

DESCRIPTION

TITLE OF THE INVENTION

PORTABLE WIRELESS COMMUNICATION DEVICE, AND INFORMATION
5 IDENTIFICATION APPARATUS USING PORTABLE WIRELESS
COMMUNICATION DEVICE

TECHNICAL FIELD

[0001]

10 One embodiment of the present invention relates to a portable wireless communication device and an information identification device using the portable wireless communication device.

BACKGROUND ART

15 [0002]

In recent years, an information transmission method using a contactless near field communication technology has been dramatically widespread and has been used in various fields. In the contactless near field communication, a portable wireless communication device with a basic construction of an
20 antenna and a semiconductor device in which an integrated circuit is mounted is used. Electromagnetic induction by a reader/writer, or radio wave induce power in the antenna, which drives an Integrated Circuit (IC) chip including various elements that do not have a power source. The IC chip performs various processes, such as reading information embedded in the IC chip,
25 writing information into the IC chip, generating and sending instructions, and receiving instructions from the reader/writer. Such a wireless communication device is generally referred to as a RFID (Radio Frequency Identification), and various names are given to the wireless communication device depending on

form and use. A wireless communication device is also referred to as an IC tag, a wireless tag, a RF tag, an IC card, etc.

[0003]

Because of the diversity of stored data and the excellent portability of the wireless communication devices themselves, the wireless communication devices are widely used as means such as product management, personal identification, security measures, electronic tickets, game cards, and commercial transaction approval.

[0004]

In the case of the IC tag, data may be read by the reader/writer with a plurality of IC tags overlapped. In this case, resonant frequency that maximizes electromotive force applied to the IC tag may fluctuate because each IC tag interferes with each other. To suppress the variation of the resonant frequency, for example, in Patent Literature 1, it is disclosed to provide a chip coil in a contactless information medium. Further, in Patent Literature 2, it is disclosed to provide a plurality of small coils as compared with the main antenna without using the chip coil.

CITATION LIST

PATENT LITERATURE

[0005]

Patent Literature 1: Japanese laid-open patent publication 2006-67479

Patent Literature 2: Japanese laid-open patent publication 2009-147560

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0006]

On the other hand, in the case of the Patent Literature 1, since it is necessary to mount a chip coil, the quality of the coil varies, alternatively the manufacturing cost of the IC tag becomes high. In addition, in the case of the Patent Literature 2, since it is difficult to increase the manufacturing tact of the antenna, it is necessary to provide a large number of manufacturing devices.

[0007]

In view of the above problems, it is an object of one embodiment of the present invention to provide a portable wireless communication device which can be mass-produced inexpensively and has less variation in quality.

SOLUTION TO PROBLEMS

[0008]

According to an embodiment of the present invention, there is provided a portable wireless communication device including an insulating substrate having a first surface and a second surface opposed to the first surface, a coil antenna arranged in the insulating substrate and having a loop shape, and an IC chip electrically connected to the coil antenna. The coil antenna includes a plurality of first electrodes arranged on the first surface side of the insulating substrate and having a first portion and a second portion, a plurality of second electrodes arranged on a second surface side of the insulating substrate and having a third portion and a fourth portion, and a plurality of through electrodes arranged in the insulating substrate. The first portion of one first electrode of the plurality of first electrodes is connected to the fourth portion of one second electrode of the plurality of second electrodes using one through electrode of the plurality of through electrodes. The second portion of the one first electrode of the plurality of first electrodes is connected to the third portion of another second electrode of the plurality of second electrodes using another

through electrode of the plurality of through electrodes.

[0009]

In the portable wireless communication device, at least one of the plurality of first electrodes and the plurality of second electrodes may have a
5 meander shape.

[0010]

According to an embodiment of the present invention, there is provided a portable wireless communication device including a coil antenna having a loop shape and an IC chip electrically connected to the coil antenna. The coil
10 antenna has a spiral shape in a circumference direction.

[0011]

In the portable wireless communication device, the coil antenna may include a first antenna having a loop shape and a second antenna arranged inside the first antenna in planar view and having a loop shape, and a portion of
15 the first antenna and a portion of the second antenna may be connected.

[0012]

In the portable wireless communication device, the coil antenna may include a first antenna having a loop shape, and a second antenna overlapped with the first antenna and having a loop shape, a portion of the first antenna
20 and a portion of the second antenna may be connected.

[0013]

According to an embodiment of the present invention, there is provided a portable wireless communication device including an insulating substrate having a first surface and a second surface on opposite to the first surface, a
25 coil antenna arranged in the insulating substrate having a loop shape, and the IC chip electrically connected to the coil antenna. The coil antenna is arranged on the first surface or the second surface of the insulating substrate and includes a plurality of insulating layers, a plurality of electrodes, and a

plurality of through electrodes arranged on the plurality of insulating layers for connecting each of the plurality of electrodes, and having a spiral shape in a cross-sectional view.

[0014]

5 In the portable wireless communication device, the portable wireless communication device may include a shield overlapped with the coil antenna.

[0015]

 In the portable radio communication device, the coil antenna may have a circular shape in a plan view.

10 [0016]

 In the portable wireless communication device, the coil antenna may have a rectangular shape in a plan view.

[0017]

 According to an embodiment of the present invention, there is provided
15 an information identification device including one or more of the above-described portable wireless communication devices and the reader/writer.

EFFECT OF INVENTION

20 [0018]

 According to an embodiment of the present invention, it is possible to provide a portable wireless communication device which can be mass-produced inexpensively and has less variation in quality.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

 FIG. 1 is a perspective view of an information identification device according to an embodiment of the present invention;

FIG. 2 is a top view and a cross-sectional view of the portable wireless communication device according to an embodiment of the present invention;

FIG. 3 is a perspective view of an antenna unit of the portable wireless communication device according to an embodiment of the present invention;

5 FIG. 4 is a block diagram of the portable wireless communication device and a reader/writer according to an embodiment of the present invention;

FIG. 5 is a cross-sectional view showing the driving status of the portable wireless communication device and a reader/writer according to an embodiment of the present invention;

10 FIG. 6 is a schematic view showing a magnetic field line in the portable wireless communication device according to an embodiment of the present invention;

FIG. 7 is a cross-sectional view showing the driving states of the portable wireless communication device and a reader/writer according to an
15 embodiment of the present invention;

FIG. 8 is a perspective view showing a method of manufacturing an antenna unit of the portable wireless communication device according to an embodiment of the present invention;

FIG. 9 is a perspective view showing the method of manufacturing the
20 antenna unit of the portable wireless communication device according to an embodiment of the present invention;

FIG. 10 is a perspective view showing the method of manufacturing the antenna unit of the portable wireless communication device according to an embodiment of the present invention;

25 FIG. 11 is a perspective view showing the method of manufacturing the antenna unit of the portable wireless communication device according to an embodiment of the present invention;

FIG. 12 is a top view of the portable wireless communication device

according to an embodiment of the present invention;

FIG. 13 is a top view of the portable wireless communication device according to an embodiment of the present invention;

FIG. 14 is a top view and cross-sectional diagram of the portable
5 wireless communication device according to an embodiment of the present invention;

FIG. 15 is a perspective view of the portable wireless communication device according to an embodiment of the present invention;

FIG. 16 is a cross-sectional view of an antenna unit of the portable
10 wireless communication device according to an embodiment of the present invention;

FIG. 17 is a specific example of the portable wireless communication device according to an embodiment of the present invention;

FIG. 18 is a top view of the portable wireless communication device
15 according to an embodiment of the present invention;

FIG. 19 is a top view of the portable wireless communication device and a top view of a shield according to an embodiment of the present invention;

FIG. 20 is a cross-sectional view of the portable wireless communication device according to an embodiment of the present invention;

FIG. 21 is a cross-sectional view showing the driving states of the
20 portable wireless communication device and a reader/writer according to an embodiment of the present invention;

FIG. 22 is a top view of the portable wireless communication device according to an embodiment of the present invention; and

FIG. 23 is a cross-sectional view showing the driving status of a
25 conventional portable wireless communication device and a reader/writer.

DESCRIPTION OF EMBODIMENTS

[0020]

Hereinafter, embodiments of the invention disclosed in the present application will be described with reference to the drawings. However, the present invention can be implemented in various forms without departing from
5 the gist thereof and should not be construed as being limited to the description of the following exemplary embodiments.

[0021]

In the drawings referred to in the present embodiment, the same portions or portions having similar functions are denoted by the same reference
10 numerals or similar reference numerals (numerals which only -1, -2, and the like are denoted after numerals), and repetitive description thereof may be omitted. In addition, the dimensional ratio in the drawings may be different from the actual ratio for convenience of description, or a part of the configuration may be omitted from the drawings.

15 [0022]

Furthermore, in the detailed description of the present invention, when defining the positional relationship between one component and another, the terms "above" and "below" include not only the case of being positioned directly above or below one component, but also the case of interposing another
20 component therebetween, unless otherwise specified.

[0023]

In the present specification, the terms "conductive layer", "electrode" and "wiring" have the same meanings and can be interchanged depending on circumstances.

25 [0024]

<First Embodiment>

Hereinafter, a portable wireless communication device (hereinafter, referred to as an IC tag) according to an embodiment of the present invention

and an information identification device including the IC tag will be described.

[0025]

FIG. 1 is a schematic view of an information identification device 10. The information identification device 10 includes an IC tag 100 and a
5 reader/writer 300.

[0026]

(1-1. IC tag Configuration)

As shown in FIG. 1, the IC tag 100 includes an IC chip 110, a coil antenna 130, a support unit 140, and a substrate 145. The IC chip 110 and
10 the coil antenna 130 are provided in the substrate 145. The IC chip 110 and the coil antenna 130 are electrically connected in part.

[0027]

The IC chip 110 is configured to generate signals in accordance with instructions from the reader/writer 300 as described below. The signal is
15 transmitted by the coil antenna 130 to the reader/writer 300.

[0028]

The support unit 140 has a function of supporting the IC chip 110, the coil antenna 130 and the substrate 145. Materials such as polyethylene terephthalate (PET), polyvinyl chloride (PVC) or paper are used for the support
20 unit 140. The thickness of the support unit 140 is not particularly limited but is appropriately selected between several hundreds of micrometers and several centimeters depending on the purpose.

[0029]

(1-2. Configuration of antenna unit)

FIG. 2 is a top view of the IC tag 100 and a cross-sectional view
25 between A1-A2 of the coil antenna 130. FIG. 3 is a perspective view of the coil antenna 130. The coil antenna 130 is an electromagnetic induction type antenna and arranged in a loop shape. The coil antenna 130 has a circular

shape at a plan view. The electromotive force (voltage) corresponding to a change in magnetic flux density passing through a region surrounded by the coil antenna 130 is generated in the coil antenna 130. This electromotive force is provided to the IC chip 110 electrically connected to the coil antenna 130 and the IC chip 110 drives. The coil antenna 130 is configured to resonate, for example, in frequency band of short wave (HF) or ultrashort wave (UHF). Specifically, the short wave corresponds to frequency band of 13.56MHz. The ultrashort wave also corresponds to frequency band of 860 to 960MHz.

[0030]

As shown in FIGS. 2B and 3, the coil antenna includes an electrode 133, an electrode 137 and a through electrode 135. The electrode 133 and the electrode 137 are electrically connected via the through electrode 135. Note that the electrode 133 may be referred to as the first electrode, and the electrode 137 may be referred to as the second electrode.

[0031]

The substrate 145 is a plate-like member having a first surface 145A and a second surface 145B. The substrate 145 is formed of high resistance insulating materials. For example, the substrate 145 is formed of a glass-epoxy substrate. The substrate 145 is may formed of resin materials such as acrylic resin and polyethylene terephthalate resin, or a paper phenolic resin substrate cured by including phenolic resin in the paper substrate, not limited to glass-epoxy resin.

[0032]

The substrate 145 may be formed of inorganic materials such as a quartz glass substrate, a soda glass substrate, a borosilicate glass substrate, an alkali-free glass substrate, a sapphire substrate, a silicon substrate, a silicon carbide substrate, an alumina (Al_2O_3) substrate, an aluminum nitride (AlN)

substrate, or a zirconia (ZrO₂) substrate.

[0033]

A plurality of electrodes 133 is arranged on the top surface (the first surface 145A) of the substrate 145. For example, the electrode 133 is formed
5 of copper.

[0034]

Note that the electrode 133 may be formed of other materials having a low resistance rate such as aluminum, silver, gold, or the like, not limited to copper. The electrode 133 may include a magnetic conductor with magnetism
10 such as iron, nickel, cobalt, or ferrite. Further, the conductor having magnetism may be a single, or an alloy. The electrode 133 may include boron in the conductor having magnetism. Further, the electrode 133 may be formed of a shape memory alloy such as titanium nickel alloy, further stainless steel or the like, not limited to a magnetic material.

15 [0035]

A plurality of electrodes 137 is arranged on the lower surface (the second surface 145B) of the substrate 145. The electrode 137 is formed using a material similar to the electrode 133.

[0036]

20 A plurality of through electrodes 135 is provided on the substrate 145. The through electrode 135 is formed of copper. Note that the through electrode 135 may be formed of materials including gold, silver, copper, nickel, or tin, not limited to copper.

[0037]

25 As shown in FIGS. 2A, 2B, and 3, each of the plurality of electrodes 133 is arranged radially. Each of the plurality of electrodes 137 is arranged at a predetermined angle with respect to the direction in which the electrode 133 is arranged. The electrode 133 has a portion 133A (also referred to as a first

portion) at one end and a portion 133B (also referred to as a second portion) at the other end. Similarly, the second electrode 137 has a portion 137A (also referred to as a third portion) at one end and a portion 137B (also referred to as a fourth portion) at the other end. In this case, the portion 133A of the electrode 133 is connected to the portion 137B of an electrode 137-1 of the plurality of electrodes 137 by using a through electrode 135-1 of the plurality of through electrodes 135. Similarly, the portion 133B of the electrode 133 is connected to the portion 137A of an electrode 137-2 of the plurality of electrodes 137 using a through electrode 135-2 of the plurality of through electrodes 135. The above connections are repeated for the other electrode 133, the other through electrode 135 and the other electrode 137. Thus, the coil antenna 130 is configured as a single connected wiring. (Concretely, they are connected to each other as a single stroke writing and are configured as a single antenna.) In this case, the coil antenna 130 may have a spiral shape as a whole.

[0038]

(1-3. Configuration of IC chip)

Next, FIG. 4A shows an exemplary configuration of the IC chip 110.

[0039]

The IC chip 110 can have, as its main configuration, a voltage limit circuit 111, a rectification circuit 113, a demodulation circuit 115, a modulation circuit 117, a control circuit 119, a storage unit 121, and a resistance 123, or the like. In addition, the IC chip 110 may include a capacitance for resonant frequency regulation.

[0040]

The voltage limit circuit 111 has the function of protecting the IC chip 110 from the voltage input when an excessive voltage is induced in the coil antenna 130. If the excessive voltage is induced, the unwanted part of the

current generated is converted to heat using the resistance 123, or emitted to the outside.

[0041]

The rectification circuit 113 has a function of converting an alternating
5 current induced in the coil antenna 130 into a direct current. The power supply voltage which became the direct current by the rectification circuit 113 is supplied to all the circuits constituting the IC tag 100.

[0042]

The demodulation circuit 115 has a function of converting the
10 information (signal) superimposed on carrier wave input from the reader/writer 300 into a signal line of 1 or 0.

[0043]

The control circuit 119 has a function of controlling transmission and reception of data between the reader/writer 300, interpreting instructions,
15 reading information from the storage unit 121, writing information to the storage unit 121, and the like. The control circuit 119 consists of various logical circuits. The control circuit 119 may be configured by a CPU (Central Processing Unit).

[0044]

20 The control circuit 119 generates a response to the instruction received from the reader/writer 300 and sends the data to the modulation circuit 117. The modulation circuit 117 modulates the carrier wave based on the data to be transmitted and generates a signal for transmission. The generated signal is transmitted from the coil antenna 130 as the carrier wave.

25 [0045]

The storage unit 121 includes memory elements for storing data. A variety of unique and rewritable information is stored in the storage unit 121.

[0046]

(1-4. Reader/Writer Configuration)

FIG. 4B shows an exemplary configuration of the reader/writer 300. The reader/writer 300 includes a control circuit 310, a storage unit 313, a modulation circuit 320, a transmission circuit 330, an antenna 340, a reception
5 circuit 350, a demodulation circuit 360, an oscillation circuit 370, and the like.

[0047]

The control circuit 310 controls the entire reader/writer 300. The control circuit 310 performs interpreting received data and instructions, writing data to the storage unit 313, reading data from the storage unit 313, and generating a
10 reply that matches the received instructions.

[0048]

The modulation circuit 320 modulates the instructions and/or data sent from the control circuit 310 by superimposing it on the carrier wave generated by the oscillation circuit 370. The modulated carrier wave is sent to the
15 transmission circuit 330 to amplify the signal, attenuate unwanted frequencies, and the like. At this time, the only frequencies to be transmitted is extract. The processed signals in this way are transmitted to the IC tag 100 via the antenna 340.

[0049]

The reception circuit 350 has the function of receiving the carrier wave
20 which is transmitted from the IC tag 100 and received by the antenna 340. The reception circuit 350 removes the noise contained in the carrier wave and amplifies the required signal. The amplified signal is sent to the demodulation circuit 360 and demodulated to the required instructions or data.

25 [0050]

The oscillation circuit 370 has a function to generate the carrier wave required to communicate. As the carrier wave, a high frequency wave, for example 13.56 MHz, is generated.

[0051]

(1-5. Operation of the information identification device 10)

Next, the operation of the information identification device 10 will be described. FIG. 5 is a cross-sectional view for explaining the information
5 identification process of the IC tag 100 when the reader/writer 300 is driven.

[0052]

As shown in FIG. 5, first, the reader/writer 300 is driven. When the reader/writer 300 is driven, a carrier wave 380 is sent from the reader/writer 300 to the coil antenna 130 of the IC tag 100. In this case, a magnetic field
10 line M130 occurs inside the ring of the coil antenna 130. The magnetic field line M130 generates electromagnetic induction, and induced electromotive force is supplied to the IC chip 110. As a result, the IC chip 110 is activated and can be transmitted and received with the reader/writer 300.

[0053]

At this time, since the current flows through the coil antenna 130, a
15 magnetic field line M131 occurs. FIG. 6 is a schematic view showing the magnetic field line in the coil antenna 130. In FIG. 6, since the coil antenna 130 has the shapes described above, the resulting magnetic field line M131 will stay inside the coil antenna 130.

20 [0054]

FIG. 7 is a cross-sectional view illustrating the information identification process of the IC tag 100 when the reader/writer 300 is driven in the state in which a plurality of IC tags 100 is stacked. As a comparative example, FIG. 23 shows an example in which a plurality of conventional common IC tag 99 is
25 overlapped. As shown in FIG. 23, when the plurality of common IC tag 99 is overlapped, mutual interferences occur due to a magnetic field M99 generated from the IC tag 99 (in particular, mutual inductances change), so that the resonant frequencies may change. In this case, electromotive force is not

generated in the IC tag 99, and the data of the IC tag 99 cannot be read.

[0055]

On the other hand, in the case of this embodiment, as shown in FIG. 6, the magnetic field line M131 stays inside the coil antenna, even when the other
5 IC tag 100 is overlapped one IC tag, it is suppressed from interfering with each other. As a result, changes in the resonant frequencies of the IC tag 100 can be suppressed, and the IC tag 100 can be read even if the plurality of IC tags 100 is overlapped.

[0056]

10 (1-6. Method of manufacturing a coil antenna)

Next, a method of manufacturing the coil antenna 130 will be described with reference to FIGS. 8 to 11.

[0057]

First, as shown in FIG. 8, a through hole 147 is formed in the substrate
15 145.

[0058]

The substrate 145 is formed of a high resistance material. For example, the substrate 145 is formed of a resin material such as glass/epoxy resin.

20 [0059]

The through hole 147 is formed by mechanical machining using drills or the like in the substrate 145. The diameter of the through hole 147 is not particularly limited, but the diameter is appropriately set to 10 μm or more and 1000 μm or less.

25 [0060]

The through hole 147 may be formed by a laser irradiating method, which may be referred to as a laser ablation method. As the laser, an excimer laser, a neodymium: YAG laser (Nd: YAG) or the like is used. For example,

when xenon chloride is used in the excimer laser, light having a wavelength of 308 nm is irradiated. Further, the through hole 147 may be formed using a photolithography method and an etching method when the substrate 145 is formed of a silicon substrate or a glass substrate.

5 [0061]

Next, as shown in FIG. 9, the through electrode 135 is formed on the through hole 147. The through electrode 135 is formed of copper. The through electrode 135 may be formed by electroplating method or electroless plating method. For example, when forming the through electrode 135 using
10 copper, a thin film of copper is formed by sputtering method on the side wall of the through hole 147. Next, the copper film is formed by electroplating method using the copper thin film as a seed layer. Finally, the through electrode 135 is filled and formed by removing the copper film on the first surface 145A and the second surface 145B of the substrate 145 by Chemical Mechanical Polishing
15 (CMP).

[0062]

Next, as shown in FIG. 10, the electrode 133 is formed on the first surface 145A side of the substrate 145. The electrode 133 is formed of copper. The electrode 133 is formed by, for example, plating method. When the
20 electrode 133 is formed by plating method, for example, the following method may be used. First, a thin film of copper (seed layer) is formed by sputtering method. Next, after a resist film is formed on the seed layer, the resist film is processed into a predetermined shape by photolithography method or the like. Next, the electrode 133 is formed on the exposed seed layer. The electrode
25 133 is formed of a copper film by electroplating method. Finally, the resist film and the seed layer under the resist film are removed.

[0063]

The electrode 133 may be formed by printing method, sputtering, CVD

method, coating method or the like, not limited to the plating method. In this case, the electrode 133 may be processed into a predetermined shape by photolithography method and etching method.

[0064]

5 Next, as shown in FIG. 11, the electrode 137 is formed on the second surface 145B of the substrate 145. The electrode 137 may be formed by the same material and method as the electrode 133.

[0065]

10 The coil antenna 130 is manufactured by the above method. By applying the present embodiment, it is possible to provide an IC tag which can be read even when a plurality of chips are stacked without applying a chip inductor. Further, by applying the present embodiment, since the chip inductor is not applied, variations in performance depending on the chip inductor is suppressed, it is possible to provide IC tag having the excellent
15 qualities. In addition, since a plurality of first electrodes, a plurality of second electrodes, and a plurality of through electrodes are formed at one time by the above described manufacturing methods. Therefore, the manufacturing tact of the coil antenna can be improved as compared with the case where the coil antenna is manufactured using a winding machine or the like one by one.
20 Further, in the case of the present embodiment, it is possible to manufacture using existing equipment. Therefore, it is not necessary to newly provide equipment as compared with the winding machine used for manufacturing the coil antenna. Further, the manufacturing facility does not have to have a high-level function. That is, the coil antenna can be manufactured using a
25 common electronic component manufacturing equipment.

[0066]

 In addition, by using the above described manufacturing method, the coil antenna 130 can be controlled by the thickness of the substrate 145. That

is, it is possible to further make the coil antenna 130 smaller by reducing the thickness of the substrate 145. Therefore, since the coil antenna 130 is made smaller, it is possible to reduce the size and thickness of the IC tag.

[0067]

5 <Second Embodiment>

In the present embodiment, a portable wireless communication device including a coil antenna having a different shape from the coil antenna of the first embodiment will be described.

[0068]

10 FIG. 12 is a top view of an IC tag 100-1. Incidentally, in FIG. 12, in order to facilitate visibility of an electrode 133-1 of a coil antenna 130-1 of the IC tag 100-1, the electrode 137 and the through electrode 135 are omitted, and the electrode 133-1, the electrode 137 and the through electrode 135 are connected so as to be one wiring as a whole as well as the first embodiment.

15 [0069]

As shown in FIG. 12, the electrode 133-1 includes an electrode 133-1-1 arranged on the outside and an electrode 133-1-2 arranged on the inside. In this case, the coil antenna 130-1 includes a loop-shaped antenna (sometimes referred to as a first antenna.) formed using the electrode 133-1-1 and a
20 loop-shaped antenna (sometimes referred to as a second antenna) arranged inside the first antenna formed using the electrode 133-1-2 in a plan view. A portion of the first antenna and a portion of the second antenna are electrically connected. Since the coil antenna 130-1 includes the electrode 133-1-1 and the inner arranged electrode 133-1-2, it is possible to increase the number of
25 turns as a whole coil antenna. In this case, the number of windings N of the coil, the magnetic flux Φ through the coil, and the time t have the relation of formula 1. In other words, since it is possible to increase the number of turns of the coil, it is possible to increase the induced electromotive force generated

in the coil antenna 130-1. This leads to the IC tag 100-1 being more sensitive to the reader/writer 300.

$$V = -N \cdot \Delta\Phi / \Delta t \quad (\text{formula 1})$$

[0070]

5 FIG. 13 is a top view of an IC tag 100-2. In FIG. 13, the electrode 137 and the through electrode 135 are omitted in order to facilitate visibility of an electrode 133-2 of a coil antenna 130-2 of the IC tag 100-2. As shown in FIG. 13, the electrode 133-2 has a meander shape. The electrode 137 may also have a meander shape. Thus, the capacitance between the electrodes at
10 least one of the electrodes 133-2 and 137 can be increased.

[0071]

 In this case, the inductance value L and the capacitance value C required for a specific resonant frequency f (e.g., 13.56 MHz) are in the relationship shown in formula 2. Since the capacitance in the IC tag 100-2
15 can be increased based on formula 2, the inductance value L can be reduced.

$$f = 1 / (2\pi\sqrt{LC}) \quad (\text{formula 2})$$

[0072]

 Furthermore, the inductance value L, the cross-sectional area S of the coil, the number of windings N of the coil antenna, and the length l of the coil,
20 there is a relationship of formula 3. Since it is possible to reduce the inductance value L based on the above, it is possible to reduce the number of windings of the coil antenna 130-2. In other words, it is possible to form the coil antenna more simply.

$$L = \mu \cdot N^2 \cdot S / l \quad (\text{formula 3})$$

25 [0073]

 As described above, by applying the present embodiment, it is possible to reduce the manufacturing accuracy of the coil antenna. This makes it possible to manufacture the IC tag including the above-mentioned coil antenna

even with the use of manufacturing equipment having a low specification, thereby reducing the manufacturing costs.

[0074]

<Third Embodiment>

5 In the present embodiment, a portable wireless communication device including a coil antenna having a configuration different from that of the first embodiment and the second embodiment will be described.

[0075]

FIG. 14 is a top view of an IC tag 100-3 and a cross-sectional view
10 between A1-A2 of a coil antenna 130-3. In FIG. 14 A, the IC chip 110 is electrically connected to the coil antenna 130-3. The coil antenna 130-3 is arranged in a loop shape.

[0076]

As shown in FIG. 14 B, between the A1-A2, the coil antenna 130-3
15 includes a plurality of electrodes 151 (an electrode 151-1, an electrode 151-2, an electrode 151-3, an electrode 151-4, an electrode 151-5, an electrode 151-6), a plurality of insulating layers 153 (an insulating layer 153-1, an insulating layer 153-2, an insulating layer 153-3, an insulating layer 153-4, an insulating layer 153-5, an insulating layer 153-6), and a plurality of through
20 electrodes 155 (a through electrode 155-1, a through electrode 155-2, a through electrode 155-3, a through electrode 155-4, a through electrode 155-5, a through electrode 155-6) in addition to the plurality of electrodes 133 on the first surface 145A of the substrate 145.

[0077]

25 In this case, the electrode 151-1 is arranged on the first surface 145A of the substrate 145. The insulating layer 153-1 is arranged on the substrate 145 and the electrode 151-1. The electrode 151-2 is arranged on the insulating layer 153-1. The insulating layer 153-2 is arranged on the insulating layer

153-1 and the electrode 151-2. The electrode 151-3 is arranged on the insulating layer 153-2. The insulating layer 153-3 is arranged on the insulating layer 153-2 and the electrode 151-3. The electrode 151-4 is arranged on the insulating layer 153-3. The insulating layer 153-4 is arranged on the insulating layer 153-3 and the electrode 151-4. The electrode 151-5 is arranged on the insulating layer 153-4. The insulating layer 153-5 is arranged on the insulating layer 153-4 and the electrode 151-5. The electrode 151-6 is arranged on the insulating layer 153-5. The insulating layer 153-6 is arranged on the insulating layer 153-5 and the electrode 151-6. The electrode 133 is arranged on the insulating layer 153-6.

[0078]

The plurality of through electrodes 155 connects each of the plurality of electrodes 151. Specifically, the through electrode 155-1 connects the electrode 151-3 and the electrode 151-4. The through electrode 155-2 connects the electrode 151-3 and the electrode 151-5. The through electrode 155-3 connects the electrode 151-2 and the electrode 151-5. The through electrode 155-4 connects the electrode 151-2 and the electrode 151-6. The through electrode 155-5 connects the electrode 151-1 and the electrode 151-6. The through electrode 155-6 connects the electrode 151-1 and the electrode 133 (corresponding to the portion 133A in FIG. 3). In this case, the through electrode 155-1 to the through electrode 155-6 is arranged in at least one of the insulating layers of the insulating layer 153-1 to 153-6. As shown in FIG. 14A, the electrode 151-4 is connected to the electrode 133 (corresponding to the portion 133B in FIG. 3) by a through electrode (not shown).

[0079]

As shown in FIG. 14 B, the coil antenna 130-3, in a cross-sectional view, has a spiral shape. By having this shape, it is possible to increase the inductance in a small area.

[0080]

<Fourth Embodiment>

In the present embodiment, a portable wireless communication device including a coil antenna having a configuration different from the first to third
5 embodiments will be described.

[0081]

FIG. 15 is a perspective view of an IC tag 100-4. FIG. 16 is a schematic cross-sectional view showing a portion of a coil antenna 130-4 of the IC tag 100-4. As shown in FIGS. 15 and 16, the coil antenna 130-4 includes
10 an antenna 130-4-1 and an antenna 130-4-2. The antenna 130-4-1 is arranged in a substrate 145-4-1 and have a loop shape. The antenna 130-4-2 is arranged in a substrate 145-4-2 and have a loop shape. The antenna 130-4-1 and the antenna 130-4-2 are arranged to overlap each other. An insulating layer 160 is arranged between the substrate 145-4-1 and the
15 substrate 145-4-2. The materials of the insulating layer 160 is not particularly limited, but may include an inorganic insulating material, an organic insulating material, or an inorganic insulating material and an organic insulating material. For example, the insulating layer 160 may be formed of a plastic molding material including epoxy resin in a fibrous glass substrate. An adhesive agent
20 may be provided between the substrate 145-4-1 and the substrate 145-4-2, and the insulating layer 160.

[0082]

The antenna 130-4-1 has a plurality of electrodes 133-4-1, a plurality of electrodes 137-4-1, and a plurality of through electrodes 135-4-1. A portion
25 133-4-1A of the electrode 133-4-1 is connected to a portion 137-4-1B of one electrode 137-4-1 via one through electrode 135-4-1. A portion 133-4-1B of the electrode 133-4-1 is connected to a portion 137-4-1A of another electrode 137-4-1 via another through electrode 135-4-1.

[0083]

Similarly, the antenna 130-4-2 has a plurality of electrodes 133-4-2, a plurality of electrodes 137-4-2 and a plurality of through electrodes 135-4-2. A portion 133-4-2A of the electrode 133-4-2 is connected to a portion 137-4-2B of one electrode 137-4-2 via one through electrode 135-4-2. A portion 133-4-2B of the electrode 133-4-2 is connected to a portion 137-4-2A of another electrode 137-4-2 via another through electrode 135-4-2.

[0084]

An electrode 133-4-3 arranged on a first surface 145-4-1A of the substrate 145-4-1 and an electrode 137-4-3 arranged on a second surface 145-4-2B of the substrate 145-4-2 are connected via a through electrode 135-4-3. That is, a portion of the antenna 130-4-1 and a portion of the antenna 130-4-2 are connected.

[0085]

By applying the above structure, two coil antennas shown in FIGS. 1 and 3 are stacked to form one coil antenna. Thus, since it is possible to increase the number of windings as a whole coil antenna, it is possible to increase the induced electromotive force. Furthermore, while maintaining a large mouth opening area of the coil antenna, it is possible to reduce the outer diameter of the coil antenna. Therefore, while reducing the shape of the IC tag, it is possible to increase the sensitivity of the coil antenna.

[0086]

Specific examples in which the IC tag 100 described in the first to fourth embodiments is mounted will be described below.

[0087]

FIG. 17 is a diagram illustrating a portable medium on which the IC tag 100 is mounted. The IC tag 100 is used, for example, in various scenes such as product control, personal identification, security measures, electronic tickets,

gaming cards, and commercial transaction approval. FIG. 17A is a schematic view of a coin 1000. FIG. 17B is a schematic view of a playing card 2000. FIG. 17C is a schematic view of an ID (Identification) card 3000.

[0088]

5 In these medium, data can be obtained even if a plurality of the IC tags 100 is overlapped.

[0089]

The embodiments described above as embodiments of the present invention can be implemented in combination as appropriate as long as they do not conflict with each other. In addition, as long as the gist of the present invention is provided, it is also within the scope of the present invention to add, delete, or change the design of components as appropriate by a person skilled in the art based on each embodiment.

[0090]

15 It is understood that the present invention naturally provides other effects different from the effects provided by the embodiments described above, which are obvious from the description of the present specification or which can be easily predicted by a person skilled in the art.

[0091]

20 (Modification 1)

In the first embodiment of the present invention, the IC tag having a circular shape in a plan view has been described, but it is not limited to this configuration. FIG. 18 is a top view of an IC tag 100-5. The IC tag 100-5 includes the IC chip 110, a coil antenna 130-5, and the substrate 145. The IC chip 110 and the coil antenna 130-5 are provided on the substrate 145. As shown in FIG. 18, the coil antenna 130-5 may have a rectangular shape at a plan view.

[0092]

(Modification 2)

The IC tag 100 may further include a shield. Fig. 19 is a top view of an IC tag 100-6 and a top view of a shield 180. FIG. 20 is a cross-sectional view between A1-A2 of the IC tag 100-6. As shown in FIG. 19 B, the shield 180 is a ring shape but has partial notches. (This allows the shield 180 to have a shape like C.) In FIG. 20, the IC tag 100-6 includes an insulating layer 170 (an insulating layer 170-1) and the shield 180 (a shield 180-1) on the first surface 145A side of the substrate 145. The IC tag 100-6 also includes the insulating layer 170 (an insulating layer 170-2) and the shield 180 (a shield 180-2) on the second surface 145B side of the substrate 145. In this case, it can be said that the shield 180 is arranged so as to overlap the coil antenna 130. The insulating layer 170 (the insulating layer 170-1 and the insulating layer 170-2) is formed of the materials similar to the insulating layer 160. The shield 180 (the shield 180-1 and the shield 180-2) is formed of magnetic materials. Specifically, the shield 180 is formed of a magnetic material having a magnetic such as iron (Fe), nickel (Ni), cobalt (Co), or ferrite. The shield 180 may be formed of a conductor such as copper (Cu), aluminum (Al), not limited to the magnetic material. The shield 180 may be arranged on either the first surface 145A or the second surface 145B.

[0093]

FIG. 21 is a cross-sectional view when a plurality of the IC tags 100-6 is stacked. In FIG. 21, in the IC tag 100-6, the magnetic field emitted by each of the coil antennas 130 is shielded by having the shield 180. Even when the plurality of the IC tags are stacked, mutual interference is prevented. As a result, even if a plurality of the IC tags is overlapped with each other, the information of the IC tag can be stably read.

[0094]

(Modification 3)

In the first embodiment of the present invention, an example in which the through electrode is formed by a plating method has been shown, but it is not limited thereto. For example, wiring patterns may be formed on the first surface 145A and the second surface 145B of the substrate 145 by a highly malleable material such as aluminum, and the wiring patterns may be physically pressurized (sometimes crimped) from both sides of the first surface 145A and the second surface 145B in the opening. As a result, it is possible to dispose the connection portion to be a through electrode for connecting the first electrode and the second electrode.

[0095]

(Modification 4)

In the first to fourth embodiments of the present invention, the coil antenna having an upper electrode, a lower electrode, and a through electrode on the insulating substrate has been described, but it is not limited thereto.

FIG. 22 is a top view of an IC tag 100-7. The IC tag 100-7 includes the IC chip 110, a coil antenna 130-7 and a support medium 149. The support medium 149 is used to support the form of the coil antenna 130-7 and is not necessarily provided.

[0096]

In FIG. 22, the coil antenna 130-7 has a spiral shape in the circumference direction. The coil antenna 130-7 may be formed using a winding machine. Even in the IC tag 100-7, since the magnetic field generated by the coil antenna 130-7 does not protrude outward, even when a plurality of IC tags 100-7 is arranged, the IC tag can be read.

REFERENCE SIGNS LIST

[0097]

100: IC tag, 110: chip, 111: voltage limit circuit, 113: rectification circuit, 115: demodulation circuit, 117: modulation circuit, 119: control circuit, 121: storage unit, 123: resistance, 130: antenna unit, 133: electrode, 135: through electrode, 137: electrode, 140: support unit, 145: substrate, 149: support medium, 151: 5 electrode, 153: insulating layer, 155: through electrode, 160: insulating layer, 170: insulating layer, 180: shield, 300: reader/writer, 310: control circuit, 313: storage unit, 320: modulation circuit, 330: transmission circuit, 340: antenna, 350: receiving circuit, 360: demodulation circuit, 370: oscillation circuit, 380: carrier wave, 1000: coin, 2000: playing card, 3000: ID (Identification) card

CLAIMS

1. A portable wireless communication device comprising:
- an insulating substrate having a first surface and a second surface opposed to the first surface;
- 5 a coil antenna arranged in the insulating substrate and having a loop shape;
- and
- an IC chip electrically connected to the coil antenna;
- wherein
- the coil antenna includes a plurality of first electrodes arranged on the first
- 10 surface side of the insulating substrate, a plurality of second electrodes arranged on the second surface side of the insulating substrate, and a plurality of through electrodes arranged inside the insulating substrate,
- each of the plurality of first electrodes includes a first portion and a second portion,
- 15 each of the plurality of second electrodes includes a third portion and a fourth portion,
- the first portion of one first electrode of the plurality of first electrodes is connected to the fourth portion of one second electrode of the plurality of second electrodes via one through electrode of the plurality of through electrodes,
- 20 the second portion of the one first electrode of the plurality of first electrodes is connected to the third portion of another second electrode of the plurality of the second electrodes via another through electrode of the plurality of through electrodes.
- 25 2. The portable wireless communication device according to Claim 1, wherein at least either one of the plurality of first electrodes and the plurality of second electrodes has meander shape.

3. The portable wireless communication device according to Claim 1,
wherein

the coil antenna includes a first antenna having a loop shape and a
5 second antenna arranged inside the first antenna in a plan view and having a
loop shape, and

a portion of the first antenna and a portion of the second antenna are
connected.

10 4. The portable wireless communication device according to Claim 1,
wherein

the coil antenna includes a first antenna having a loop shape and a
second antenna overlapped with the first antenna and having a loop shape, and

a portion of the first antenna and a portion of the second antenna are
15 connected.

5. The portable wireless communication device according to Claim 1
comprising;

a shield overlapped with the coil antenna.
20

6. The portable wireless communication device according to Claim 1,
wherein

the coil antenna has a circular shape in a plan view.

25 7. The portable wireless communication device according to Claim 1,
wherein

the coil antenna has a rectangular shape in a plan view.

8. A portable wireless communication device comprising:
a coil antenna having a loop shape; and
an IC chip electrically connected to the coil antenna;
wherein
5 the coil antenna has a spiral shape in a circumference direction.
9. The portable wireless communication device according to Claim 8,
wherein
the coil antenna includes a first antenna having a loop shape and a
10 second antenna arranged inside the first antenna in a plan view and having a
loop shape, and
a portion of the first antenna and a portion of the second antenna are
connected.
- 15 10. The portable wireless communication device according to Claim 8,
wherein
the coil antenna includes a first antenna having a loop shape and a
second antenna overlapped with the first antenna and having a loop shape, and
a portion of the first antenna and a portion of the second antenna are
20 connected.
11. The portable wireless communication device according to Claim 8
comprising;
a shield overlapped with the coil antenna.
25
12. The portable wireless communication device according to Claim 8,
wherein
the coil antenna has a circular shape in a plan view.

13. The portable wireless communication device according to Claim 8,
wherein

the coil antenna has a rectangular shape in a plan view.

5

14. A portable wireless communication device comprising:

an insulating substrate having a first surface and a second surface
opposed to the first surface;

a coil antenna arranged in the insulating substrate and having a loop
10 shape; and

an IC chip electrically connected to the coil antenna;

wherein

the coil antenna is arranged on the first surface or the second surface of
the insulating substrate,

15 the coil antenna includes a plurality of insulating layers, a plurality of
electrodes, and a plurality of through electrodes arranged on the plurality of
insulating layers and connected with each of the plurality of electrodes, and

the coil antenna has a spiral shape in a cross-sectional view.

20 15. The portable wireless communication device according to Claim 14
comprising;

a shield overlapped with the coil antenna.

16. The portable wireless communication device according to Claim 14,
25 wherein

the coil antenna has a circular shape in a plan view.

17. The portable wireless communication device according to Claim 14,

wherein

the coil antenna has a rectangular shape in a plan view.

18. An information identification device comprising;

5 one or more portable wireless communication devices according to
any one of claims 1 to 17;

and

a reader/writer.