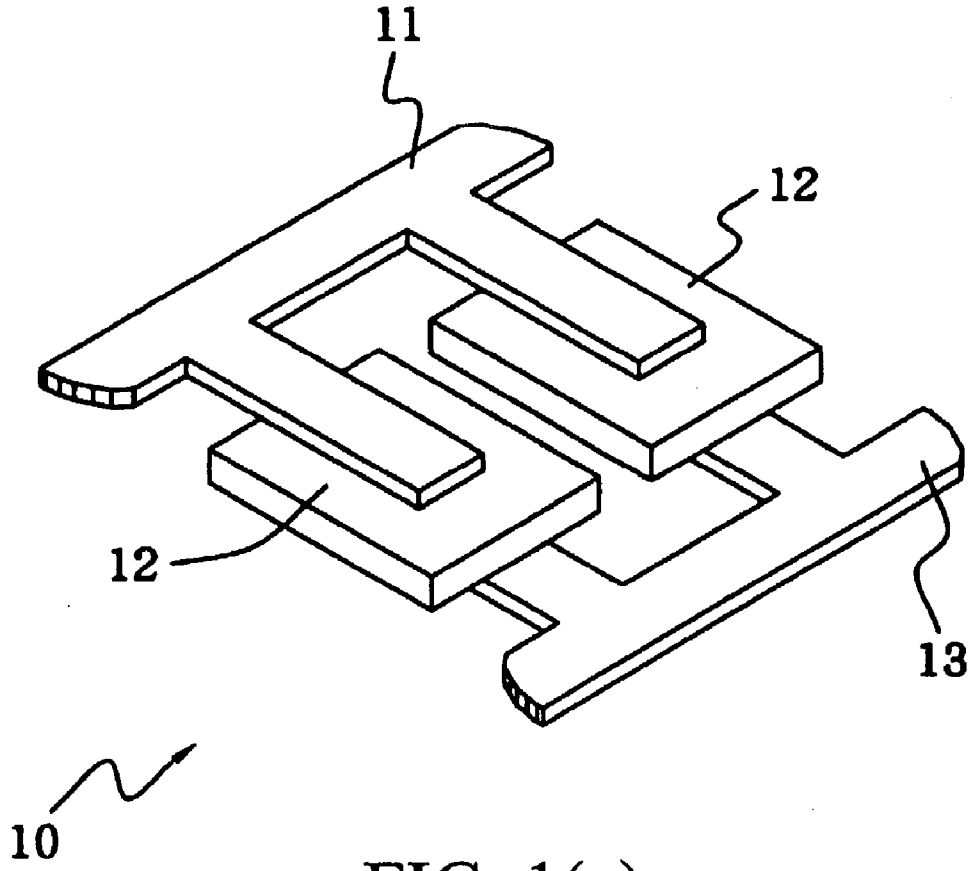


FIG. 1(a)

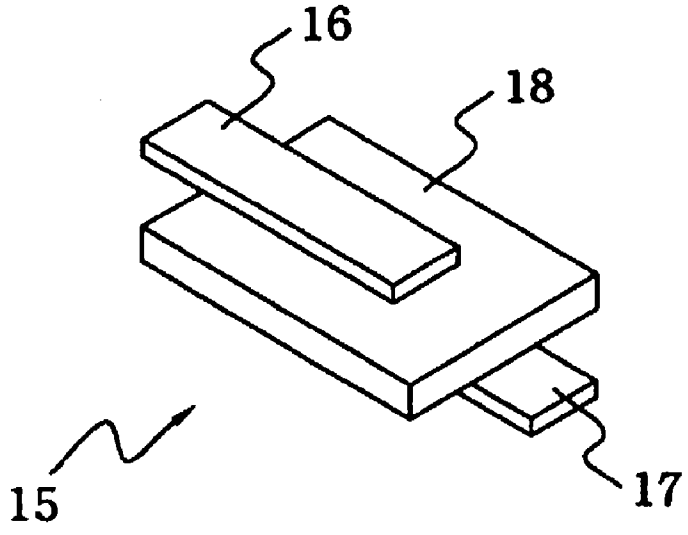


FIG. 1(b)

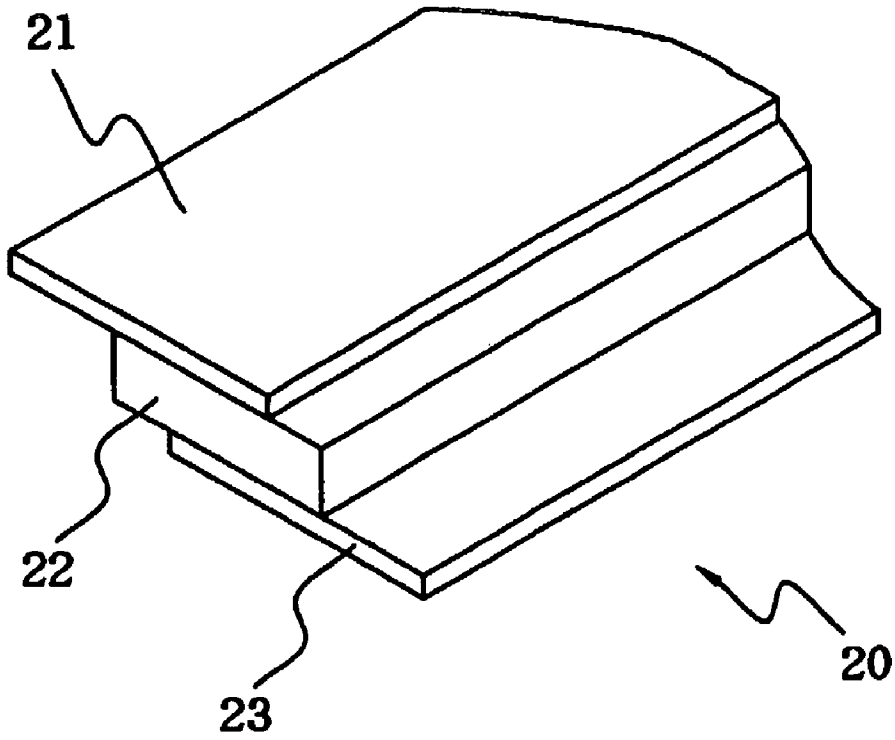


FIG. 2(a)

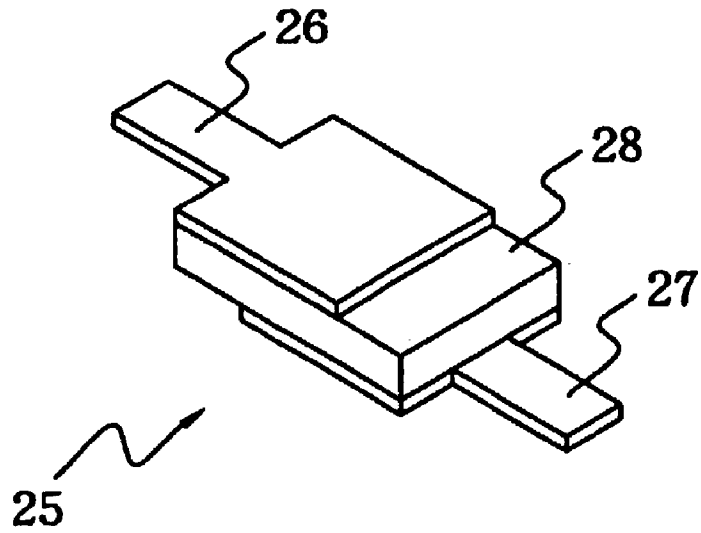


FIG. 2(b)

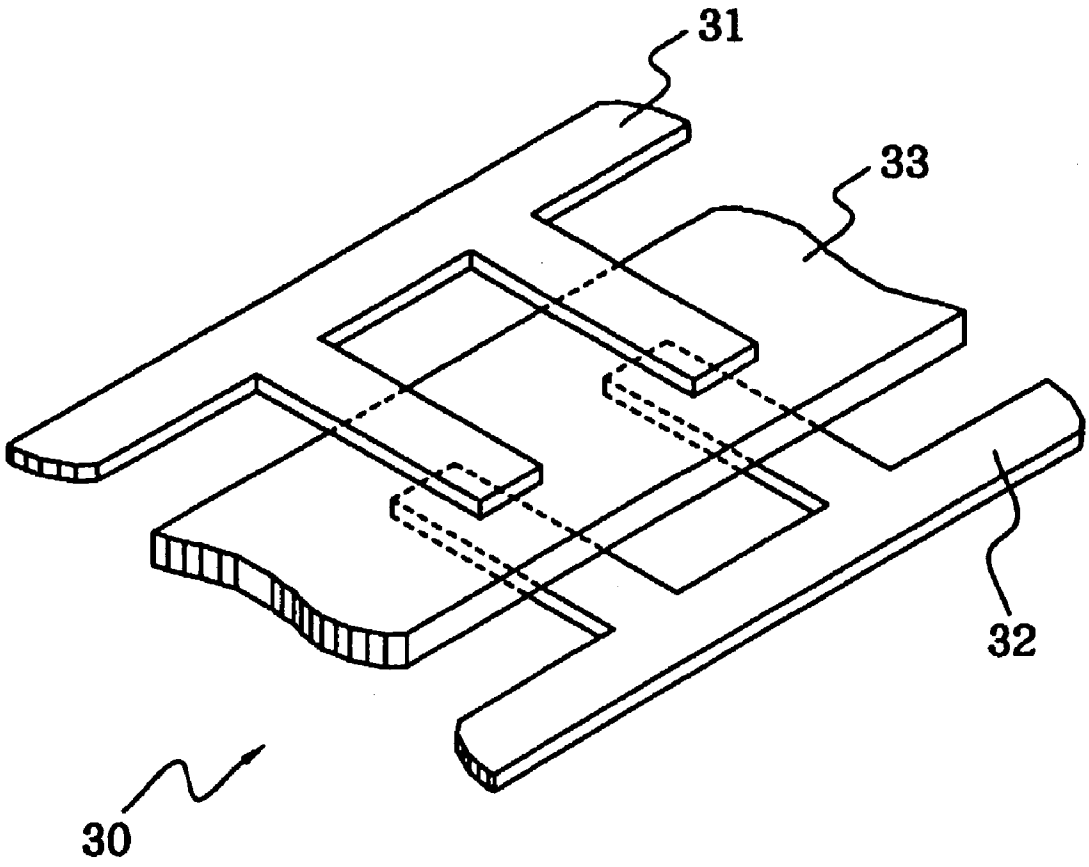


FIG. 3(a)

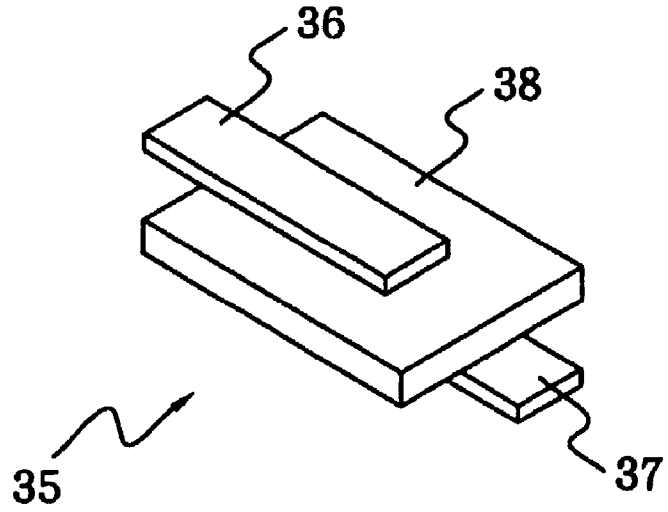


FIG. 3(b)

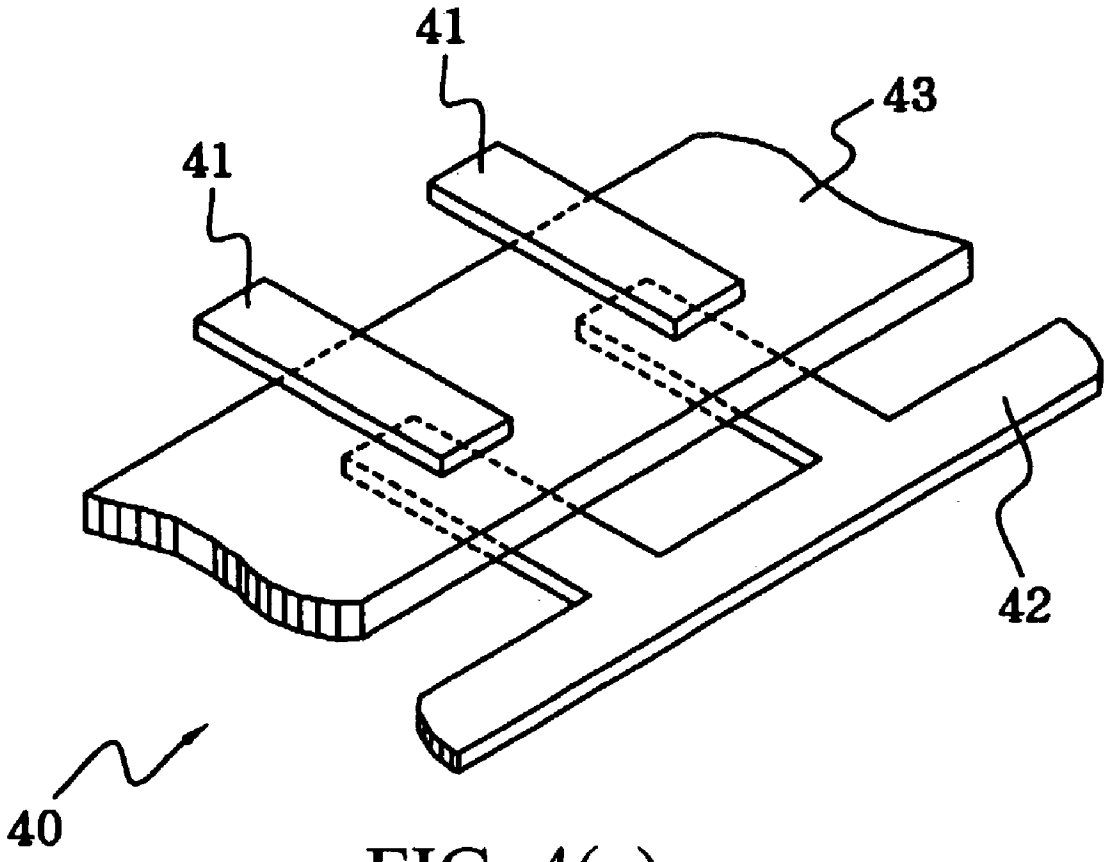


FIG. 4(a)

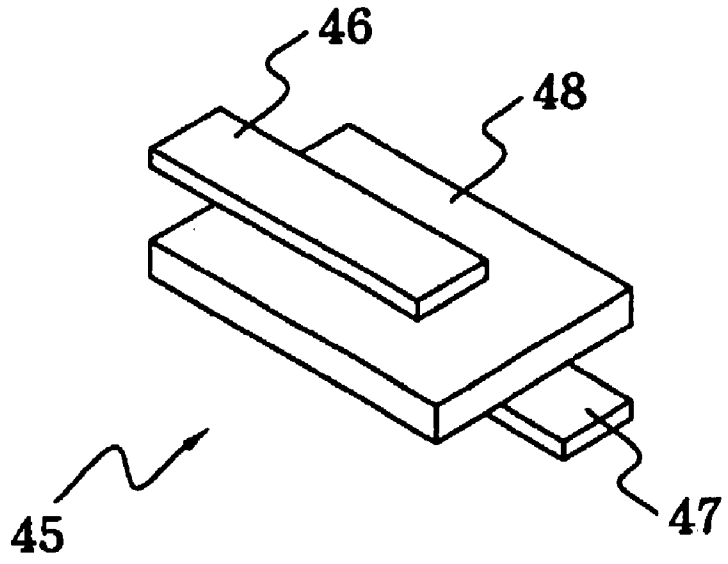


FIG. 4(b)

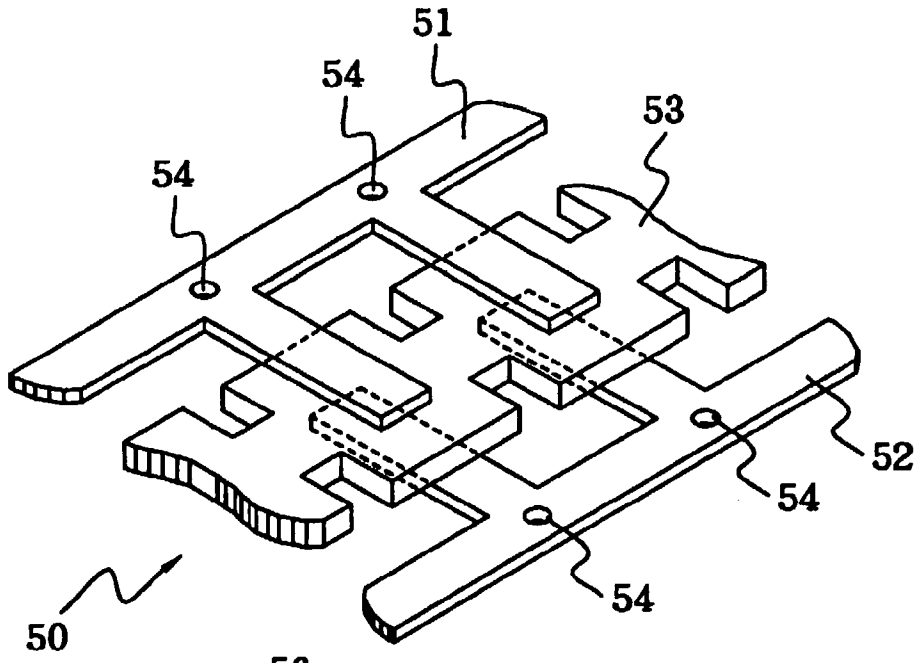


FIG. 5(a)

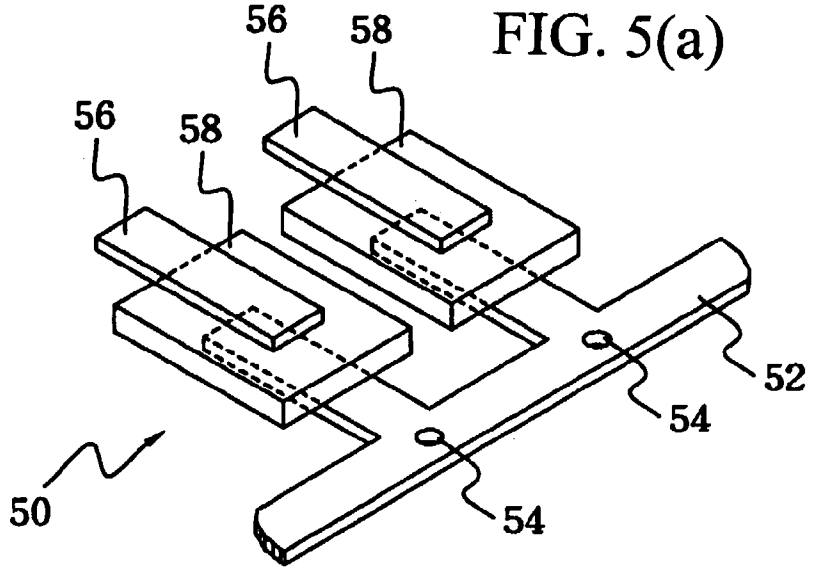


FIG. 5(b)

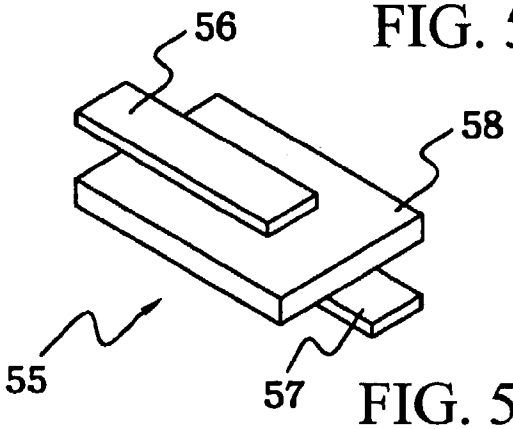


FIG. 5(c)

MANUFACTURING METHOD FOR OVER-CURRENT PROTECTION DEVICE

BACKGROUND OF THE INVENTION

[0001] (A) Field of the Invention

[0002] The present invention relates to a manufacturing method for over-current protection devices, and more specifically, to a manufacturing method for the over-current protection devices using current-sensitive material strips.

[0003] (B) Description of Related Art

[0004] **FIG. 1**(*a*) and **FIG. 1**(*b*) illustrate a conventional manufacturing method for over-current protection devices, where a plurality of current-sensitive elements **12** are individually adhered to the comb-like electrode strips **11, 13** to form a stacked structure **10**, and then the comb-like electrode strips **11, 13** are broken to produce several over-current protection devices **15**. Each over-current protection device **15** comprises a first electrode **16**, a second electrode **17** and a current-sensitive material layer **18**. As the over-current protection device **15** is used to protect a secondary battery, the surfaces of the first electrode **16** and the second electrode **17** are further adhered to metal foils (not shown) served as the leads for electrically connecting the cathode and anode of the secondary battery. The major disadvantage of this method is that the process is too complex to increase the production efficiency.

[0005] Nowadays, the current-sensitive material layer **18** is usually composed of an upper layer of metal foil, a lower layer of metal foil, and a center layer of conductive material having positive temperature coefficient (PTC) which includes a polymer and a conductive filler. The resistance of the PTC conductive material can be kept extremely low at normal operation due to its low sensitivity to temperature variance so that the circuit can operate normally. However, if an over-current or over-temperature effect occurs, the resistance will immediately be increased to a high resistance state (e.g. above 10^4 ohm.) Therefore, the over-current will be reversely eliminated and the objective to protect the circuit device can be achieved.

SUMMARY OF THE INVENTIION

[0006] The main object of the present invention is throughput improvement and cost saving of the production of the over-current protection devices. In brief, a current-sensitive material strip is combined with the first and the second electrode strips, and then they are punched by a mold to produce the required shape. A solder layer can be formed on the surfaces of the current-sensitive material strip, the first electrode or the second electrode by tin-lead solder electroplating or tin solder spotting, and thus the current-sensitive material strip can be adhered to the first electrode and the second electrode by following re-flowing soldering or thermal pressing, so as to avoid the inconvenience of individually combining each current-sensitive element to the first and the second electrode strips as in the prior art.

[0007] The manufacturing method for the over-current protection devices according to the present invention includes the following steps of (1) connecting a current-sensitive material strip to a first electrode strip and a second electrode strip to form a strip-like stacked structure, and (2) cutting the stacked structure into the over-current protection devices, where each over-current protection device comprises a first electrode, a second electrode and a current-sensitive material layer, in which the first electrode, the second electrode and the current-sensitive material layer are formed from the first electrode strip, the second electrode strip and the current-sensitive material strip, respectively.

[0008] The current-sensitive material strip may contain a PTC material. The first and the second electrode strips may be in the form of a comb-like electrode strip of Ni alloy.

[0009] Moreover, one of the first and the second electrode strips can be replaced with a plurality of sheet electrodes, or adding a step of cutting one of the first and the second electrode strips into the plurality of sheet electrodes in advance, so as to facilitate the automation of the following inspection and tape winding processes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **FIG. 1**(*a*) and **FIG. 1**(*b*) illustrate a known manufacturing method of over-current protection devices;

[0011] **FIG. 2**(*a*) and **FIG. 2**(*b*) illustrate the manufacturing method of over-current protection devices of the first preferred embodiment in accordance with the present invention;

[0012] **FIG. 3**(*a*) and **FIG. 3**(*b*) illustrate the manufacturing method of over-current protection devices of the second preferred embodiment in accordance with the present invention;

[0013] **FIG. 4**(*a*) and **FIG. 4**(*b*) illustrate the manufacturing method of over-current protection devices of the third preferred embodiment in accordance with the present invention; and

[0014] **FIG. 5**(*a*) to **FIG. 5**(*c*) illustrate the manufacturing method of over-current protection devices of the fourth preferred embodiment in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] **FIG. 2**(*a*) and **FIG. 2**(*b*) illustrate the manufacturing method for over-current protection devices of the first preferred embodiment according to the present invention. **FIG. 2**(*a*) shows a strip-like stacked structure **20** comprising a sheet-like electrode strip **21**, a PTC material strip **22**, and another sheet-like electrode strip **23**. The sheet-like electrode strips **21, 23** may be made of Ni alloy. The PTC material strip **22** comprises an upper layer of metal foil, a lower layer of metal foil, and a center layer of conductive material having positive temperature coefficient (PTC). The PTC material strip **22** can be connected to the sheet-like electrode strips **21, 23** by adding soldering-assistant agent on the junction through electroplating, solder spotting or printing like manner and sequentially performed in a re-flowing soldering furnace, or by thermal pressing using hot bar. The hot bar can heat locally to melt the interface between the sheet-like electrode strips **21, 23** and the PTC material strip **22** for connection so that the increase of the resistance of the PTC material strip **22** caused by temperature raising can be avoided. Referring to **FIG. 2**(*b*), a plurality of PTC devices **25** are generated by punching with a mold into the required shape. The sheet-like electrode

strips **21**, **23** are cut into a first electrode **26** and a second electrode **27**, respectively. Additionally, the PTC material strip **22** is cut into the PTC material layers **28** with equal span.

[**0016**] **FIG. 3**(*a*) and **FIG. 3**(*b*) illustrate the manufacturing method for the over-current protection devices of the second preferred embodiment according to the present invention. **FIG. 3**(*a*) shows a strip-like stacked structure **30** comprising a comb-like electrode strip **31**, a PTC material strip **33** and another comb-like electrode strip **32**. The PTC material strip **33** comprises an upper layer of metal foil, a lower layer of metal foil, and a center layer of conductive material having positive temperature coefficient (PTC). The dashed lines in **FIG. 3**(*a*) shows the sheet-like electrode strips **31**, **32** adhered to the PTC material strip **33** are overlapped by an offset. Similarly, the PTC material strip **33**, and the comb-like electrode strips **31**, **32** can be combined by electroplating, solder spotting or hot bar. In **FIG. 3**(*b*), the stacked structure **30** is punched by a mold into the required shape to generate a plurality of PTC devices **35**, in which the comb-like electrode strips **31**, **32** are cut to form a first electrode **36** and a second electrode **37** respectively, and the PTC material strip **33** is cut into the PTC material layers **38** with equal span. **FIG. 4**(*a*) and **FIG. 4**(*b*) illustrate the manufacturing method for the over-current protection devices of the third preferred embodiment according to the present invention. In **FIG. 4**(*a*), a strip-like stacked structure **40** includes a plurality of sheet electrodes **41**, a comb-like electrode strip **42** and a PTC material strip **43**, i.e. the comb-like electrode **31** shown in **FIG. 3**(*a*) is replaced with a plurality of sheet electrodes **41** in this case. In **FIG. 4**(*b*), the stacked structure **40** is punched into a plurality of PTC devices **45** by a mold, each PTC device comprising a first electrode **46**, a second electrode **47** and a PTC material layer **48**. The comb-like electrode strip **42** and the PTC material strip **43** are cut into the second electrode **47** and the PTC material layer **48**, respectively, and the first electrode **46** is directly made from the sheet electrode **41** without any further machining. Moreover, the sheet electrode **41** can be cut to be of a suitable size as required during manufacturing.

[**0017**] **FIG. 5**(*a*) to **FIG. 5**(*c*) illustrate the manufacturing method for the over-current protection devices of the fourth preferred embodiment according to the present invention. A strip-like stacked structure **50** shown in **FIG. 5**(*a*) comprises a comb-like electrode strip **51**, a PTC material strip **53** and another comb-like electrode strip **52**. The PTC material strip **53** contains concave portions at equal span, and the corresponding convex portions are used as the PTC material layers of PTC devices. In such case, the manufacturing cost of the PTC material can be reduced, but the position for punching must be more precise. The T-shape intersections of the comb-like electrode strips **51**, **52** are provided with alignment holes **54**, which can be driven by the manufacturing machine to improve the precision of punching. In **FIG. 5**(*b*), the comb-like electrode strip **51** and the PTC material strip **53** are punched into a plurality of first electrodes **56** and PTC material layers **58** respectively. In **FIG. 5**(*c*), the comb-like electrode strip **52** is punched to form the second electrode **57** whereby a plurality of PTC devices **55** are produced. In this case, the PTC devices are manufactured by two-stage punching. After the first-stage punching is done, the comb-like electrode strip **52** is still connected to each PTC material layer **58** so that it can facilitate the automation application for the following resistance testing or tape winding.

[**0018**] The above-described embodiments of the present invention are intended to be illustrative only. Numerous alternative embodiments may be devised by those skilled in the art without departing from the scope of the following claims.

What is claimed is:

1. A manufacturing method for over-current protection devices, comprising the steps of:

combining a current-sensitive material strip, a first electrode strip and a second electrode strip as a strip-like stacked structure; and

cutting the strip-like stacked structure into a plurality of over-current protection devices, each over-current protection device including a first electrode, a second electrode and a current-sensitive material layer, wherein the first electrode, the second electrode and the current-sensitive material layer are formed from the first electrode strip, the second electrode strip and the current-sensitive material strip, respectively.

2. The manufacturing method for over-current protection devices in accordance with claim 1, wherein at least one of the first electrode strip and the second electrode strip is a comb-like electrode strip.

3. The manufacturing method for over-current protection devices in accordance with claim 2, wherein the comb-like electrode strip comprises a plurality of alignment holes.

4. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the combination of the current-sensitive material strip with the first electrode strip and the second electrode strip is employed by re-flowing soldering followed by tin-lead solder electroplating.

5. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the combination of the current-sensitive material strip with the first electrode strip and the second electrode strip is employed by re-flowing soldering followed by tin solder spotting.

6. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the combination of the current-sensitive material strip with the first electrode strip and the second electrode strip is by means of a hot bar.

7. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the current-sensitive material strip, the first electrode strip and the second electrode strip are cut by punching.

8. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the current-sensitive material strip has a concave-convex shape.

9. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the current-sensitive material strip includes a PTC material.

10. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the current-sensitive material strip comprises an upper layer of metal foil, a lower layer of metal foil, and a center layer of conductive material having positive temperature coefficient.

11. The manufacturing method for over-current protection devices in accordance with claim 1, wherein the first electrode and the second electrode are made of Ni alloy.

12. A manufacturing method for over-current protection devices, comprising the steps of:

combining a current-sensitive material strip, a comb-like electrode strip and a plurality of sheet electrodes as a strip-like stacked structure; and

cutting the strip-like stacked structure into a plurality of over-current protection devices, each over-current protection device including a first electrode, a second electrode and a current-sensitive material layer, wherein the current-sensitive material layer and the second electrode are formed by the current-sensitive material strip and the comb-like electrode strip, respectively, and the first electrode is formed by the sheet electrode.

13. The manufacturing method for over-current protection devices in accordance with claim 12, wherein the current-sensitive material strip and the comb-like electrode strip is cut by punching.

14. The manufacturing method for over-current protection devices in accordance with claim 12, wherein the plurality of sheet electrodes are formed by cutting a electrode strip.

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