

## **DESCRIPTION**

### **TITLE OF INVENTION**

### **COIN-TYPE CONTACTLESS INFORMATION MEDIUM AND MANUFACTURING METHOD THEREOF**

### **TECHNICAL FIELD**

[0001]

An embodiment of the present invention relates to a coin-type contactless information medium. Further, an embodiment of the present invention relates to a method for manufacturing a coin-type contactless information medium.

### **BACKGROUND ART**

[0002]

Since a contactless information medium including RFID is connected to a reader/writer by wireless communication, the contactless information medium is not required to come into contact with the reader/writer. Therefore, the contactless information medium is highly convenient, and thus the demand for the contactless information medium is increasing. In particular, a coin-type contactless information medium equipped with an IC chip has begun to be used as a chip in a casino because the coin-type contactless information medium has high security and can be authenticated (see Patent Literature 1 or Patent Literature 2, for example).

### **CITATION LIST**

#### **PATENT LITERATURE**

[0003]

Patent Literature 1: U.S. Patent Publication No. 6,021,949

Patent Literature 2: U.S. Patent Publication No. 3,766,452

## **SUMMARY OF INVENTION**

### **TECHNICAL PROBLEM**

[0004]

When a coin-type contactless information medium is used as a casino chip, it is necessary to accurately read information on each of the plurality of coin-type contactless information media. Further, since a plurality of casino chips often collide with each other, it is necessary to prevent an IC chip from being damaged by the collision. In particular, since the coin-type contactless information medium used as the casino chip requires weight to give a sense of luxury, the coin-type contactless information medium may include a weight member. The impact of a collision between coin-type contactless information media including a weight member is greater than the impact of a collision between coin-type contactless information media that does not include a weight member, and therefore the impact transmitted to the IC chip is also greater.

[0005]

In view of the above problems, one object of an embodiment of the present invention is to provide a coin-type contactless information medium that has high shock resistance and is capable of performing accurate wireless communication even when a plurality of coin-type contactless information media are close to each other. Further, one object of an embodiment of the present invention is to provide a method for manufacturing the coin-type contactless information medium.

### **SOLUTION TO PROBLEM**

[0006]

A coin-type contactless information medium includes a substrate provided

with an IC chip, a metal ring including at least one slit portion, and a protective member covering the substrate and the metal ring. The IC chip of the substrate is provided in a gap of the slit portion.

[0007]

The substrate includes a protruding portion that fits into the at least one slit portion. The IC chip is provided on the protruding portion.

[0008]

An upper surface of the IC chip may be located lower than an upper surface of the metal ring in a side view.

[0009]

The metal ring may include a step portion inside. A peripheral edge portion of the substrate may be in contact with the step portion.

[0010]

The substrate may be further provided with an antenna and an inductor connected in series to the antenna.

[0011]

A coin-type contactless information medium according to an embodiment of the present invention includes a substrate provided with an IC chip, a metal ring including at least one slit portion and a first recessed portion that is recessed inward from a surface thereof, and a protective member covering the substrate and the metal ring. The first recessed portion overlaps the substrate. The IC chip is located in a space formed by the first recessed portion and the substrate.

[0012]

An opening surface of the first recessed portion may be closed by the substrate.

[0013]

The substrate may be further provided with an antenna and an inductor serially connected to antenna. The metal ring may further include a second

recessed portion that is recessed inward from the surface. The inductor may be located in a space formed by the second recessed portion and the substrate.

[0014]

The substrate may be provided with a capacitor electrically connected in parallel to the IC chip. The metal ring may further include a third recessed portion that is recessed inward from the surface. The capacitor may be located in a space formed by the third recessed portion and the substrate.

[0015]

A method for manufacturing a coin-type contactless information medium according to an embodiment of the present invention, includes the steps of mounting an IC chip on a protruding portion of a substrate, arranging the substrate on a metal ring including at least one slit portion so that the protruding portion fits into the at least one slit portion, and forming a protective member covering the substrate and the metal ring using injection molding.

[0016]

The substrate may be arranged on the metal ring so that an upper surface of the IC chip is located lower than an upper surface of the metal ring in a side view.

[0017]

The substrate may be arranged on the metal ring so that a peripheral edge portion of the substrate is engaged with a step portion on an inside of the metal ring.

[0018]

The method for manufacturing a coin-type contactless information medium further includes the step of mounting an inductor so as to be connected in series to the antenna formed on the substrate.

[0019]

A method for manufacturing a coin-type contactless information medium

according to an embodiment of the present invention, includes the steps of mounting an IC chip on a protruding portion of a substrate, arranging the substrate on a metal ring including a first recessed portion that is recessed inward from a surface thereof so that the first recessed portion covers the IC chip, and forming a protective member covering the substrate and the metal ring using injection molding.

[0020]

The substrate may be arranged on the metal ring so that an opening portion of the first recessed portion is covered with the substrate.

[0021]

The method for manufacturing a coin-type contactless information medium may further include the step of mounting an inductor so as to be connected in series to the antenna formed on the substrate. The metal ring may further include a second recessed portion that is recessed inward from the surface. The metal ring may be arranged on the substrate so that the second recessed portion covers the inductor.

[0022]

The method for manufacturing a coin-type contactless information medium further includes the step of mounting a capacitor connected in parallel to the IC chip. The metal ring may further include a third recessed portion that is recessed inward from the surface. The metal ring may be arranged on the substrate so that the third recessed portion covers the capacitor.

[0023]

The inductor may be a chip inductor mounted on the substrate.

## **ADVANTAGEOUS EFFECTS OF INVENTION**

[0024]

Since a coin-type contactless information medium according to an

embodiment of the present invention reduces the impact transmitted to an IC chip, the coin-type contactless information medium has high impact resistance. Further, even when a plurality of coin-type contactless information media are close to each other, mutual interference between the coils is suppressed, so that the change in the resonant frequency or voltage of the resonant circuit of the coin-type contactless information medium is small, and accurate wireless communication can be performed. Furthermore, even when a plurality of coin-type contactless information media are stacked, the change in the resonant frequency of each of the resonant circuits of the plurality of coin-type contactless information media is small, and the decrease in voltage generated by the coin-type contactless information medium is suppressed, so that the number of coin-type contactless information media read by the reader/writer is increased.

## **BRIEF DESCRIPTION OF DRAWINGS**

[0025]

FIG. 1 is a perspective view showing an overview of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 2 is a cross-sectional view of a coin-type contactless information medium according to one embodiment of the present invention.

FIG. 3 is a side view of a substrate and a metal ring of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 4 is a top view of a substrate and a metal ring of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 5 is an exploded perspective view of a substrate and a metal ring of a coin-type contactless information medium according to an embodiment of the

present invention.

FIG. 6 is a block diagram showing a configuration of an IC chip of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 7 is a circuit diagram of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 8 is a flowchart showing a method for manufacturing a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 9 is a side view of a substrate and a metal ring of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 10 is an exploded perspective view of a substrate and a metal ring of a coin-type contactless information medium according to one embodiment of the present invention.

FIG. 11 is a perspective view showing an overview of a coin-type contactless information medium according to one embodiment of the present invention.

FIG. 12 is a cross-sectional view of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 13 is a cross-sectional view of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 14 is a top view of a substrate and a metal ring of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 15 is a bottom view of a metal ring of a coin-type contactless information medium according to an embodiment of the present invention.

FIG. 16 is a flowchart showing a method for manufacturing a coin-type

contactless information medium according to an embodiment of the present invention.

FIG. 17 is a bottom view of a metal ring of a coin-type contactless information medium according to an embodiment of the present invention.

## **DESCRIPTION OF EMBODIMENTS**

[0026]

Hereinafter, each of the embodiments of the present invention are described with reference to the drawings. However, the present invention can be embodied in various forms without departing from the scope of the present invention, and the present invention should not be interpreted as being limited to the description of the embodiments exemplified below.

[0027]

For the sake of clarity of the description, the drawings may be schematically represented with respect to the widths, thicknesses, shapes, and the like of the respective portions in comparison with actual embodiments. However, the illustrated shapes are merely examples and are not intended to limit the interpretation of the present invention. Further, in the specification and each drawing, elements having the same functions as those described in the previous drawings may be given the same reference numerals, and duplicate descriptions may be omitted.

[0028]

In the specification and the drawings, when multiple configurations which are identical or similar are expressed in general, the same reference numerals or the same reference numerals with an upper-case letter of the alphabet may be used. When multiple parts of one configuration are distinguished, the same reference numerals with a hyphen and natural numbers may be used.

[0029]

In the specification, terms such as "first", "second", or "third" attached to each configuration are convenient terms used to distinguish each configuration, and have no further meaning unless otherwise explained.

[0030]

In the specification, when a substrate included in a coin-type contactless information medium is a reference, a surface on which an IC chip is provided is referred to as an "upper surface" and a surface opposite to the upper surface is referred to as a "lower surface". Further, a surface orthogonal to the upper surface and the lower surface is referred to as a "side surface".

[0031]

In the specification, "close to" includes not only a case where a plurality of coin-type contactless information media are close to each other with a space interposed therebetween but also a case where a plurality of coin-type contactless information media are in direct contact with each other. For example, "close to" includes a state where a plurality of coin-type contactless information media overlap each other.

[0032]

<First Embodiment>

A coin-type contactless information medium 10 according to an embodiment of the present invention is described with reference to FIGS. 1 to 8.

[0033]

[1. Overview of Coin-type Contactless Information Medium 10]

FIG. 1 is a perspective view showing an overview of the coin-type contactless information medium 10 according to an embodiment of the present invention. As shown in FIG. 1, the coin-type contactless information medium 10 includes a substrate 110, a metal ring 120, and a protective member 130. The substrate 110 and the metal ring 120 are located inside the coin-type contactless information medium 10, and are both covered by the protective member 130.

[0034]

The protective member 130 forms the external shape of the coin-type contactless information medium 10 and protects the substrate 110 and the metal ring 120 against external impact. Therefore, in the coin-type contactless information medium 10, it is preferable that the substrate 110 and the metal ring 120 are completely covered by the protective member 130. The protective member 130 is a resin, and may be a thermosetting resin or a thermoplastic resin. For example, acrylonitrile butadiene styrene, polycarbonate, polyphthalamide, polyoxymethylene, polymethyl methacrylate, polyethylene, polypropylene, polybutylene terephthalate, or vinyl chloride may be used for the protective member 130.

[0035]

Although the coin-type contactless information medium 10 as shown in FIG. 1 is a circular flat plate, the shape of the coin-type contactless information medium 10 is not limited thereto. The coin-type contactless information medium 10 may be an elliptical flat plate or a polygonal flat plate. Although the coin-type contactless information medium 10 is preferably a flat plate whose thickness is smaller than the diameter of the lower surface, the coin-type contactless information medium 10 may be a cylinder whose thickness is larger than the diameter of the lower surface.

[0036]

Although the coin-type contactless information medium 10 is, for example, a chip (coin or token) used in a casino or an amusement facility, the use of the coin-type contactless information medium 10 is not limited thereto. For example, the coin-type contactless information medium 10 can be a tag used for the management of goods.

[0037]

## [2. Configuration of Coin-type Contactless Information Medium 10

FIG. 2 is a cross-sectional view of the coin-type contactless information medium 10 according to an embodiment of the present invention. Specifically, FIG. 2 is a cross-sectional view of the coin-type contactless information medium 10 cut from the upper surface to the lower surface along a line A1-A2 shown in FIG. 1. FIG. 3 is a side view of the substrate 110 and the metal ring 120 of the coin-type contactless information medium 10 according to an embodiment of the present invention. Specifically, FIG. 3 is a side view of the substrate 110 and the metal ring 120 in the coin-type contactless information medium 10 from which the protective member 130 is removed, as viewed from a direction B shown in FIG. 1. FIG. 4 is a top view of the substrate 110 and the metal ring 120 of the coin-type contactless information medium 10 according to an embodiment of the present invention. Specifically, FIG. 4 is a top view of the substrate 110 and the metal ring 120 in the coin-type contactless information medium 10 from which the protective member 130 is removed. FIG. 5 is an exploded perspective view of the substrate 110 and the metal ring 120 of the coin-type contactless information medium 10 according to an embodiment of the present invention. Specifically, FIG. 5 is an exploded perspective view of the substrate 110 and the metal ring 120 in the coin-type contactless information medium 10 from which the protective member 130 is removed.

[0038]

An antenna 140, an inductor 150, a capacitor 160, and an IC chip 170 are provided on the substrate 110 (for example, see FIG. 4 or 5). That is, the substrate 110 can function as a base member supporting the antenna 140, the inductor 150, the capacitor 160, and the IC chip 170. For example, a paper phenol substrate, a paper epoxy substrate, a glass epoxy substrate, an epoxy substrate including a composite base, a glass composite substrate, a glass polyimide substrate, a BT substrate, a Teflon (registered trademark) substrate, a PPO substrate, or the like can be used as the substrate 110.

[0039]

The antenna 140 receives a signal from a reader/writer that performs wireless communication, or transmits a signal to the reader/writer. The number of turns of the coil of the antenna 140 is preferably greater than or equal to 1 and less than or equal to 3, and more preferably 2. When the antenna 140 is compared with conventional antennas, the number of turns of the coil of the antenna 140 is significantly smaller. The antenna 140 is formed so as to have a predetermined shape on the substrate 110 using a conductive material such as metal. The antenna 140 can be formed using a method such as printing, coating, or etching. The inductor 150, the capacitor 160, and the IC chip 170 are mounted on the substrate 110. Therefore, the inductor 150 and the capacitor 160 are respectively a mountable chip inductor and a chip capacitor. The inductor 150 is electrically connected in series to the antenna 140 (for example, see FIG. 4 or 5). The capacitor 160 and the IC chip 170 are electrically connected to the antenna 140 at connection points 142, 144 (for example, see FIG. 4). The capacitor 160 and the IC chip 170 are electrically connected in parallel to each other.

[0040]

Here, the IC chip 170 is described with reference to FIG. 6.

[0041]

FIG. 6 is a block diagram showing a configuration of the IC chip 170 of the coin-type contactless information medium 10 according to an embodiment of the present invention. As shown in FIG. 6, the IC chip 170 includes a control unit 172, a communication unit 174, and a storage unit 176. The control unit 172 controls the processing operations of the communication unit 174 and the storage unit 176. The control unit 172 processes a signal received from the reader/writer via the antenna 140, and extracts information requested by the reader/writer from the storage unit 176. Further, the communication unit 174 transmits a signal corresponding to the extracted information to the reader/writer via the antenna 140.

The storage unit 176 stores various information including identification information for identifying the coin-type contactless information medium 10.

[0042]

An induced current from a resonant circuit formed by the antenna 140, the inductor 150, and the capacitor 160 is supplied to the IC chip 170. The IC chip 170 starts operating when a voltage value corresponding to the induced current is greater than or equal to a threshold value (operable voltage value).

[0043]

The configuration of the coin-type contactless information medium 10 is described with reference to FIGS 2 to 5 again.

[0044]

The substrate 110 generally has a circular shape and includes a protruding portion 112 that protrudes to the outside (for example, see FIG. 5). The IC chip 170 is provided on the protruding portion 112.

[0045]

The metal ring 120 can function as a weight member that adds weight to the coin-type contactless information medium 10. For example, brass or aluminum can be used for the metal ring 120. The metal ring 120 generally has an annular shape and includes a slit portion 122 in which a part of the metal ring 120 is cut and cross-sectional surfaces of end portions of the metal ring 120 are exposed (for example, see FIG. 5). In other words, the metal ring 120 has a C-shape including the slit portion 122.

[0046]

The inner diameter of the metal ring 120 is approximately the same as or slightly larger than the diameter of the substrate 110. Further, the width of the gap of the slit portion 122 of the metal ring 120 is approximately the same as or slightly larger than the width of the protruding portion 112 of the substrate 110. Therefore, the substrate 110 can be inserted inside the metal ring 120 so that the

protruding portion 112 fits into the slit portion 122. In other words, the protruding portion 112 is inserted into the gap of the slit portion 122. A step portion 124 is provided on the inside of the metal ring 120 (for example, see FIG. 5). When the protruding portion 112 is inserted into the gap of the slit portion 122, the substrate 110 is engaged by the step portion 124 (for example, see FIG. 2) and the position of the substrate 110 is fixed.

[0047]

The IC chip 170 provided on the protruding portion 112 is located in the gap of the slit portion 122, that is, between the end surfaces (or cut surfaces) of the metal ring 120. In the side view, the upper surface of the IC chip 170 is located lower than the upper surface of the metal ring 120 (for example, see FIG. 3).

[0048]

In addition, although it is sufficient that at least one slit portion 122 is provided into which the protrusion 112 is fitted, the metal ring 120 may include a plurality of slit portions 122.

[0049]

As described above, the IC chip 170 is located in the gap of the slit portion 122 and is protected by the end surfaces of the metal ring 120 in the coin type contactless information medium 10. Therefore, even when the coin type contactless information medium 10 is subjected to an impact from the outside, such as from being dropped, the impact transmitted to the IC chip 170 can be mitigated because the impact is absorbed by the metal ring 120.

[0050]

### [3. Electrical Characteristics of Coin-type Contactless Information Medium 10]

FIG. 7 is a circuit diagram of the coin-type contactless information medium 10 according to an embodiment of the present invention. As shown in FIG. 7, the antenna 140 and the inductor 150 are electrically connected in series to each other,

and a closed circuit is formed by the antenna 140, the inductor 150, and the capacitor 160. The closed circuit formed by the antenna 140, the inductor 150, and the capacitor 160 is a so-called resonant circuit.

[0051]

The resonant frequency  $f_r$  of the resonant circuit formed by the antenna 140, the inductor 150, and the capacitor 160 is expressed by the following equation (1).

[0052]

[Equation 1]

$$f_r = \frac{1}{2\pi\sqrt{(L_a + L_b)C}} \quad \dots (1)$$

[0053]

Here,  $L_a$ ,  $L_b$ , and  $C$  in the equation (1) are the inductance of antenna 140, the inductance of inductor 150, and the capacitance of capacitor 160, respectively.

[0054]

When the resonant frequency  $f_r$  of the resonant circuit of the coin-type contactless information medium 10 coincides with the frequency  $f_c$  of the reader/writer, the induced current flows in the resonant circuit of the coin-type contactless information medium 10. The inductance  $L_a$  of the antenna 140 and the inductance  $L_b$  of the inductor 150 are set so that the resonant frequency  $f_r$  of the resonant circuit of the coin-type contactless information medium 10 coincides with the frequency  $f_c$  of the reader/writer, so that the coin-type contactless information medium 10 can receive power from the reader/writer with high efficiency.

[0055]

As described above, since the inductor 150 is a chip inductor, its size is sufficiently small. Therefore, the inductor 150 can be said to be a lumped-constant inductor that can be made into a lumped constant. In the coin-type

contactless information medium 10, the number of turns of the coil of the antenna 140 is small, and the inductance  $L_a$  of the antenna 140 is smaller than the inductance  $L_b$  of the inductor 150. Thus, in the coin-type contactless information medium 10, the inductance of the resonant circuit is increased by increasing the inductance  $L_b$  of the inductor 150, and thereby, the resonant frequency  $f_r$  of the coin-type contactless information medium 10 coincides with the frequency  $f_c$  of the reader/writer. In the coin-type contactless information medium 10, even when the inductance  $L_a$  of the antenna 140 is small, it is sufficient to increase the inductance  $L_b$  of the inductor 150, and it is not required to increase the capacitance  $C$  of the capacitor 160. Thus, the capacitance  $C$  of the capacitor 160 can be almost the same as the capacitance of the conventional capacitor. Therefore, the coin-type contactless information medium 10 can be made smaller without increasing the size of the capacitor 160. Further, since the capacitance  $C$  of the capacitor 160 does not increase in the coin-type contactless information medium 10, the  $Q$  factor does not decrease. Therefore, the power generation efficiency does not decrease, and sufficient power can be supplied to the IC chip 170. As a result, in the coin-type contactless information medium 10, a malfunction of the IC chip 170 caused by a power shortage is prevented. Therefore, the coin-type contactless information medium 10 can perform stable wireless communication with the reader/writer.

[0056]

Next, wireless communication between a plurality of coin-type contactless information media 10 and a reader/writer is described.

[0057]

In the conventional coin-type contactless information medium without the inductor 150, the resonant frequency  $f_r$  is adjusted by increasing the number of turns of the antenna coil to increase the inductance of the antenna. When the antenna with a large number of turns of the coil close to each other, mutual

interference occurs between the coils. Therefore, in the conventional coin-type contactless information medium, since the resonant frequency or voltage of the resonant circuit formed by the antenna and the capacitor changes, it is not possible to perform accurate wireless communication with the reader/writer.

[0058]

In contrast, in the coin-type contactless information medium 10, the number of turns of the coil of the antenna 140 is one, which is significantly less than the number of turns of the coil of the antenna of the conventional coin type contactless information medium. Therefore, even when a plurality of coin-type contactless information media 10 are close to each other, mutual interference between the coils due to the antenna 140 is unlikely to occur.

[0059]

Further, the shape of the coil affects mutual interference between the coils. Since the larger the shape of the coil, the greater the region where the coils overlap each other, mutual interference between the coils is likely to occur. However, the inductor 150 included in the coin-type contactless information medium 10 is sufficiently small in size and the shape of the coil is also small. Therefore, even when a plurality of coin-type contactless information media 10 are close to each other, mutual interference between the coils due to the inductor 150 is unlikely to occur.

[0060]

Accordingly, since mutual interference between coils is suppressed in the coin-type contactless information medium 10, accurate wireless communication can be performed between a plurality of coin-type contactless information media 10 and the reader/writer even when the plurality of coin-type contactless information media 10 are close to each other.

[0061]

Further, the ratio of inductance to capacitance of the resonance circuit in

the coin-type contactless information medium 10 is almost the same as that in the conventional coin-type contactless information medium. Therefore, even when a plurality of coin-type contactless information media 10 are close to each other, the resonance intensity can be maintained at a predetermined value or higher, so that power can be efficiently received from the reader/writer. As a result, each of the plurality of coin-type contactless information media 10 can smoothly start operating.

[0062]

As described above, even when a plurality of coin-type contactless information media 10 are close to each other, mutual interference between the coils is suppressed and power is supplied efficiently, so that accurate wireless communication can be performed in the coin-type contactless information medium 10.

[0063]

#### [4. Manufacturing Method of Coin-type Contactless Information Medium 10]

FIG. 8 is a flowchart showing a method for manufacturing the coin-type contactless information medium 10 according to an embodiment of the present invention. The coin-type contactless information medium 10 is manufactured by steps S100 to S120. However, the method for manufacturing the coin-type contactless information medium 10 is not limited thereto and may include other steps.

[0064]

In step S100, the inductor 150, the capacitor 160, and the IC chip 170 are mounted on the substrate 110 on which the antenna 140 having a predetermined shape is formed. In this way, the inductor 150, the capacitor 160, and the IC chip 170 are electrically connected to the antenna 140. Further, the closed circuit is formed by the antenna 140, the inductor 150, and the capacitor 160.

[0065]

In step S110, the substrate 110 is inserted inside the metal ring 120 so that the protruding portion 112 fits into the slit portion 122. The substrate 110 and the metal ring 120 can be aligned by the engagement of the protruding portion 112 with the slit portion 122, so that an alignment marker is not separately required to be provided on the substrate 110. The inserted substrate 110 is locked by the step portion 124 on the inside of the metal ring 120, and the position of the substrate 110 is fixed.

[0066]

In step S120, injection molding is used to mold the protective member 130 that covers the substrate 110 and the metal ring 120. Specifically, the protective member 130 is formed by injecting resin onto the substrate 110 and the metal ring 120 that are arranged in a mold, and molding the resin under a predetermined temperature and pressure.

[0067]

As described above, in the coin-type contactless information medium 10, the IC chip 170 is located in the slit portion 122 of the metal ring 120 and is protected by the end surfaces of the metal ring 120. Therefore, the coin-type contactless information medium 10 has high impact resistance. Further, in the coin-type contactless information medium 10, since mutual interference is suppressed by the inductor 150, the coin-type contactless information medium 10 has a small change in the resonance frequency of the resonance circuit, and can perform accurate wireless communication even when a plurality of coin-type contactless information media 10 are close to each other. Furthermore, even when a plurality of coin-type contactless information media 10 are stacked, the change in the resonance frequency of each of the plurality of coin-type contactless information media 10 is small, and a decrease in the voltage generated by the coin-type contactless information medium 10 is suppressed, so that the number of coin-type contactless information media 10 read by the reader/writer is increased.

Moreover, when a plurality of coin-type contactless information media 10 are stacked, a cylindrical body is formed by the stacked metal rings 120, and a radio wave can pass through while being reflected inside the cylindrical body. Therefore, the radio wave can reach the coin-type contactless information medium 10 that is far from the reader/writer, and the number of coin-type contactless information media 10 read by the reader/writer is increased.

[0068]

<Modification of First Embodiment>

A coin-type contactless information medium 10A which is a modification of the coin-type contactless information medium 10 is described with reference to FIGS. 9 and 10. In the following description, when a configuration of the coin-type contactless information medium 10A is similar to the configuration of the coin-type contactless information medium 10, the description of the configuration of the coin-type contactless information medium 10A may be omitted.

[0069]

FIG. 9 is a side view of a substrate 110A and a metal ring 120A of the coin-type contactless information medium 10A according to an embodiment of the present invention. Further, FIG. 10 is an exploded perspective view of the substrate 110A and the metal ring 120A of the coin-type contactless information medium 10A according to an embodiment of the present invention.

[0070]

An antenna 140, an inductor 150, a capacitor 160, and an IC chip 170 are provided on the substrate 110A (for example, see FIG. 10). The metal ring 120A includes a slit portion 122A. The outer periphery of the metal ring 120A approximately coincides with the outer periphery of the substrate 110A, and the metal ring 120A is arranged on the substrate 110A (for example, see FIG. 9).

[0071]

In the coin-type contactless information medium 10A, the substrate 110A

does not include a protruding portion, and the metal ring 120A does not include a step portion. However, the IC chip 170 on the substrate 110A on which the metal ring 120A is arranged is located in a gap of the slit portion 122A, that is, between end surfaces of the metal ring 120A, and is protected by the end surfaces of the metal ring 120A. Further, the upper surface of the IC chip 170 is located lower than the upper surface of the metal ring 120A (for example, see FIG. 9).

[0072]

As described above, in the coin-type contactless information medium 10A, the IC chip 170 is located in the slit portion 122A of the metal ring 120A and is protected by the end surfaces of the metal ring 120A. Therefore, the coin-type contactless information medium 10A has high impact resistance. Further, in the coin-type contactless information medium 10A, since mutual interference is suppressed by the inductor 150, the coin-type contactless information medium 10A has a small change in the resonance frequency of the resonance circuit, and can perform accurate wireless communication even when a plurality of coin-type contactless information media 10A are close to each other. Furthermore, even when a plurality of coin-type contactless information media 10A are stacked, the change in the resonance frequency of each of the plurality of coin-type contactless information media 10A is small, and a decrease in the voltage generated by the coin-type contactless information medium is suppressed, so that the number of coin-type contactless information media 10A read by the reader/writer is increased. Moreover, when a plurality of coin-type contactless information media 10A are stacked, a cylindrical body is formed by the stacked metal rings 120A, and a radio wave can pass through while being reflected inside the cylindrical body. Therefore, the radio wave can reach the coin-type contactless information medium 10A that is far from the reader/writer, and the number of coin-type contactless information media 10A read by the reader/writer is increased.

[0073]

## <Second Embodiment>

A coin-type contactless information medium 20 according to an embodiment of the present invention is described with reference to FIGS. 11 to 16. In the following description, when a configuration of the coin-type contactless information medium 20 is similar to the configuration of the coin-type contactless information medium 10, the description of the configuration of the coin-type contactless information medium 20 may be omitted.

[0074]

### [1. Overview of Coin-type Contactless Information Medium 20]

FIG. 11 is a perspective view showing an overview of the coin-type contactless information medium 20 according to an embodiment of the present invention. As shown in FIG. 11, the coin-type contactless information medium 20 includes a substrate 210, a metal ring 220, and a protective member 230. The substrate 210 and the metal ring 220 are located inside the coin-type contactless information medium 20, and are both covered by the protective member 230.

[0075]

### [2. Configuration of Coin-type Contactless Information Medium 20]

FIGS. 12 and 13 are cross-sectional views of the coin-type contactless information medium 20 according to an embodiment of the present invention. Specifically, FIG. 12 is a cross-sectional view of the coin-type contactless information medium 20 cut from the upper surface to the lower surface along a line C1-C2 shown in FIG. 11, and FIG. 13 is a cross-sectional view of the coin-type contactless information medium 20 cut from the upper surface to the lower surface along a line D1-D2 shown in FIG. 11. FIG. 14 is a top view of the substrate 210 and the metal ring 220 of the coin-type contactless information medium 20 according to an embodiment of the present invention. Specifically, FIG. 14 is a top view of the substrate 210 and the metal ring 220 in the coin-type contactless information medium 20 from which the protective member 230 is removed. FIG.

15 is a bottom view of the metal ring 220 of the coin-type contactless information medium 20 according to an embodiment of the present invention. Specifically, FIG. 15 is a bottom view of the metal ring 220 in the coin-type contactless information medium 20 from which the substrate 210 and the protective member 230 are removed.

[0076]

An antenna 240, an inductor 250, a capacitor 260, and an IC chip 270 are provided on the substrate 110 (for example, see FIG. 14). The number of turns of the coil of the antenna 240 is one. The inductor 250 and the capacitor 260 are a chip inductor and a chip capacitor, respectively. The inductor 250 is electrically connected in series to the antenna 240. The capacitor 260 and the IC chip 270 are electrically connected to the antenna 240 at connection points 242 and 244. In addition, the capacitor 260 and the IC chip 270 are electrically connected in parallel to each other.

[0077]

The metal ring 220 is arranged on the substrate 210 (for example, see FIG. 12 or 13). The metal ring 220 includes a slit portion 222 formed by cutting a portion of the metal ring 220 (for example, see FIG. 14 or 15). Further, a recessed portion 224 recessed inward from a lower surface (a surface on the side of the substrate 210) is provided on the lower surface of the metal ring 220 (see, for example, FIG. 13, 14, or 15). The recessed portion 224 overlaps the substrate 210.

[0078]

The opening area of the recess 224 is larger than the mounting area of the IC chip 270 (for example, see FIG. 14). The depth of the recessed portion 224 is larger than the height from the surface of the substrate 210 to the upper surface of the IC chip 270 (for example, see FIG. 13). Therefore, when the metal ring 220 is arranged on the substrate 210, a space closed by the substrate 210 and

the recessed portion 224 is formed, and the IC chip 270 is located in the formed space. Although it is sufficient that at least a part of the opening surface of the recessed portion 224 is closed by the substrate 210, it is preferable that the entire opening surface of the recessed portion 224 is closed. When the opening surface of the recess 224 is completely closed by the substrate 210, the formed space is surrounded by the substrate 210 and the metal ring 220, so that the IC chip 270 located in the space is not in contact with the protective member 230.

[0079]

The opening shape of the recessed portion 224 is not limited to a rectangle, and the opening shape of the recessed portion 224 may be a circle, an ellipse, a polygon, or the like.

[0080]

As described above, the IC chip 270 is located in the recessed portion 224 provided in the metal ring 220 and is protected by the recessed portion 224 in the coin-type contactless information medium 20. Therefore, even when the coin-type contactless information medium 20 is subjected to an impact from the outside, such as from being dropped, the impact transmitted to the IC chip 270 can be mitigated because the impact is absorbed by the metal ring 220. Further, in the coin-type contactless information medium 20, even when a plurality of coin-type contactless information media 20 are close to each other, mutual interference between the coils is suppressed and power is supplied efficiently, so that accurate wireless communication can be performed in the coin-type contactless information medium 20.

[0081]

### [3. Manufacturing Method of Coin-type Contactless Information medium 20

FIG. 16 is a flowchart showing a method for manufacturing the coin-type contactless information medium 20 according to an embodiment of the present invention. The coin-type contactless information medium 20 is manufactured by

steps S200 to S220. However, the method for manufacturing the coin-type contactless information medium 20 is not limited thereto and may include other steps.

[0082]

In step S200, the inductor 250, the capacitor 260, and the IC chip 270 are mounted on the substrate 210 on which the antenna 240 having a predetermined shape is formed. In this way, the inductor 250, the capacitor 260, and the IC chip 270 are electrically connected to the antenna 240. Further, the closed circuit is formed by the antenna 240, the inductor 250, and the capacitor 260.

[0083]

In step S210, the metal ring 220 is arranged on the substrate 210 so that the recessed portion 224 covers the IC chip 270. The alignment between the substrate 210 and the metal ring 220 may be performed using the slit portion 222 of the metal ring 220. For example, the substrate 210 is provided with a slit portion of the same size as the slit portion 222, and the substrate 210 and the metal ring 220 can be aligned with each other by the slit portion 222 of the metal ring 220 coinciding with the slit portion of the substrate 210. Alternatively, the substrate is provided with a protruding portion that fits into the slit portion 222 of the metal ring 220, and the substrate 210 and the metal ring 220 can be aligned with each other by the protruding portion of the substrate 210 fitting into the slit portion 222 of the metal ring 220.

[0084]

In step S220, injection molding is used to mold the protective member 230 that covers the substrate 210 and the metal ring 220. Specifically, the protective member 230 is formed by injecting resin onto the substrate 210 and the metal ring 220 that are arranged in a mold, and molding the resin under a predetermined temperature and pressure. At this time, the IC chip 270 is protected by the recessed portion 224 and is not in contact with the resin. Therefore, since the IC

chip 270 is less susceptible to the effects of the temperature and pressure in molding the resin, damage to the IC chip 270 in the injection molding process is reduced.

[0085]

As described above, in the coin-type contactless information medium 20, the IC chip 270 is located in the recessed portion 224 provided in the metal ring 220 and is protected by the recessed portion 224. Therefore, the coin-type contactless information medium 10 has high impact resistance and reduces damage to the IC chip 270 during the injection molding process. Further, in the coin-type contactless information medium 20, since mutual interference is suppressed by the inductor 250, the coin-type contactless information medium 20 has a small change in the resonance frequency of the resonance circuit, and can perform accurate wireless communication even when a plurality of coin-type contactless information media 20 are close to each other. Furthermore, even when a plurality of coin-type contactless information media 20 are stacked, the change in the resonance frequency of each of the resonance circuits of the plurality of coin-type contactless information media 20 is small, and a decrease in the voltage generated by the coin-type contactless information medium is suppressed, so that the number of coin-type contactless information media 20 read by the reader/writer is increased. Moreover, when a plurality of coin-type contactless information media 20 are stacked, a cylindrical body is formed by the stacked metal rings 220, and a radio wave can pass through the cylindrical body while being reflected inside the cylindrical body. As a result, the radio wave can reach the coin-type contactless information medium 20 that is far from the reader/writer, and the number of coin-type contactless information media 20 read by the reader/writer is increased.

[0086]

<Modification of Second Embodiment>

A coin-type contactless information medium 20A which is a modification of the coin-type contactless information medium 20 with reference to FIG. 17. In the following description, when a configuration of the coin-type contactless information medium 20A is similar to the configuration of the coin-type contactless information medium 20, the description of the configuration of the coin-type contactless information medium 20A may be omitted.

[0087]

FIG. 17 is a bottom view of the metal ring 220A of the coin-type contactless information medium 20A according to an embodiment of the present invention. As shown in FIG. 17, the metal ring 220A includes a slit portion 222A formed by cutting a part of the metal ring 220A. Further, a first recessed 224A-1 recessed inward from a lower surface is provided on the lower surface of the metal ring 220A.

[0088]

Further, the metal ring 220A is provided with a first protruding portion 226A-1 and a second protruding portion 226A-2 on the inside of the annular shape. The first protruding portion 226A-1 and the second protruding portion 226A-2 are provided with a second recessed portion 224A-2 and a third recessed portion 224A-3 recessed inward from the lower surface, respectively.

[0089]

When the metal ring 220A is arranged on the substrate 210, the first recessed portion 224A-1, the second recessed portion 224A-2, and the third recessed portion 224A-3 can cover the IC chip 270, the inductor 250, and the capacitor 260, respectively. That is, the IC chip 270 is located in a space formed by the substrate 210 and the first recessed portion 224A-1, the inductor 250 is located in a space formed by the substrate 210 and the second recessed portion 224A-2, and the capacitor 260 is located in a space formed by the substrate 210 and the third recessed portion 224A-3. Since all of the spaces are surrounded by the substrate 210 and the metal ring 220A, the IC chip 270, the inductor 250,

and the capacitor 260 located in the spaces are not in contact with the protective member.

[0090]

As described above, in the coin type contactless information medium 20A, the IC chip 270, the inductor 250, and the capacitor 260 are protected by the first recessed portion 244A-1, the second recessed portion 244A-2, and the third recessed portion 244A-3, respectively. Therefore, the coin type contactless information medium 20A has high impact resistance and reduces damage to the IC chip 270, the inductor 250, and the capacitor 260 in the injection molding process. Further, in the coin type contactless information medium 20A, since mutual interference is suppressed by the inductor 250, the coin type contactless information medium 20A has a small change in the resonance frequency of the resonance circuit, and can perform accurate wireless communication even when a plurality of coin type contactless information media 20A are close to each other. Furthermore, even when a plurality of coin-type contactless information media 20A are stacked, the change in the resonance frequency of each of the resonance circuits of the plurality of coin-type contactless information media 20A is small, and a decrease in the voltage generated by the coin-type contactless information media is suppressed, so that the number of coin-type contactless information media 20A read by the reader/writer is increased. Moreover, when a plurality of coin-type contactless information media 20A are stacked, a cylindrical body is formed by the stacked metal rings 220A, and a radio wave can pass through while being reflected within the cylindrical body. Therefore, the radio wave can reach coin-type contactless information media 20A that is far from the reader/writer, and the number of coin-type contactless information media 20A read by the reader/writer is increased.

[0091]

Each of the embodiments described above as an embodiment of the

present invention can be appropriately combined and implemented as long as they do not contradict each other. Additions, deletions, or design changes of constituent elements as appropriate based on the respective embodiments are also included within the scope of the present invention as long as the gist of the present invention is provided.

[0092]

Further, other effects which differ from those brought about by each of the embodiments described above, but which are apparent from the description herein or which can be readily predicted by those skilled in the art, are naturally understood to be brought about by the present invention.

## **REFERENCES SIGNS LIST**

[0093]

10, 10A: coin-type contactless information medium, 110, 110A: substrate, 112: protruding portion, 120, 120A: metal ring, 122, 122A: slit portion, 124: step portion, 130: protective member, 140: antenna, 142, 144: connection point, 150: inductor, 160: capacitor, 170: IC chip, 172: control unit, 174: communication unit, 176: memory unit,

20, 20A: coin-type contactless information medium, 210: substrate, 220, 220A: metal ring, 222, 222A: slit portion, 224, 224A: recessed portion, 226A: protruding portion, 230: protective member, 240: antenna, 242, 244: connection point, 250: inductor, 260: capacitor, 270: IC chip,

## CLAIMS

1. A coin-type contactless information medium, comprising:  
a substrate provided with an IC chip;  
a metal ring including at least one slit portion; and  
a protective member covering the substrate and the metal ring,  
wherein the IC chip is located in a gap of the slit portion.
2. The coin-type contactless information medium according to claim 1,  
wherein the substrate comprises a protruding portion that fits into the at  
least one slit portion, and  
wherein the IC chip is provided on the protruding portion.
3. The coin-type contactless information medium according to claim 1 or 2,  
wherein the substrate is further provided with an antenna and an inductor  
connected in series to the antenna.
4. The coin-type contactless information medium according to claim 1 or 2,  
wherein an upper surface of the IC chip is located lower than an upper surface of  
the metal ring in a side view.
5. The coin-type contactless information medium according to claim 1 or 2,  
wherein the metal ring includes a step portion inside, and  
wherein a peripheral edge portion of the substrate is in contact with the  
step portion.
6. The coin-type contactless information medium according to claim 5,  
wherein the substrate is further provided with an antenna and an inductor

connected in series to the antenna.

7. The coin-type contactless information medium according to claim 6, wherein the inductor is a chip inductor mounted on the substrate.

8. A coin-type contactless information medium, comprising:  
a substrate provided with an IC chip;  
a metal ring including at least one slit portion and a first recessed portion that is recessed inward from a surface thereof; and  
a protective member covering the substrate and the metal ring,  
wherein the first recessed portion overlaps the substrate, and  
wherein the IC chip is located in a space formed by the first recessed portion and the substrate.

9. The coin-type contactless information medium according to claim 8, wherein an opening surface of the first recessed portion is closed by the substrate.

10. The coin-type contactless information medium according to claim 8 or 9, wherein the substrate is further provided with an antenna and an inductor serially connected to antenna,  
wherein the metal ring further comprises a second recessed portion that is recessed inward from the surface, and  
wherein the inductor is located in a space formed by the second recessed portion and the substrate.

11. The coin-type contactless information medium according to claim 10, wherein the inductor is a chip inductor mounted on the substrate.

12. The coin-type contactless information medium according to claim 8 or 9, wherein the substrate is provided with a capacitor connected in parallel to the IC chip,

wherein the metal ring further comprises a third recessed portion that is recessed inward from the surface, and

wherein the capacitor is located in a space formed by the third recessed portion and the substrate.

13. A method for manufacturing a coin-type contactless information medium, comprising the steps of:

mounting an IC chip on a protruding portion of a substrate;

arranging the substrate on a metal ring including at least one slit portion so that the protruding portion fits into the at least one slit portion; and

forming a protective member covering the substrate and the metal ring using injection molding.

14. The method for manufacturing a coin-type contactless information medium according to claim 13, wherein the substrate is arranged on the metal ring so that an upper surface of the IC chip is located lower than an upper surface of the metal ring in a side view.

15. The method for manufacturing a coin-type contactless information medium according to claim 13 or 14, further comprising the step of mounting an inductor so as to be connected in series to the antenna formed on the substrate.

16. The method for manufacturing a coin-type contactless information medium according to claim 13 or 14, wherein the substrate is arranged on the metal ring so that a peripheral edge portion of the substrate is engaged with a step portion

on an inside of the metal ring.

17. The method for manufacturing a coin-type contactless information medium according to claim 16, further comprising the step of mounting an inductor so as to be connected in series to the antenna formed on the substrate.

18. The method for manufacturing a coin-type contactless information medium according to claim 17, wherein the inductor is a chip inductor.

19. A method for manufacturing a coin-type contactless information medium, comprising the steps of:

mounting an IC chip on a substrate;

arranging the substrate on a metal ring including a first recessed portion that is recessed inward from a surface thereof so that the first recessed portion covers the IC chip; and

forming a protective member covering the substrate and the metal ring using injection molding.

20. The method for manufacturing a coin-type contactless information medium according to claim 19, wherein the substrate is arranged on the metal ring so that an opening portion of the first recessed portion is covered with the substrate.

21. The method for manufacturing a coin-type contactless information medium according to claim 19 or claim 20, further comprising the step of mounting an inductor so as to be connected in series to the antenna formed on the substrate,

wherein the metal ring further comprises a second recessed portion that is recessed inward from the surface, and

wherein the metal ring is arranged on the substrate so that the second

recessed portion covers the inductor.

22. The method for manufacturing a coin-type contactless information medium according to claim 21, wherein the inductor is a chip inductor.

23. The method for manufacturing a coin-type contactless information medium according to claim 19 or claim 20, further comprising the step of mounting a capacitor connected in parallel to the IC chip,

wherein the metal ring further comprises a third recessed portion that is recessed inward from the surface, and

wherein the metal ring is arranged on the substrate so that the third recessed portion covers the capacitor.