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(54) **METAL PATTERN ON ELECTROMAGNETIC ABSORBER STRUCTURE**

(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)

(72) Inventors: **Babak Radi**, Hsinchu (TW); **Yuan-Chin Hsu**, Hsinchu (TW); **Yu-Fu Kuo**, Hsinchu (TW); **Tzu-Min Wu**, Hsinchu (TW); **Tzu-Wen Chuang**, Hsinchu (TW); **Shih-Hong Chen**, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corp.**, Hsinchu (TW)

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***H01Q 17/00*** (2006.01)

(52) **U.S. Cl.**
CPC ................................ ***H01Q 17/004*** (2013.01)

(58) **Field of Classification Search**
CPC .................................................... H01Q 17/004
USPC ............................................................. 342/1
See application file for complete search history.

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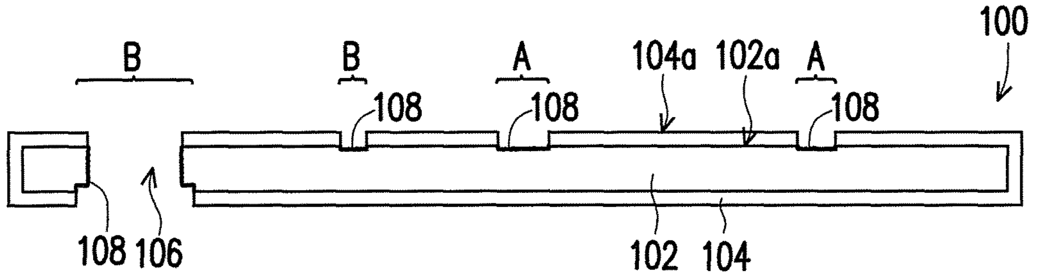
*Primary Examiner* — Timothy A Brainard
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A metal pattern formed in the electromagnetic absorber structure is provided. By performing the laser treatment to form the active layer thereon, the metal pattern can be regionally formed on the electromagnetic absorber structure in the following electroless plating processes.

**14 Claims, 3 Drawing Sheets**



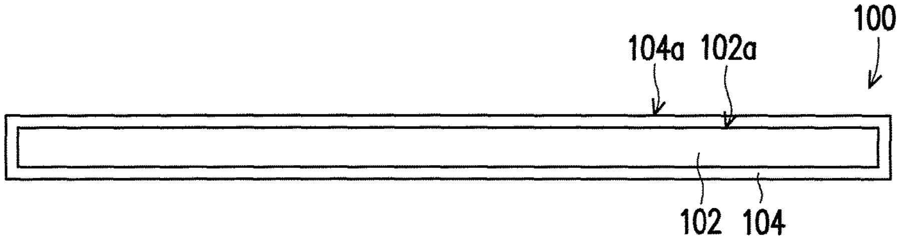


FIG. 1A

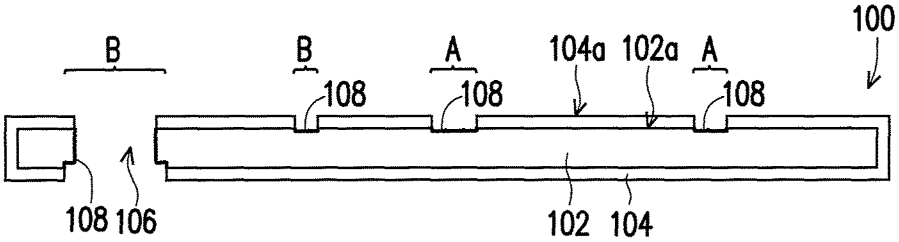


FIG. 1B

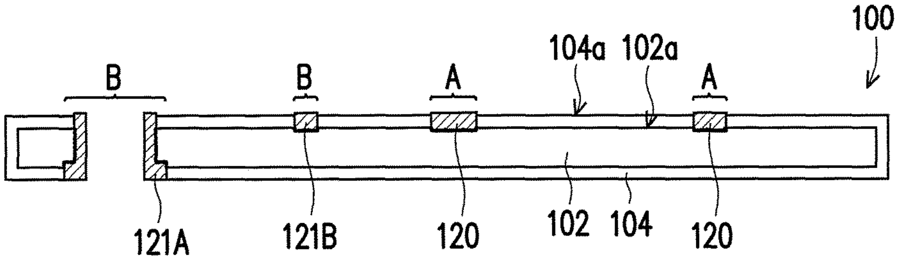


FIG. 1C

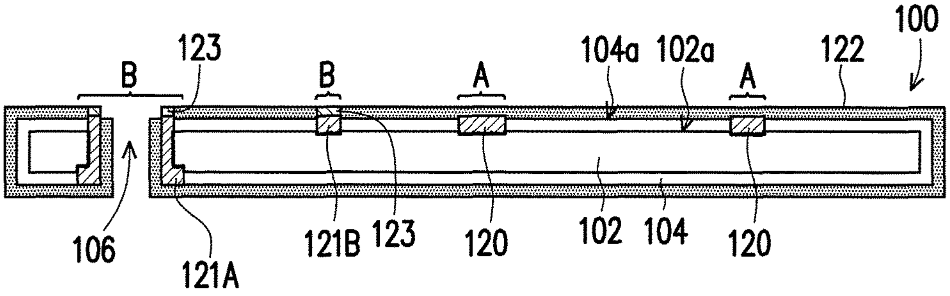

123
B
B
A
104a
102a
A
122
100
106
121A
121B
123
120
102
104
120

FIG. 1D

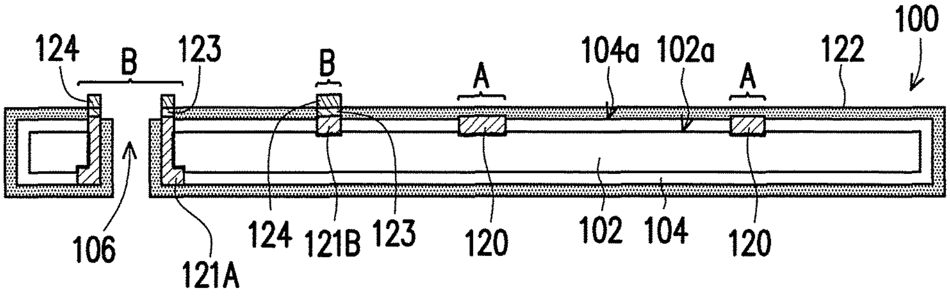

124
B
123
B
A
104a
102a
A
122
100
106
121A
124
121B
123
120
102
104
120

FIG. 1E

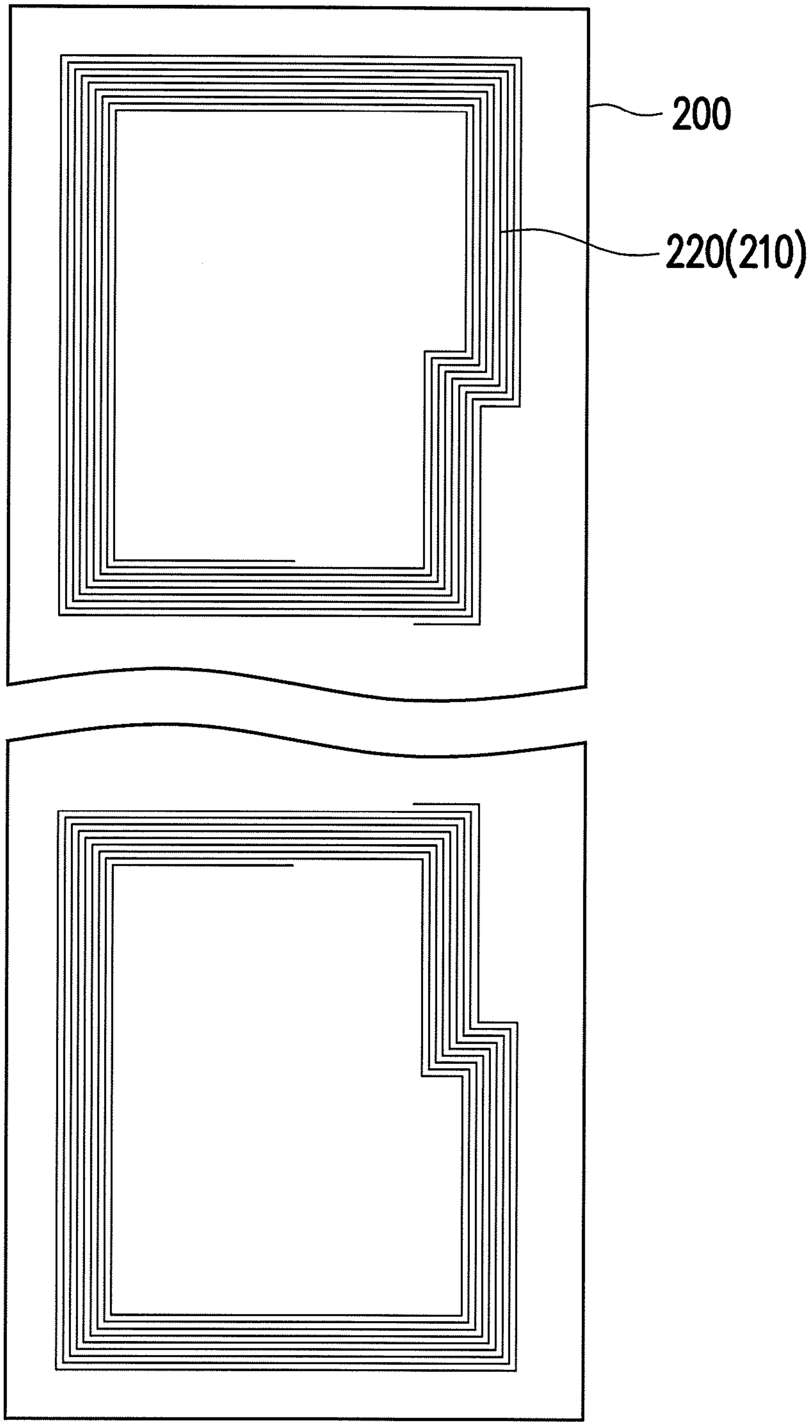


FIG. 2

# METAL PATTERN ON ELECTROMAGNETIC ABSORBER STRUCTURE

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan application serial no. 103130786, filed on Sep. 5, 2014. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

## BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is related to a metal pattern on a surface of an electromagnetic absorber structure.

Description of Related Art

Near field communication (NFC), also called short distance wireless communication, is a short distance high frequency wireless communication technology that allows non-contact point-to-point data transmission to be carried out between electronic devices and the data can be exchanged within the distance of 10 centimeters (3.9 inches). Since the NFC technology requires lower frequency, the corresponding antenna elements typically have a longer resonant path.

For the mobile devices, it is common to use the electromagnetic absorber material in an antenna structure for NFC. Generally, at least one layer of the electromagnetic absorber material is further attached to the antenna structure in order to avoid communal interference between an NFC antenna and other electronic devices and/or metal elements in the mobile device. In view of the miniaturization trend for the designs of communication field, it is necessary to consider further reducing the total thickness of the overall antenna structure, and such design has to be compatible with the manufacturing processes.

## SUMMARY OF THE INVENTION

An electromagnetic absorber structure having a metal pattern thereon is provided in the present invention. The aforementioned metal pattern is formed by applying laser to a predetermined region on the electromagnetic absorber, followed by electroless plating the predetermined region in order to form the metal pattern on the electromagnetic absorber structure.

According to an embodiment of the present invention, the electromagnetic absorber structure includes an electromagnetic absorber layer and at least one insulative layer disposed on the surface of the electromagnetic absorber layer. The electromagnetic absorber structure has at least one predetermined region, and the insulative layer within the predetermined region does not cover the surface of the electromagnetic absorber layer. The metal pattern is disposed in the predetermined region of the electromagnetic absorber structure and is located on the surface of the electromagnetic absorber layer within the predetermined region.

According to another embodiment of the present invention, the electromagnetic absorber structure includes an electromagnetic absorber layer and at least one insulative layer disposed on the surface of the electromagnetic absorber layer, and the electromagnetic absorber structure has at least one predetermined region. An active layer is located on the surface of the electromagnetic absorber layer within the predetermined region. The metal pattern is located on the active layer of the surface of the electromagnetic absorber layer within the predetermined region.

According to the embodiments of the present invention, the material of the electromagnetic absorber layer may be manganese-zinc ferrite or nickel-zinc ferrite.

According to the embodiments of the present invention, the surface of the electromagnetic absorber layer within the predetermined region is treated with laser, thereby activating an active layer formed on the surface of the electromagnetic absorber layer and removing the insulative layer. The metal pattern is formed via an electroless plating process by using the active layer as a seed layer.

According to the embodiments of the present invention, the region of the electromagnetic absorber layer, where the metal pattern is to be formed, is activated first via the laser treatment, so that the metal pattern is ensured to be formed in the predetermined position during the following electroless plating process. By doing so, the formation of an unexpected metal layer that may depreciate the function or appearance can be avoided, thereby making the metal pattern to be formed more precisely.

In order to make the aforementioned features and advantages of the invention more comprehensible, embodiments accompanying figures are described in detail below.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A-**1**E are cross-sectional schematic views illustrating process steps for forming a metal pattern on an electromagnetic absorber structure according to an embodiment of the present invention.

FIG. **2** is a top view illustrating a metal pattern formed on an electromagnetic absorber structure according to an embodiment of the present invention.

## DESCRIPTION OF EMBODIMENTS

A metal pattern directly formed on an electromagnetic absorber and a forming method thereof are provided. By using laser treatment, a predetermined region on the surface of the electromagnetic absorber is activated and an insulative layer within the predetermined region on the electromagnetic absorber will be removed accordingly. Thereafter, a metal pattern is formed in the predetermined region on the surface of the electromagnetic absorber by using an electroless plating process. The laser treatment is capable of either directly activating the predetermined region (predetermined pattern) on the surface of the electromagnetic absorber, or penetrating through a specific region of the electromagnetic absorber to form a through hole. No metal layer will be formed in the region not treated by the laser treatment during the subsequent electroless plating process. Thus, with such forming method, a metal pattern having a precise pattern (with precise border) can be formed in situ at the predetermined region on the surface of the electromagnetic absorber via the electroless plating process.

Here, the material of the electromagnetic absorber may be a high magnetic permeability material. Generally speaking, the electromagnetic absorber material can effectively absorb electromagnetic radiation and avoid magnetic field interference within a specific frequency range, thus eliminating electromagnetic or radio frequency interference caused by nearby electronic devices. The electromagnetic absorber material may be, for example, ferrite, which is majorly made of iron oxide. There are various kinds of ferrites, including manganese-zinc ferrite, nickel-zinc ferrite, etc. Nickel-zinc ferrite is more capable of absorbing frequencies greater than 1 MHz.

FIGS. **1**A-**1**E are cross-sectional schematic views illustrating process steps for forming a metal pattern on an electromagnetic absorber structure according to an embodiment of the present invention.

Referring to FIG. **1**A, an electromagnetic absorber structure **100** is provided, the electromagnetic absorber structure **100** has an electromagnetic absorber layer **102** and at least one insulative layer **104** covering the surface **102***a* of the electromagnetic absorber layer **102**. The insulative layer **104** may be, for example, a stacked layer of a thermal-plastic material layer and an adhesive layer. The material of the thermal-plastic material layer may be, such as polyethylene terephthalate (PET). The thermal-plastic material layer can be attached to the electromagnetic absorber layer **102** via the adhesive layer, and the thickness of the PET/adhesive stacked layer is approximately 5-10 μm. The material of the electromagnetic absorber layer **102** may be manganese-zinc ferrite or nickel-zinc ferrite. The thickness of the electromagnetic absorber layer **102** is, for instance, between 0.045-0.3 mm.

Referring to FIG. **1**B, a laser treating step is performed to apply laser to predetermined regions A and B of the surface **104***a* of the insulative layer **104** for removing a part of the insulative layer **104** within the predetermined region A to expose the surface **102***a* of the electromagnetic absorber layer **102** underneath the insulative layer **104**, and removing the insulative layer **104** within the predetermined region B and penetrating through the electromagnetic absorber layer **102** to form an through-hole **106**. The surface of the electromagnetic absorber layer **102** overlapping with the predetermined regions A and B is not covered by the insulative layer **104**.

Referring to FIG. **1**B, nickel-zinc ferrite is used as an example as the material of the electromagnetic absorber in this embodiment. In the laser treating process, the laser will activate the exposed surface **102***a* of the electromagnetic absorber layer **102** within the treated regions (i.e., regions A & B) to form an active layer **108** on the surface **102***a* of the electromagnetic absorber layer **102** within the regions A & B. The activation mechanism relies on the reduction reaction caused by exposing to laser. The iron oxide contained in nickel-zinc ferrite is than being reduced into iron thereby constituting the active layer **108** being used as a seed layer in the subsequent electroless plating process. The active layer **108** is very thin, and the laser treated regions (i.e., regions A & B) are corresponded to the locations to be formed with conductive patterns. The laser treating step allows the location and shape of the subsequently formed pattern to be controlled precisely.

Accordingly, the laser treatment process may ensure the active layer **108** to be formed on the surface **102***a* of the electromagnetic absorber material within the predetermined region and used as a seed layer in the subsequent electroless plating process. The location of the active layer **108** corresponds to the location where the conductive pattern is to be formed subsequently, and a precise metal pattern will then be formed in the predetermined location during the subsequent electroless plating process. The aforementioned predetermined region A of the electromagnetic absorber structure **100** may be a region where an antenna is to be disposed, and the predetermined region B of the electromagnetic absorber structure **100** may be a region wherein a contacting or a connecting structure is to be disposed. The laser used in the laser treating step is, for example, infrared (IR) laser having a power of 8-10 W, at a frequency of 40-75 kHz, and a wavelength of 1064 nm.

Here, the active layer **108** is formed on the surface **102***a* of the electromagnetic absorber layer **102** within the regions A & B, and the region(s) not treated by the laser treatment is still covered by the insulative layer **104**. Therefore the surface **102***a* in the untreated region(s) is isolated from the outer environment. As a result, in the electroless plating process performing subsequently, since the untreated region(s) (i.e., the non-predetermined region(s)) of the surface of the electromagnetic absorber structure **100** is isolated by the insulative layer **104**, no plating reaction will occur between the non-predetermined region and the electroless plating solution.

After the laser treating step is performed, the electromagnetic absorber structure **100** is immersed into an electroless plating solution(s) for performing a series of electroless plating processes.

Referring to FIG. **1**C, a first electroless plating process is conducted at the electromagnetic absorber structure **100**. Since the active layer **108** is formed within the predetermined regions A & B that were treated with the laser treatment, metal patterns **120** and **121** are respectively formed on the active layer **108** in the predetermined regions A & B of the electromagnetic absorber structure **100** during the electroless plating process through the active layer **108**. In this embodiment, the first electroless plating process utilizes the active layer **108** as a seed pattern for electroless plating, and therefore the metal pattern **120** can be precisely formed on the distributed range of the active layer **108** within the predetermined region A. Likewise, metal patterns **121**A and **121**B are precisely formed over the distributed range of the active layer **108** within the predetermined region B (including portions of the surface **102***a* of the electromagnetic absorber layer **102** and the inner surface of the through-hole **106**). Actually, the metal pattern **121**A should be a through-hole conductive structure which fully covers the inner sidewall of the through-hole **106**, and the metal pattern **121**B is a contact pad. Here, the first electroless plating process is exemplified by a copper electroless plating process. The formed metal pattern **120** is, for example, a copper pattern having a thickness of not thicker than 60 μm and a surface thereof being slightly higher than the surface **104***a* of the insulative layer **104**. The metal pattern **121**A may be a copper plug, and the metal pattern **121**B may be a copper contact pad. In this embodiment, the metal pattern **120** may be a continuous pattern or non-continuous patterns; and the metal pattern **120** may be, for example, a metal antenna structure. No plating occurs in the portions (i.e., regions other than the regions A & B) which are covered by the insulative layer **104**.

In fact, the surface of the metal pattern **120** is slightly higher than the surface **104***a* of the insulative layer **104**, and therefore the metal pattern **120** may be seen as being partially inlaid in the electromagnetic absorber structure **100**. Accordingly, in the present invention, the metal pattern is directly embedded in the electromagnetic absorber structure **100**, which may further reduce the entire thickness of the metal pattern or metal antenna structure. Hence, the entire structure can be much more suitable to be integrated in mobile communication electronic devices such as cell phones, tablet PCs or wireless high frequency communication devices and the like.

By applying laser, the obtained metal pattern may form a high precision profile. Moreover, since the scanning of the laser can be easily adapted to the shape or profile of the electromagnetic absorber structure, the metal pattern may be precisely formed on a planar surface or an uneven object.

Referring to FIGS. **1**D-**1**E, an organic protecting layer **122** is formed covering the electromagnetic absorber structure **100**. The organic protecting layer **122** covers the metal pattern **120** formed in the predetermined region A, whereas the layer **122** does not cover the metal patterns **121**A and **121**B formed in the predetermined region B. Thereafter, a second electroless plating process and a third electroless plating process are performed in sequence. A metal layer **123** and a metal layer **124** are sequentially formed on the metal patterns **121**A and **121**B within the predetermined region B of the electromagnetic absorber structure **100**. Here, the first electroless plating process is exemplified by a copper electroless plating process. The second electroless plating process and the third electroless plating process are respectively exemplified by a nickel electroless plating process and a gold electroless plating process. The metal layers **123**/**124** may be, for example, a nickel layer, and a gold layer, respectively.

In the embodiment, the metal pattern may be, for example, an antenna pattern of a single conductive layer and a contact pad having multiple conductive layers. Firstly, a copper (layer) pattern having good conductivity is formed on an electromagnetic absorber material. Then, an organic protecting layer or a nickel layer and a gold layer is formed on the copper pattern in order to reduce oxidization of the copper layer. The metal pattern may be used as an antenna, a connecting terminal or other metal components. The material of the metal pattern includes copper, nickel, gold, silver or any combinations of the above elements.

In this embodiment, a stacked-layer structure is composed by the metal pattern **120**/the organic protecting layer **122** formed in the predetermined region A of the electromagnetic absorber structure **100**. The stacked-layer structure at least includes a metal antenna structure (i.e., the metal pattern **120**), and the electromagnetic absorber layer **102** underneath may effectively absorb electromagnetic radiation and magnetic field interference, which may avoid electromagnetic interference or radio frequency interference interfering the antenna structure caused by other electronic devices.

FIG. **2** is a top view illustrating a metal pattern formed on an electromagnetic absorber structure according to an embodiment of the present invention. FIG. **2** is only partially showing of the metal pattern **210** formed on an electromagnetic absorber structure **200**, and the figure is mainly to show a metal antenna structure **220** of the metal pattern **210**. FIG. **2** shows that the metal antenna structure **220** (pattern) is designed as an annular antenna, and the annular antenna may be, for example, an annular rectangle with a dimension of 4 cm×5 cm or of other suitable sizes. Certainly, the antenna may be in an annular shape or any other geometric shapes. In the embodiment, the metal antenna structure **220** may be a magneto-inductive antenna or a near-field communication (NFC) antenna. The level of the magnetic flux needs to be taken into consideration while designing the sizes and shapes of the magneto-inductive antenna. In order to prevent interferences to the metal antenna structure, in this embodiment, the size of the electromagnetic absorber structure **200** is designed to be greater than the metal antenna structure **220**. The total thickness of the metal antenna structure **210** may be smaller than approximately 500 μm. A thinner metal antenna structure is suitable to be used with a flexible substrate, and can be applied to the peripheral appliances of mobile devices. In this embodiment, the thickness of the metal antenna structure can be 100-500 μm.

The electromagnetic absorber structure **200** is similar to the electromagnetic absorber structure **100** described in the above embodiment (see FIG. **1**A), which at least has one electromagnetic absorber layer and at least one insulative layer covering the surface of the electromagnetic absorber layer. Here, the following descriptions may be clearly understood by referring to the above embodiment. The metal pattern **210** (including the metal antenna structure **220** as well) is directly formed on the electromagnetic absorber structure **200**. In fact, the metal pattern **210** and the metal antenna structure **220** may even be partially inlaid in the electromagnetic absorber structure **200**. While comparing with conventional designs which use a portion of a flexible printed circuit as an antenna which is also being printed on a substrate, in the present invention, the metal antenna pattern is directly embedded in the electromagnetic absorber structure **200**, which may further reduce the entire thickness of the structure having the electromagnetic absorber material and the metal pattern or the metal antenna.

In the aforementioned embodiments, the metal pattern may be formed on the electromagnetic absorber material by electroless plating, and the metal pattern may be, for example, an antenna including a single-layered copper pattern. However, the metal pattern may also include multi-layered conductive patterns. The metal pattern may be used as an antenna, a connector or other metal components. The material of the metal pattern includes copper, nickel, gold, silver or any combination of the above elements.

More specifically, since the material of the metal antenna structure **220** is mainly made of metals which might be easily interfered by kinds of interferences, the electromagnetic absorber material disposed underneath the metal antenna structure **220** may absorb and reduce magnetic or radio frequency interferences caused by other metal components or other electronic devices. Hence, the performance of the antenna will not be adversely affected and can be enhanced.

The metal pattern formed in the electromagnetic absorber structure provided in the present invention is also fully applicable to slim antennas commonly used in the communication industry.

In the aforementioned embodiments, the metal pattern structure formed in the electromagnetic absorber material may be further attached to a portable device, such as a case of a cell phone or a circuit board through other fixing means.

Specifically, the electromagnetic absorber material may be immersed into an electroless plating solution to form the metal pattern. Because the laser treatment is performed to activate the region where the metal pattern is to be formed prior to the subsequent plating processes, the metal pattern can be precisely formed in that predetermined location during the electroless plating process. In addition, because the process set forth in the present invention does not employ any screen printing, pad printing, or transfer printing, etc., to form the metal pattern, there is no need for photo-masks, developers or inks.

Although the invention has been disclosed by the above embodiments, the embodiments are not intended to limit the invention. It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the invention without departing from the scope or spirit of the invention. Therefore, the protecting range of the invention falls in the appended claims.

What is claimed is:

**1**. An electromagnetic absorber structure having a metal pattern, the electromagnetic absorber structure comprising:

an electromagnetic absorber layer disposed in the electromagnetic absorber structure;

at least an insulative layer covering the surface of the electromagnetic absorber layer, wherein the electromagnetic absorber structure has at least a predetermined region, and the surface of the electromagnetic absorber layer overlapping with the predetermined region is not covered by the insulative layer; and

the metal pattern located within the predetermined region and on the surface of the electromagnetic absorber layer of the electromagnetic absorber structure.

**2**. The electromagnetic absorber structure according to claim **1**, wherein the insulative layer is a stack of a polyethylene terephthalate layer and an adhesive layer.

**3**. The electromagnetic absorber structure according to claim **1**, wherein the material of the electromagnetic absorber layer is manganese-zinc ferrite or nickel-zinc ferrite.

**4**. The electromagnetic absorber structure according to claim **3**, wherein the metal pattern further comprises an antenna structure.

**5**. The electromagnetic absorber structure according to claim **4**, wherein the material of the antenna structure comprises copper, nickel, gold, silver or a combination thereof.

**6**. The electromagnetic absorber structure according to claim **4**, wherein the metal pattern comprises at least a contact pad or a metal thorough hole.

**7**. The electromagnetic absorber structure according to claim **6**, wherein the contact pad is a copper pad covered by a nickel layer and a gold layer.

**8**. An electromagnetic absorber structure having a metal pattern, the electromagnetic absorber structure comprising:

an electromagnetic absorber layer disposed in the electromagnetic absorber structure;

at least an insulative layer covering the surface of the electromagnetic absorber layer, wherein the electromagnetic absorber structure has at least a predetermined region, and the surface of the electromagnetic absorber layer overlapping with the predetermined region has an active layer; and

the metal pattern directly disposed on the active layer of the surface of the electromagnetic absorber layer in the predetermined region.

**9**. The electromagnetic absorber structure according to claim **8**, wherein the material of the electromagnetic absorber layer is manganese-zinc ferrite or nickel-zinc ferrite.

**10**. The electromagnetic absorber structure according to claim **9**, wherein the surface of the electromagnetic absorber layer overlapping with the predetermined region is treated by laser, thereby activating the surface of the electromagnetic absorber layer to form the active layer.

**11**. The electromagnetic absorber structure according to claim **10**, wherein the metal pattern is formed by using the active layer as a seed layer via an electroless plating process.

**12**. The electromagnetic absorber structure according to claim **11**, wherein the metal pattern further comprises an antenna structure, and the material of the antenna structure comprises copper, nickel, gold, silver or a combination thereof.

**13**. The electromagnetic absorber structure according to claim **11**, wherein the metal pattern comprises at least a contact pad or a metal thorough hole.

**14**. The electromagnetic absorber structure according to claim **13**, wherein the contact pad is a copper pad covered by a nickel layer and a gold layer.

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