

DESCRIPTION

TITLE OF INVENTION

5 CONTACTLESS INFORMATION MEDIUM

TECHNICAL FIELD

[0001]

10 An embodiment of the present invention relates to a contactless information medium.

BACKGROUND ART

[0002]

15 A contactless information medium communication system is capable of contactless communication between a contactless information medium and a reader/writer, has high convenience, and has increased demand.

[0003]

20 In the contactless information medium communication system, the contactless information medium and the reader/writer wirelessly communicate with each other using an antenna, and transmit and receive information to and from each other. The contactless information medium includes a coil antenna that receives radio waves, an IC chip that processes information included in the radio waves, a capacitor, and an inductor, and operates using power generated by electromagnetic induction using radio
25 waves received from the reader/writer. For example, the contactless information medium can receive radio waves efficiently by adjusting a capacitance of the capacitor (see Patent Literature 1).

CITATION LIST

PATENT LITERATURE

[0004]

Patent Literature 1: Japanese patent publication No. 2007-233703

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SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005]

10 A method of adjusting a capacitance of a capacitor for efficiently receiving radio waves includes operations such as disconnection of the capacitor (see Patent Literature 1), selection and mounting of the capacitor, and the like, and the adjustment is not easy. In addition, a contactless information medium may be damaged due to cutting of the capacitor, and the selection and mounting of the capacitor.

15 [0006]

An object of an embodiment of the present invention is to provide a contactless information medium capable of easily adjusting a capacitance of a capacitor or an inductance of an inductor, and a contactless information medium communication system including the contactless information medium. In addition, another object of an embodiment of the present invention is to provide a contactless information medium capable of suppressing damage when adjusting a capacitance of a capacitor or an inductance of an inductor, and a contactless information medium communication system including the contactless information medium.

25

SOLUTION TO PROBLEM

[0007]

A contactless information medium includes a substrate including a

first surface and a second surface, a coil antenna arranged on the first surface or the second surface, a capacitor electrically connected to the coil antenna, and including a first electrode arranged on the first surface and a second electrode arranged on the second surface facing the first surface, and a first cover member having a first recess covering the first electrode and forming a first gap between the first recess and the first electrode.

[0008]

The contactless information medium may include a protective member covering the first cover member, and the protective member may be different from the first cover member.

[0009]

The contactless information medium may include an inductor arranged on the first surface and electrically connected to the coil antenna and the first electrode, and a second cover member including a second recess covering the inductor and forming a second gap between the second recess and the inductor, and the protective member may be in contact with the substrate between the first cover member and the second cover member.

[0010]

A dielectric constant of a material arranged in the first gap may be different from that of the first cover member.

[0011]

A magnetic permeability of a material arranged in the second gap may be different from that of the second cover member.

[0012]

A first distance between the first electrode and the first cover member may be different from a second distance between the inductor and the second cover member.

[0013]

The number of turns of the coil antenna may be one.

[0014]

The contactless information medium may include an IC chip arranged on the first surface and electrically connected to the coil antenna,
5 the capacitor, and the inductor.

[0015]

The contactless information medium may include an inductor arranged on the first surface and electrically connected to the first electrode and the coil antenna, the first cover member may include a second recess
10 covering the inductor, and may form a second gap between the second recess and the inductor.

[0016]

The contactless information medium may include a third recess covering the second electrode, and a second cover member forming a third
15 gap between the third recess and the second electrode.

[0017]

A dielectric constant of a material arranged in the third gap may be different from that of the second cover member.

[0018]

20 A third distance between the third recess and the second electrode may be different from a first distance between the first electrode and the first cover member or a second distance between the inductor and the first cover member, in the contactless information medium.

[0019]

25 The first cover member may include a mounting portion at a periphery of the first cover member, and the mounting portion may contact a periphery of the second cover member.

[0020]

The first cover member may include a metal ring including a slit and a mounting portion at a periphery of the first cover member, the mounting portion may contact a periphery of the second cover member, and a metal ring may contact the periphery of the first cover member and the periphery
5 of the second cover member.

[0021]

The slit may be arranged on an extension line connecting a position where the IC chip is arranged and a position where the capacitor is arranged, and may be arranged on the opposite side to the position where the
10 capacitor is arranged with respect to the position where IC chip is arranged, in a plan view.

[0022]

The contactless information medium may include a protective member arranged to cover the first cover member, the second cover
15 member and the metal ring.

[0023]

The first cover member may include a fourth recess, cover the IC chip with the fourth recess, and be arranged so as to form a fourth gap between the fourth recess and the IC chip.
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ADVANTAGEOUS EFFECT OF INVENTION

[0024]

According to an embodiment of the present invention, it is possible to provide a contactless information medium capable of easily adjusting a
25 capacitance of a capacitor or an inductance of an inductor, and a contactless information medium communication system including the contactless information medium. In addition, according to an embodiment of the present invention, it is possible to provide a contactless information

medium capable of suppressing damage when adjusting a capacitance of a capacitor or an inductance of an inductor, and a contactless information medium communication system including the contactless information medium.

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BRIEF DESCRIPTION OF DRAWINGS

[0025]

FIG. 1 is a plan view showing an outline of a contactless information medium according to a first embodiment.

10 FIG. 2A is a cross-sectional view along a line A1-A2 shown in FIG.

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FIG. 2B is a plan view showing a first recess shown in FIG. 1.

FIG. 2C is a plan view showing a third recess shown in FIG. 1.

FIG. 2D is a plan view showing a second recess shown in FIG. 1.

15 FIG. 2E is an enlarged view of the first recess and the third recess of FIG. 2A.

FIG. 2F is an enlarged view of the second recess of FIG. 2A.

FIG. 3 is a block diagram showing a configuration of an IC chip of a contactless information medium according to the first embodiment.

20 FIG. 4A and FIG. 4B are circuit diagrams of a contactless information medium according to the first embodiment.

FIG. 5 is a plan view showing an outline of a contactless information medium according to the first embodiment.

25 FIG. 6 is a cross-sectional view of a cross-sectional structure along a line B1-B2 shown in FIG. 5.

FIG. 7 is a plan view showing an outline of a contactless information medium according to the first embodiment.

FIG. 8A is a cross-sectional view showing a cross-sectional structure

for explaining a manufacturing method for arranging a cover member.

FIG. 8B is a cross-sectional view showing a cross-sectional structure along a line C1-C2 shown in FIG. 7.

FIG. 9 is a flowchart showing a method for manufacturing a
5 contactless information medium according to the first embodiment.

FIG. 10 is a block diagram showing a configuration of a contactless information medium communication system according to the first embodiment.

FIG. 11 is a plan view showing an outline of a contactless information
10 medium according to a second embodiment.

FIG. 12A is a cross-sectional view of a cross-sectional structure along a line D1-D2 shown in FIG. 11.

FIG. 12B is a plan view showing a fourth recess shown in FIG. 11.

FIG. 12C is an enlarged view of the fourth recess shown in FIG. 12A.

FIG. 13 is a plan view showing an outline of a contactless
15 information medium according to the second embodiment.

FIG. 14 is a cross-sectional view of a cross-sectional structure along a line E1-E2 shown in FIG. 13.

FIG. 15 is a plan view showing a contactless information medium
20 according to the second embodiment.

FIG. 16A is a cross-sectional view showing a cross-sectional structure for explaining a manufacturing method for arranging a cover member.

FIG. 16B is a cross-sectional view along a line F1-F2 shown in FIG.
25 15.

FIG. 17 is a plan view showing an outline of a contactless information medium according to the second embodiment.

FIG. 18A is a cross-sectional view combining a cross-sectional

structure shown in FIG. 14 and a cross-sectional structure of a metal ring.

FIG. 18B is a cross-sectional view of a cross-sectional structure along a line of G1-G2 shown in FIG. 17.

FIG. 19 is a flowchart showing a method for manufacturing a
5 contactless information medium according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

[0026]

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

[0027]

15 In the drawings, the widths, thicknesses, shapes, and the like of the respective portions may be schematically represented in comparison with the actual embodiments for clarity of explanation, but the drawings are merely examples, and do not limit the interpretation of the present invention. Further, in the present specification and the drawings, elements having the
20 same functions as those described with respect to the above-described drawings are denoted by the same reference signs, and redundant description may be omitted.

[0028]

In the present specification and the drawings, when a plurality of the
25 same or similar components is collectively represented, they may be described using the same reference signs or the same reference signs adding with capital letters. In describing a plurality of parts of one configuration separately, the same reference signs may be used, and

hyphens and natural numbers may be further used.

[0029]

In the present specification, terms such as “first”, “second”, and “third” added to each configuration are convenient labels used to distinguish each configuration, and do not have any further meaning unless otherwise described.

[0030]

In the present specification, based on a substrate included in the contactless information medium, a surface on which an IC chip is arranged is referred to as a “top surface”, and a surface opposite the top surface is referred to as a “bottom surface”. In addition, a surface intersecting the top surface and the bottom surface will be described as a “side surface”.

[0031]

In the present specification, “close” includes not only the case where a plurality of contactless information mediums is close to each other with a space, but also the case where the plurality of contactless information mediums is in direct contact with each other. In addition, “close” includes a state in which the plurality of contactless information mediums overlaps each other.

[0032]

1. First Embodiment

1-1. Configuration of Contactless Information Medium 10

FIG. 1 is a plan view showing an outline of a contactless information medium 10, and FIG. 2A is a cross-sectional view of a cross-sectional structure of the contactless information medium 10 shown in FIG. 1 along a line A1-A2. A configuration of the contactless information medium 10 will be described with reference to FIG. 1 or FIG. 2A. As shown in FIG. 1 or FIG. 2A, the contactless information medium 10 includes a substrate 20 and

a protective member 90. The substrate 20 is positioned inside the contactless information medium 10 and is covered with the protective member 90.

[0033]

5 The protective member 90 forms an appearance shape of the contactless information medium 10. In addition, the protective member 90 protects the substrate 20 against external impacts. In the contactless information medium 10, the substrate 20 is preferably completely covered with the protective member 90. The protective member 90 is made of resin.

10 For example, the resin is a thermosetting resin or a thermoplastic resin. Specifically, the resin is acrylonitrile butadiene styrene, polycarbonate, polyphthalamide, polyoxymethylene, polymethyl methacrylate, polyethylene, polypropylene, polybutylene terephthalate, or vinyl chloride.

[0034]

15 Although the shape of the contactless information medium 10 is a circular plate shape in a plan view, the shape of the contactless information medium 10 is not limited to the shape shown in FIG. 1. For example, the shape of the contactless information medium 10 may be an elliptical plate shape or a polygonal plate shape.

20 [0035]

 For example, although the contactless information medium 10 is a chip (coin or token) used in a casino, an amusement facility, or the like, the use of the contactless information medium 10 is not limited to the example shown here. For example, the contactless information medium 10 may be
25 used as a tag for article management.

[0036]

 As shown in FIG. 1, the substrate 20 has a top surface 22 and a bottom surface 24. The substrate 20 includes a coil antenna 30, an IC

chip 40, a first capacitor 50, a first inductor 60, a first cover member 70, a second cover member 80, and connecting portions 102 and 104. The substrate 20 is a substrate that supports the coil antenna 30, the IC chip 40, the first capacitor 50, the first inductor 60, the first cover member 70, the second cover member 80, and the connecting portions 102 and 104. For example, the substrate 20 is a paper phenolic 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, or a PPO substrate. In addition, the top surface 22 may be referred to as a first surface, and the bottom surface 24 may be referred to as a second surface. Further, the top surface 22 may be referred to as a second surface, and the bottom surface 24 may be referred to as a first surface.

[0037]

The coil antenna 30 is arranged on the top surface 22 of the substrate 20 (see FIG. 2A) and is arranged outside the IC chip 40. One end of the coil antenna 30 is electrically connected to the connecting portion 102, and the other end of the coil antenna 30 is electrically connected to the first inductor 60. The coil antenna 30 transmits and receives radio waves by wireless communication with an antenna (see FIG. 10) included in a reader/writer 202 (see FIG. 10). For example, the radio wave includes an electric signal, and the electric signal includes information. For example, the information includes a request from the reader/writer 202, and identification information unique to the contactless information medium 10, and the like. In addition, the coil antenna 30 may be arranged in the bottom surface 24 of the substrate 20. A through hole (not shown) that penetrates the substrate 20 and connects the top surface 22 and the bottom surface 24 is arranged in the substrate 20. In addition, a conductive film

(not shown) is formed in the through hole. In the first embodiment, using the conductive film formed in the through hole, the coil antenna 30 arranged on the top surface 22 is electrically connected to a member arranged on the bottom surface 24, and the coil antenna 30 arranged on the bottom surface 24 is electrically connected to a member arranged on the top surface 22.

[0038]

In the first embodiment, the number of turns of the coil of the coil antenna 30 is preferably one or more and three or less, particularly preferably two. As an example, in the contactless information medium 10 shown in FIG. 1, the number of turns of the coil of the coil antenna 30 is one. The number of turns of the coil of the coil antenna 30 is significantly smaller than that of the conventional coil antenna. For example, the coil antenna 30 is formed to have a predetermined shape on the substrate 20 by printing, coating, or etching. A material forming the coil antenna 30 is a conductive material. For example, the conductive material is copper, aluminum or the like.

[0039]

Although details will be described later, the IC chip 40 is arranged on the top surface 22 of the substrate 20 (see FIG. 2A), and is electrically connected in parallel with the first capacitor 50 between the connecting portion 102 and the connecting portion 104. In addition, similar to the coil antenna 30, the IC chip 40 may be arranged on the bottom surface 24 of the substrate 20, and using the conductive film formed in the through hole connecting the top surface 22 and the bottom surface 24, the IC chip 40 arranged on the top surface 22 is electrically connected to the member arranged on the bottom surface 24, and the IC chip 40 arranged on the bottom surface 24 is electrically connected to the member arranged on the top surface 22.

[0040]

The first capacitor 50 is configured by using a first electrode 56A arranged on the top surface 22 of the substrate 20, a second electrode 56B arranged on the bottom surface 24 of the substrate 20, and the substrate 20 sandwiched between the first electrode 56A and the second electrode 56B (see FIG. 2A). In the contactless information medium 10, for example, the first electrode 56A is formed in the same layer as the coil antenna 30 using a similar material and a similar method, and the second electrode 56B is formed using a similar material and a similar method in a different process so as to face the first electrode 56A. In addition, similar to the coil antenna 30, the first electrode 56A may be arranged on the bottom surface 24 of the substrate 20 and the second electrode 56B may be arranged on the top surface 22. Furthermore, using the conductive film formed in the through hole connecting the top surface 22 and the bottom surface 24, the first electrode 56A arranged on the top surface 22 is electrically connected to the member arranged on the bottom surface 24 and the second electrode 56B arranged on the bottom surface 24 is electrically connected to the member arranged on the top surface 22, and the first electrode 56A arranged on the bottom surface 24 is electrically connected to the member arranged on the top surface 22 and the second electrode 56B arranged on the top surface 22 is electrically connected to the member arranged on the bottom surface 24.

[0041]

For example, the first electrode 56A is electrically connected to the connecting portion 102. For example, a through hole (not shown) that penetrates the substrate 20 and connects the top surface 22 and the bottom surface 24 is arranged in the substrate 20. For example, the second electrode 56B is electrically connected to the connecting portion 104 using

the conductive film formed in the through hole connecting the top surface 22 and the bottom surface 24. In addition, the first electrode 56A and the second electrode 56B may be interchanged.

[0042]

5 The first inductor 60 is arranged on the top surface 22 of the substrate 20 (see FIG. 2A) and is electrically connected in series with the coil antenna 30. One end of the first inductor 60 is electrically connected to the other end of the coil antenna 30, and the other end of the first inductor 60 is electrically connected to the connecting portion 104. The first
10 inductor 60 is a form (chip inductor) that can be mounted on the substrate 20. In addition, similar to the coil antenna 30, the first inductor 60 may be arranged on the bottom surface 24 of the substrate 20, using the conductive film formed on the through hole connecting the top surface 22 and the bottom surface 24, the first inductor 60 arranged on the top surface 22 is
15 electrically connected to the member arranged on the bottom surface 24, and the first inductor 60 arranged on the bottom surface 24 is electrically connected to the member arranged on the top surface 22.

[0043]

 The connecting portions 102 and 104 are formed in the same layer
20 as the coil antenna 30 and the first electrode 56A using a similar material and a similar method.

[0044]

 The first cover member 70 includes a first upper cover member 72 (see FIG. 2A) arranged on the top surface 22 and a first lower cover member
25 74 (see FIG. 2A) arranged on the bottom surface 24. A first recess 59 (see FIG. 2A) of the first upper cover member 72 and a third recess 58 (see FIG. 2A) of the first lower cover member 74 sandwich the first capacitor 50. Although details will be described later, the first cover member 70 has a

function of adjusting a capacitance of the contactless information medium 10, and constitutes a second capacitor 52 (see FIG. 4A) in which the capacitance of the contactless information medium 10 is adjusted. In addition, a capacitance of the first capacitor 50 is a capacitance C_a , and a
5 capacitance of the second capacitor 52 is a capacitance C_b . Further, the first cover member 70 has a function of protecting the first capacitor 50 from the outside.

[0045]

For example, the shape of the first upper cover member 72 is
10 quadrilateral and includes the first recess 59 (see FIG. 2A) in the center and a smaller recess than the first recess 59 in the vicinity of each of the four corners. For example, the first lower cover member 74 is quadrilateral and has the third recess (see FIG. 2A) in the center and a protrusion in the vicinity of each of the four corners. Each of the protrusions at the four
15 corners of the first lower cover member 74 corresponds to each of the recesses at the four corners of the first upper cover member 72 on a one-to-one basis. Each of the protrusions at the four corners of the first lower cover member 74 is inserted through a first through hole 54 formed in the substrate 20 (see FIG. 2A) and is inserted through each of the
20 corresponding recesses of the first upper cover member 72. In addition, the first upper cover member 72 may be arranged on the bottom surface 24 and the first lower cover member 74 may be arranged on the top surface 22. That is, the first upper cover member 72 and the first lower cover member 74 may be interchanged.

25 [0046]

The second cover member 80 includes a second upper cover member 82 (see FIG. 2A) arranged on the top surface 22 and a second lower cover member 84 (see FIG. 2A) arranged on the bottom surface 24.

A second recess 69 (see FIG. 2A) of the second upper cover member 82 and the second lower cover member 84 sandwich the first inductor 60. Although details will be described later, the second cover member 80 has a function of adjusting the inductance of the contactless information medium 10, and constitutes a second inductor 62 (see FIG. 4A) in which the inductance of the contactless information medium 10 is adjusted. In addition, an inductance of the first inductor 60 is an inductance L_a , and an inductance of the second inductor 62 is an inductance L_b . Further, the second cover member 80 has a function of protecting the first inductor 60 from the outside.

[0047]

A shape of the second upper cover member 82 and a shape of the second lower cover member 84 are similar to the shape of the first upper cover member 72 and the shape of the first lower cover member 74. The shape of the second upper cover member 82 is quadrilateral and includes the second recess 69 (see FIG. 2A) in the center and a recess in the vicinity of each of the four corners, and the shape of the second lower cover member 84 is quadrilateral and includes a protrusion in the vicinity of each of the four corners. Each of the protrusions at the four corners of the second lower cover member 84 corresponds to each of the recesses at the four corners of the second upper cover member 82 in a one-to-one manner. Each of the protrusions at the four corners of the second lower cover member 84 is inserted through a second through hole 64 (see FIG. 2A) formed in the substrate 20 and is inserted through each of the corresponding recesses of the second upper cover member 82.

[0048]

For example, the first upper cover member 72, the first lower cover member 74, the shape of the second upper cover member 82, and the

second lower cover member 84 are formed by injection molding using a material similar to the protective member 90.

[0049]

In addition, the first upper cover member 72, the first lower cover member 74, the second upper cover member 82, and the second lower cover member 84 are not limited to the configurations described in the first embodiment. The first cover member 70 (the first upper cover member 72 and the first lower cover member 74) may have a function of adjusting the capacitance C_b of the second capacitor 52 and a function of protecting the first capacitor 50 from the outside. For example, the first upper cover member 72 and the first lower cover member 74 may be circular and may have at least two or more recesses or protrusions inside the circular perimeter, and the first upper cover member 72 and the first lower cover member 74 may be configured so as to be able to be assembled using the recess or protrusion. In addition, the second upper cover member 82 and the second lower cover member 84 may have a function of adjusting the inductance L_b of the second inductor 62, have a function of protecting the first inductor 60 from the outside and be configured to be assembled using a similar configuration as the first upper cover member 72 and the first lower cover member 74.

[0050]

1-2. Configuration of IC Chip 40

FIG. 3 is a diagram showing a configuration of the IC chip 40 of the contactless information medium 10. The configuration of the IC chip 40 will be described with reference to FIG. 3. In the configuration of the IC chip 40, descriptions of the same or similar configurations as those in FIG. 1 and FIG. 2A may be omitted.

[0051]

As shown in FIG. 3, the IC chip 40 includes a control unit 42, a communication unit 44, and a memory unit 46. The communication unit 44 processes radio waves received from the reader/writer 202 (see FIG. 10) via the coil antenna 30. The control unit 42 controls the operation of the communication unit 44 and the memory unit 46. For example, the control unit 42 receives information included in the processed electrical signal from the communication unit 44 and extracts the information included in the processed electrical signal from the memory unit 46. In addition, the control unit 42 generates an electric signal corresponding to the extracted information, and transmits the generated electric signal to the communication unit 44. Further, the communication unit 44 transmits the generated electric signal on the radio waves, and transmits the radio waves to the reader/writer 202 via the coil antenna 30. The memory unit 46 stores various types of information. As described above, for example, the various types of information include a request from the reader/writer 202, and identification information unique to the contactless information medium 10 for identifying the contactless information medium 10, and the like.

[0052]

Although details will be described later, in the contactless information medium 10, a resonant circuit 100 (see FIG. 4A) is configured by using the second capacitor 52 and the second inductor 62. The resonant circuit 100 generates power by electromagnetic induction using radio waves received from the reader/writer 202. When the power generated using the resonant circuit 100 is greater than or equal to a threshold voltage value (operable voltage value), the IC chip 40 starts operating.

[0053]

1-3. Electrical Characteristics of Contactless Information Medium 10

FIG. 2B is a plan view showing the first recess 59 shown in FIG. 1, FIG. 2C is a plan view showing the third recess 58 shown in FIG. 1, FIG. 2D is a plan view showing the second recess 69 shown in FIG. 1, FIG. 2E is an enlarged view of the first recess 59 and the third recess 58 shown in
5 FIG. 2A, and FIG. 2F is an enlarged view of the second recess 69 shown in FIG. 2A. FIG. 4A is an equivalent circuit diagram of the contactless information medium 10 after the capacitance and the inductance are adjusted, and FIG. 4B is an equivalent circuit diagram of a contactless information medium 12 before the capacitance and the inductance are
10 adjusted. The contactless information medium 10 before the capacitance and the inductance are adjusted is represented as the contactless information medium 12. The electrical characteristics of the contactless information medium 10 will be described with reference to FIG. 2A to FIG. 2F, FIG. 4A, and FIG. 4B. In the electrical characteristics of the
15 contactless information medium 10, descriptions of the same or similar configurations as those in FIG. 1 and FIG. 3 may be omitted.

[0054]

As shown in FIG. 4A, in the contactless information medium 10, the second inductor 62 is electrically connected in series between the
20 connecting portion 104 and the connecting portion 102, the IC chip 40 and the second capacitor 52 are electrically connected in parallel between the connecting portion 104 and the connecting portion 102, and the second capacitor 52 and the second inductor 62 form a closed circuit. The closed circuit formed using the second inductor 62 and the second capacitor 52 is
25 a so-called resonant circuit 100. In addition, the second capacitor 52 includes the first capacitor 50, and the second inductor 62 includes the coil antenna 30 and the first inductor 60.

[0055]

As shown in FIG. 4B, in the contactless information medium 12, the coil antenna 30 and the first inductor 60 are electrically connected in series between the connecting portion 104 and the connecting portion 102, the IC chip 40 and the second capacitor 52 are electrically connected in parallel between the connecting portion 104 and the connecting portion 102, and the coil antenna 30, the first capacitor 50, and the first inductor 60 form a closed circuit. The closed circuit formed using the coil antenna 30, the first capacitor 50, and the first inductor 60 is a resonant circuit 100A.

[0056]

The second capacitor 52 will be described with reference to FIG. 2A, FIG. 2B, FIG. 2C, FIG. 2E, and FIG. 4A. As described above, the second capacitor 52 is a capacitor in which the capacitance of the contactless information medium 10 is adjusted. The second capacitor 52 is configured using at least the first cover member 70 (the first upper cover member 72 and the first lower cover member 74) and the first capacitor 50. The first capacitor 50 is sandwiched and covered with the first recess 59 and the third recess 58. In the first upper cover member 72, a part facing the top surface 22, except for at least the small recesses at four corners and the first recess 59, is in contact with the top surface 22. In addition, in the first lower cover member 74, a part facing the bottom surface 24, except for at least protrusions at four corners and the third recess 58, is in contact with the bottom surface 24.

[0057]

In the first embodiment, a space surrounded by the first recess 59, the first electrode 56A, and the top surface 22 other than the top surface 22 in contact with the first electrode 56A forms a first gap 51, and a distance between the first recess 59 and the top surface of the first electrode 56A is referred to as a first distance H1. For example, the first distance H1 may

be the closest distance (length) between the top surface of the first electrode 56A and the first recess 59, and may be the closest distance (length) extending vertically from the substrate 20. For example, in the case where a thickness of the first electrode 56A is thinner than the substrate 20 and the first distance H1, a size of the first gap 51 can be approximated by using a size of the first distance H1 and the first recess 59 in a top view (width W1 × width W2).

[0058]

In addition, the first gap 51 may be filled with air, and a first member 55 may be arranged as shown in FIG. 2E. The first member 55 may be formed using a material having the same dielectric constant as the first upper cover member 72 and may be formed using a material having a dielectric constant different from that of the first upper cover member 72.

[0059]

Similar to the first gap 51, in the first embodiment, a space surrounded by the third recess 58, the second electrode 56B, and the bottom surface 24 other than the bottom surface 24 in contact with the second electrode 56B forms a third gap 53, and a distance between the third recess 58 and the top surface of the second electrode 56B is referred to as a third distance H3. For example, the third distance H3 may be the closest distance (length) between the top surface of the second 56B and the third recess 58, and may be the closest distance (length) extending vertically from the substrate 20. For example, in the case where a thickness of the second electrode 56B is thinner than the substrate 20 and the third distance H3, a size of the third gap 53 can be approximated by using the third distance H3 and a size of the third recess 58 in a top view (width W3 × width W4). Further, in the first embodiment, the width W1, the width W2, the width W3, and the width W4 are the same or substantially the

same, but the width W1, width W2, width W3 and width W4 may not be the same or substantially the same. In addition, the first distance H1 may be the same as or substantially the same as or different from the third distance H3.

5 [0060]

In addition, the third gap 53 may be filled with air, and a third member 57 may be arranged as shown in FIG. 2E. The third member 57 may be formed using a material having the same dielectric constant as the first lower cover member 74 and may be formed using a material having a dielectric constant different from that of the first lower cover member 74.

[0061]

In this case, as described above, for example, the capacitance of the first capacitor 50 is the capacitance Ca, and the capacitance of the second capacitor 52 is the capacitance Cb. The capacitance Cb includes the capacitance Ca. The capacitance Cb can be adjusted by changing the size of the first gap 51 and the size of the third gap 53. In addition, the capacitance Cb can be adjusted by changing the material arranged in the first gap 51 and the material arranged in the third gap 53.

[0062]

20 Next, the second inductor 62 will be described with reference to FIG. 2D and FIG. 4A. As described above, the second inductor 62 is an inductor in which the inductance of the contactless information medium 10 is adjusted. The second inductor 62 is configured with at least the coil antenna 30, the second cover member 80 (the second upper cover member 82 and the second lower cover member 84), and the first inductor 60. The first inductor 60 is sandwiched and covered with the second recess 69 and the second lower cover member 84. In the second upper cover member 82, except for at least the second recess 69, a part facing the top surface

22 is in contact with the top surface 22 and the second lower cover member 84 is in contact with the bottom surface 24.

[0063]

In the first embodiment, a space surrounded by the second recess 5 69 and the top surface 22 other than the top surface 22 in contact with the first inductor 60 forms a second gap 61, and a distance between the second recess 69 and the top surface of the first inductor 60 is referred to as a second distance H2. For example, the second distance H2 may be the closest distance (length) between the top surface of the first inductor 60 10 and the second recess 69, and may be the closest distance (length) extending vertically from the substrate 20. For example, in the case where a thickness of the first inductor 60 is thinner than the substrate 20 and the second distance H2, a size of the second gap 61 can be approximated by using the second distance H2 and a size of the second recess 69 (width W5 15 × width W6) in a top view. Further, in the first embodiment, the width W5 and the width W6 are the same or substantially the same, but the width W5 and the width W6 may not be the same or substantially the same. In addition, the second distance H2 may be the same as or substantially the same as or different from the first distance H1 or the third distance H3.

20 [0064]

In addition, the second gap 61 may be filled with air, and a second member 63 may be arranged as shown in FIG. 2F. The second member 63 may be formed using a material having the same magnetic permeability as the second upper cover member 82 and may be formed using a material 25 having a magnetic permeability different from that of the second upper cover member 82.

[0065]

In the first embodiment, the shapes of the first recess 59, the second

recess 69, and the third recess 58 are rectangular recesses opposite the top surface 22 of the substrate 20, as an example. The shapes of the first recess 59, the second recess 69, and the third recess 58 are not limited to the shapes shown here. For example, the shapes of the first recess 59, the second recess 69, and the third recess 58 may be a recess having a curved surface facing the top surface 22 of the substrate 20.

[0066]

In this case, as described above, for example, the inductance of the first inductor 60 is the inductance La, and the inductance of the second inductor 62 is the inductance Lb. In addition, the inductance of the coil antenna 30 is an inductance Lc. The inductance Lb includes the inductance Lc and the inductance La. The second inductance Lb can be adjusted by changing the size of the second gap 61. For example, the second inductance Lb can be adjusted by changing the material arranged in the second gap 61.

[0067]

A resonant frequency fr of the resonant circuit 100 configured using the second capacitor 52 and the second inductor 62 is expressed by the following formula (1) using the capacitance Cb of the second capacitor 52 and the inductance Lb of the second inductor 62.

[0068]

[Formula 1]

$$f_r = \frac{1}{2\pi\sqrt{L_b \times C_b}} \quad \cdots (1)$$

[0069]

When the resonance frequency fr of the resonant circuit 100 coincides with a frequency (predetermined frequency) fc of the radio wave transmitted from the reader/writer 202 (FIG. 10), the resonant circuit 100

can generate the largest power by electromagnetic induction using the radio wave of the frequency f_c received from the reader/writer 202.

[0070]

In the first embodiment, a resonant frequency f_{ra} before the
5 capacitance and inductance of the contactless information medium 10 are
adjusted can be obtained using the contactless information medium 12.
That is, the resonant frequency f_{ra} of the contactless information medium
12 can be obtained using the contactless information medium 12 in a state
before the first cover member 70 and the second cover member 80 are
10 arranged in the substrate 20. For example, the contactless information
medium 12 includes the resonant circuit 100A as shown in FIG. 4B. The
resonant frequency f_{ra} is expressed by the following formula (2) using the
capacitance C_a of the first capacitor 50, the inductance L_a of the first
inductor 60, and the inductance L_c of the coil antenna 30.

15 [0071]

[Formula 2]

$$f_{ra} = \frac{1}{2\pi\sqrt{(L_a + L_c) \times C_a}} \quad \cdots (2)$$

[0072]

In the first embodiment, the capacitance C_b of the second capacitor
20 52 or the inductance L_b of the second inductor 62 can be adjusted so that
the resonant frequency f_r coincides with or substantially coincides with the
frequency f_c of the radio wave transmitted from the reader/writer 202.

[0073]

For example, in the first cover member 70, at least one of the first
25 distance H_1 , the width W_1 , the width W_2 , the third distance H_3 , the width
 W_3 , and the width W_4 is adjusted. As a result, the capacitance C_b of the
second capacitor 52 can be adjusted so as to coincide with or substantially

coincide with the frequency f_c of the radio wave transmitted from the reader/writer 202. In the contactless information medium 10, the capacitance C_b of the second capacitor 52 can be adjusted by using the first cover member 70 and the second cover member 80 so as to suppress variations in the properties or performance of the first capacitor 50.

[0074]

Further, in the second cover member 80, at least one of the second distance H_2 , the width W_5 , and the width W_6 may be adjusted, and the inductance L_b of the second inductor 62 may be adjusted so as to coincide with or substantially coincide with the frequency f_c of the radio wave transmitted from the reader/writer 202. In the contactless information medium 10, the inductance L_b of the second inductor 62 can be adjusted by using the second cover member 80 so as to suppress variations in the properties or performance of the first inductor 60 or the coil antenna 30. In addition, both the capacitance C_b and the inductance L_b may be adjusted in the contactless information medium 10.

[0075]

For example, in adjusting the resonant frequency f_r , a plurality of first cover members 70 adjusted to a different capacitance C_b and a plurality of second cover members 80 adjusted to a different inductance L_b are prepared in advance. One first cover member 70 and one second cover member 80 are selected from the plurality of first cover members 70 and the plurality of second cover members 80 so that the resonant frequency f_r coincides with or substantially coincides with the frequency f_c of the radio waves transmitted from the reader/writer 202. In the first embodiment, by implementing the selected first cover member 70 and the second cover member 80 in the contactless information medium 12, the resonant frequency f_r coincides with or substantially coincides with the frequency f_c

of the radio wave transmitted from the reader/writer 202, and an optimum contactless information medium 10 can be formed.

[0076]

In addition, as described above, the first inductor 60 is a chip
5 inductor. Therefore, the size of the first inductor 60 is sufficiently smaller
than that of the coil antenna 30, and the first inductor 60 can also be
referred to as a lumped-constant inductor capable of being lumped. In the
contactless information medium 10, the number of turns of the coil of the
coil antenna 30 is smaller than that of the conventional contactless
10 information medium, and the inductance L_c of the coil antenna 30 is smaller
than the inductance L_a of the first inductor 60. In the contactless
information medium 10, the inductance of the resonant circuit 100 can be
increased by increasing the inductance L_a of the first inductor 60, and the
inductance L_b of the second inductor 62 can be adjusted by using the
15 second cover member 80.

[0077]

Furthermore, in the contactless information medium 10, even if the
inductance L_c of the coil antenna 30 is small at the design stage, the
inductance L_b of the first inductor 60 which is a chip inductor can be
20 increased after the design. Since the resonant frequency f_r can be
adjusted by adjusting the inductance L_b of the first inductor 60 after the
design, the capacitance C_a of the first capacitor 50 need not be increased
unnecessarily in the design stage. Therefore, the capacitance C_a of the
first capacitor 50 may be the same or substantially the same as the
25 conventional capacitance. Further, in the contactless information medium
10, the capacitance C_b of the second capacitor 52 can be adjusted
independently using the first cover member 70, and the inductance L_b of
the second inductor 62 can be adjusted independently using the second

cover member 80.

[0078]

Therefore, the contactless information medium 10 can be miniaturized and the resonant frequency f_r can be adjusted without increasing the size of the first capacitor 50. Further, in the contactless information medium 10, since the capacitance C_a of the first capacitor 50 does not need to be increased, there is no need to charge and discharge a large capacitance. Therefore, in the contactless information medium 10, the load for charging and discharging the capacitance C_a of the first capacitor 50 is suppressed, and the resonance frequency f_r can be made to coincide with or substantially coincide with the frequency f_c of the radio wave transmitted from the reader/writer 202 as much as possible, so that the large power generated using the resonant circuit 100 is sufficiently supplied to the IC chip 40. As a result, a malfunction of the IC chip 40 caused by a power shortage can be suppressed in the contactless information medium 10. Therefore, the contactless information medium 10 can perform stable wireless communication with the reader/writer 202.

[0079]

1-4. Method For Manufacturing Contactless Information Medium 10

FIG. 5 is a plan view schematically showing the contactless information medium 10. FIG. 6 is a cross-sectional view of a cross-sectional structure along a line B1-B2 of the contactless information medium 10 shown in FIG. 5. FIG. 7 is a plan view schematically showing the contactless information medium 10 for explaining the manufacturing method of the contactless information medium 10. FIG. 8A is a cross-sectional view showing a cross-sectional structure for explaining a manufacturing method for arranging the first upper cover member 72, the first lower cover member 74, the second upper cover member 82, and the

second lower cover member 84, and FIG. 8B is a cross-sectional view showing a cross-sectional structure along a line C1-C2 of the contactless information medium 10 shown in FIG. 7. FIG. 9 is a flowchart showing a method for manufacturing the contactless information medium 10.

5 [0080]

A method for manufacturing the contactless information medium 10 will be described with reference to FIG. 1 and FIG. 5 to FIG. 9. In the method for manufacturing the contactless information medium 10, descriptions of the same or similar configurations as those in FIG. 2A to
10 FIG. 2D, FIG. 3, FIG. 4A, and FIG. 4B may be omitted. The contactless information medium 10 is manufactured according to the manufacturing methods of step S30 to step S34 shown in FIG. 9. The method for manufacturing the contactless information medium 10 is not limited to the manufacturing method shown in FIG. 9, and may include another step.

15 [0081]

First, the step S30 shown in FIG. 9 will be described with reference to FIG. 5 and FIG. 6. In the step S30, the IC chip 40 and the first inductor 60 are mounted on the substrate 20 on which the coil antenna 30, the connecting portions 102 and 104, and the first capacitor 50 having
20 predetermined shapes are formed. In the step S30, the first inductor 60 is electrically connected between the coil antenna 30 and the connecting portion 104, and the IC chip 40 is electrically connected between the connecting portion 102 and the connecting portion 104. As a result, the coil antenna 30, the connecting portions 102 and 104, the first capacitor 50,
25 the first inductor 60, and the IC chip 40 are electrically connected to form the contactless information medium 12 in the state before the first cover member 70 and the second cover member 80 are arranged in the substrate 20. In addition, a closed circuit is formed by using the coil antenna 30, the

first capacitor 50, the first inductor 60, and the IC chip 40, and the resonant circuit 100A (FIG. 4B) is formed by the coil antenna 30, the first capacitor 50, and the first inductor 60.

[0082]

5 Next, in the step S31 shown in FIG. 9, the resonant frequency is adjusted using the contactless information medium 12. For example, information such as a communication distance, the resonance frequency, the capacitance C_a of the first capacitor 50, and the inductance L_a of the first inductor 60 is acquired in advance using the reader/writer 202 and a
10 plurality of contactless information mediums 12, and a table in which the communication distance, the resonance frequency, the capacitance C_a of the first capacitor 50, the inductance L_a of the first inductor 60, and the like are linked is prepared. The formed contactless information medium 12 is made to wirelessly communicate with the reader/writer 202, and the
15 communication distance is measured. For example, the measured communication distance and the table are used to calculate the resonance frequency. Using the calculated resonant frequency, one first cover member 70 and one second cover member 80 are selected from the plurality of first cover members 70 and the plurality of second cover members 80 so
20 as to coincide with or substantially coincide with the frequency f_c of the radio wave transmitted from the reader/writer 202.

[0083]

 Next, the step S32 shown in FIG. 9 will be described with reference to FIG. 7, FIG. 8A, and FIG. 8B. In the step S32, the first cover member
25 70 and the second cover member 80 selected in the step S31 are implemented in the contactless information medium 12.

[0084]

 Specifically, each of the protrusions of the first lower cover member

74 is inserted through the first through hole 54 and inserted through each of the corresponding recesses of the first upper cover member 72. As a result, the first capacitor 50 is sandwiched by the first recess 59 of the first cover member 72 and the third recess 58 of the first lower cover member 74 and covered with the first recess 59 of the first upper cover member 72 and the third recess 58 of the first lower cover member 74.

[0085]

In addition, each of the protrusions at the four corners of the second lower cover member 84 is inserted through the second through hole 64 and inserted through each of the corresponding recesses of the second upper cover member 82. As a result, the first inductor 60 is sandwiched by the second recess 69 of the second upper cover member 82 and the second cover member 84 and covered with the second recess 69 of the second upper cover member 82 and the second lower cover member 84.

[0086]

As a result, in the step S32, the second capacitor 52 and the second inductor 62 are formed, and the resonant circuit 100 (FIG. 4A) is configured using the second capacitor 52 and the second inductor 62.

[0087]

Finally, in the step S34 shown in FIG. 9, injection molding is used to mold the protective member 90 that covers the coil antenna 30, the IC chip 40, the first capacitor 50, the first inductor 60, the first cover member 70, and the second cover member 80 arranged in the substrate 20. Specifically, the protective member 90 that covers the coil antenna 30, the IC chip 40, the first capacitor 50, the first inductor 60, the first cover member 70, and the second cover member 80 arranged in the substrate 20 is molded by injecting resin into the substrate 20 arranged in the mold and molding the resin at a predetermined temperature and pressure. In this case, the

protective member 90 contacts the substrate 20 between the coil antenna 30 and the IC chip 40, between the coil antenna 30 and the first cover member 70, between the coil antenna 30 and the second cover member 80, between the IC chip 40 and the first cover member 70, between the IC chip 40 and the second cover member 80, and between the first cover member 70 and the second cover member 80. Further, for example, the material forming the protective member 90 is different from the material forming the first cover member 70 and the material forming the second cover member 80.

10 [0088]

The contactless information medium 10 is manufactured using the manufacturing method described above. In addition, the capacitor and the inductor are protected by using the protective member 90, the first cover member 70, and the second cover member 80 in the contactless information medium 10. Therefore, in the contactless information medium 10, the capacitance of the capacitor and the inductance of the inductor can be easily adjusted without damaging the capacitor and the inductor. In addition, the contactless information medium 10 is protected by the protective member 90, the first cover member 70, and the second cover member 80, and has high-impact resistance.

[0089]

1-5. Configuration of Contactless Information Medium Communication System 200

FIG. 10 is a block diagram showing a configuration of a contactless information medium communication system 200. The contactless information medium communication system 200 will be described with reference to FIG. 10. In the contactless information medium communication system 200, descriptions of the same or similar

configurations as those in FIG. 1 to FIG. 9 may be omitted.

[0090]

As shown in FIG. 10, the contactless information medium communication system 200 includes a contactless information medium group 120 including a plurality of contactless information mediums 10, and the reader/writer 202. Although the wireless communication between the contactless information medium group 120 and the reader/writer 202 is described in the first embodiment, one contactless information medium 10 of the contactless information medium group 120 may wirelessly communicate with the reader/writer 202.

[0091]

The reader/writer 202 includes an input portion 204, a processing portion 206, an output portion 208, and an antenna 210. For example, the antenna 210 has a function of supplying power to the contactless information medium 10 and transmitting and receiving electric signals including information to and from the contactless information medium 10 via radio waves of a predetermined frequency. For example, the input portion 204 has a function of inputting instruction information for instructing an operation of the reader/writer 202. For example, the processing portion 206 has a function of processing radio waves received from the contactless information medium 10 via the antenna 210, and operating the reader/writer 202 using information included in the processed electric signals. For example, the output portion 208 has a function of outputting an electric signal including information processed by the processing portion 206. The reader/writer 202 has an anti-collision function, and can receive information from each of the plurality of contactless information mediums 10 of the contactless information medium group 120.

[0092]

As described in “1-3. Electrical Characteristics of Contactless Information Medium 10”, the contactless information medium 10 is adjusted so that the resonant frequency f_r of the resonant circuit 100 configured by using the second capacitor 52 and the second inductor 62 matches or substantially matches the frequency f_c of the radio wave transmitted from the reader/writer 202.

[0093]

In this case, the conventional contactless information medium that does not include the second inductor 62 will be described. For example, in the conventional contactless information medium that does not include the second inductor 62, the resonant frequency f_r is adjusted by increasing the inductance of the antenna by increasing the number of turns of the coil of the antenna. When the antennas having a large number of turns of the coil are close to each other, mutual interference between the coils occurs, and therefore, in a contactless information medium group including the conventional contactless information medium, a resonance frequency of a resonant circuit configured by using an antenna, a capacitor, and an inductor is changed. As a result, the power generated by electromagnetic induction using the resonant circuit changes, and the contactless information medium group including the conventional contactless information medium is not supplied with sufficient power, so that it is difficult to perform accurate wireless communication between the contactless information medium group including the conventional contactless information medium and the reader/writer.

[0094]

In addition, the shape of the coils also affects the mutual interference between the coils. For example, in a contactless information medium group including the conventional contactless information medium,

a region where the coils overlap increases as the shapes of the coils becomes larger. As a result, mutual interference between the coils is likely to occur.

[0095]

5 On the other hand, as described above, in the contactless information medium 10, the capacitance C_b of the second capacitor 52 can be adjusted by using the first cover member 70 and the second cover member 80 so as to suppress variations in the properties or performance of the first capacitor 50. Further, in the contactless information medium
10 10, the inductance L_b of the second inductor 62 can be adjusted by using the second cover member 80 so as to suppress variations in the properties or performance of the first inductor 60 or the coil antenna 30.

[0096]

 Further, in the contactless information medium 10, the number of
15 turns of the coil of the coil antenna 30 is one, which is significantly less than the number of turns of the coil of the antenna of the conventional contactless information medium. Therefore, even in the case where the contactless information medium group 120 including the plurality of contactless information mediums 10 is close to each other, mutual
20 interference between the coils by the coil antenna 30 is less likely to occur.

[0097]

 Therefore, in the contactless information medium communication system 200, even in the case where the contactless information medium group 120 including the plurality of contactless information mediums 10 is
25 close to each other, mutual interference between the coils by the second inductor 62 including the first inductor 60 is less likely to occur.

[0098]

 Therefore, in the contactless information medium communication

system 200, mutual interference between the coils in the contactless information medium group 120 including the plurality of contactless information mediums 10 is suppressed. As a result, in the contactless information medium communication system 200, even in the case where the contactless information medium group 120 including the plurality of contactless information mediums 10 is close to each other, each of the plurality of contactless information mediums 10 is efficiently supplied with power necessary for the operation, thereby starting the operation smoothly. Therefore, in the contactless information medium communication system 200, accurate wireless communication can be performed between the contactless information medium group 120 including the plurality of contactless information mediums 10 and the reader/writer 202.

[0099]

2. Second Embodiment

A contactless information medium 10A according to the second embodiment is different from the contactless information medium 10 according to the first embodiment in that a first cover member 78 in which the first upper cover member 72 and the second upper cover member 82 are integrated and a second cover member 88 in which the first lower cover member 74 and the second lower cover member 84 are integrated are used to form the second capacitor 52 and the second inductor 62, and has a metal ring. In addition, the contactless information medium 10A is different from the contactless information medium 10 in that the substrate 20 is clamped with the first cover member 78 and the second cover member 88, and then the metal ring is attached, and in that state, covered with the protective member. In the contactless information medium 10A, since the other configurations are the same as those of the contactless information medium 10, differences from the contactless information medium 10 will be

mainly described in the description of the contactless information medium 10A.

[0100]

2-1. Configuration of Contactless Information Medium 10A

5 FIG. 11 is a plan view schematically showing the contactless information medium 10A. FIG. 12A is a cross-sectional view of the cross-sectional structure along a line D1-D2 of the contactless information medium 10A shown in FIG. 11, FIG. 12B is a plan view showing a fourth recess 49 shown in FIG. 11, and FIG. 12C is an enlarged view of the fourth
10 recess 49 shown in FIG. 12A. A configuration of the contactless information medium 10A will be described with reference to FIG. 11 and FIG. 12A to FIG. 12C. In the configuration of the contactless information medium 10A, the same or similar configurations as those in FIG. 1 to FIG. 10 may be omitted.

15 [0101]

As shown in FIG. 11 or FIG. 12A, the contactless information medium 10A includes the substrate 20, a metal ring 110, and the protective member 90. The shape and use of the contactless information medium 10A is the same as the contactless information medium 10.

20 [0102]

The coil antenna 30, the IC chip 40, the first capacitor 50, the first inductor 60, and the connecting portions 102 and 104 similar to those of the contactless information medium 10 are arranged in the substrate 20. In addition, the first cover member 78 and the second cover member 88 are
25 arranged in the substrate 20. The substrate 20 is a substrate that supports the coil antenna 30, the IC chip 40, the first capacitor 50, the first inductor 60, the first cover member 78, the second cover member 88, and the connecting portions 102 and 104.

[0103]

The protective member 90 covers the substrate 20, the first cover member 78, the second cover member 88, and the metal ring 110, and forms the appearance shape of the contactless information medium 10. In addition, the protective member 90 protects the substrate 20, the first cover member 78, the second cover member 88, and the metal ring 110 against external impacts. In the contactless information medium 10A, the substrate 20, the first cover member 78, the second cover member 88, and the metal ring 110 are preferably completely covered with the protective member 90. The protective member 90 of the contactless information medium 10A is formed using the same material as the protective member 90 of the contactless information medium 10.

[0104]

Since the configurations of the coil antenna 30, the IC chip 40, the first capacitor 50, the first inductor 60, and the connecting portions 102 and 104 in the contactless information medium 10A are the same as the configurations of the contactless information medium 10, descriptions may be omitted. In this case, the first cover member 78 and the second cover member 88 will be mainly described.

[0105]

The first cover member 78 integrates the first upper cover member 72 and the second upper cover member 82 and includes the first recess 59 and the second recess 69. In addition, the first cover member 78 includes the fourth recess 49. In the first cover member 78, except for the first recess 59, the second recess 69, and the fourth recess 49, a surface of the substrate 20 facing the top surface 22 is in contact with the top surface 22 of the substrate 20. The first recess 59 covers the first electrode 56A of the first capacitor 50, the second recess 69 covers the first inductor 60, and

the fourth recess 49 covers the IC chip 40.

[0106]

Further, in a plan view, the first cover member 78 has a circular plate shape as shown in FIG. 11, similar to the contactless information medium 10A. Further, in a plan view, the diameter of the first cover member 78 is larger than the diameter of the substrate 20, and in a cross-sectional view, a peripheral portion 76 of the first cover member 78 is positioned outside the side surface of the substrate 20 (see FIG. 12A).

[0107]

Furthermore, the first cover member 78 (the first recess 59) has a function of adjusting the capacitance of the contactless information medium 10A, and together with the second cover member 88 (the third recess 58), constitutes the second capacitor 52 in which the capacitance of the contactless information medium 10A is adjusted. In addition, the first cover member 78 (the second recess 69) has a function of adjusting the inductance of the contactless information medium 10A, and constitutes the second inductor 62 in which the inductance of the contactless information medium 10A is adjusted.

[0108]

In addition, a space surrounded by the fourth recess 49 of the first cover member 78, the IC chip 40, and the top surface 22 other than the top surface 22 in contact with the IC chip 40 forms a fourth gap 41, and a distance between the fourth recess 49 and the top surface of the IC chip 40 is referred to as a fourth distance H4 (see FIG. 12A). For example, the fourth distance H4 may be the closest distance (length) between the top surface of the IC chip 40 and the fourth recess 49, and may be the closest distance (length) extending vertically from the substrate 20. For example, in the case where a thickness of the IC chip 40 is thinner than the substrate

20 and the fourth distance H4, the volume of the fourth gap 41 can be approximated by using the fourth distance H4 and a size of the fourth recess 49 (width W7 × width W8) in a top view (see FIG. 12A to FIG. 12C).

[0109]

5 In addition, the fourth gap 41 may be filled with air, and a fourth member 47 may be arranged in the fourth gap 41 as shown in FIG. 12C. The fourth member 47 may be formed using a material having the same dielectric constant as the first cover member 78 and may be formed using a material having a dielectric constant different from that of the first upper
10 cover member 72. In addition, the fourth member 47 may be formed using a material having the same magnetic permeability as the first cover member 78, and may be formed using a material having a magnetic permeability different from that of the first upper cover member 72.

[0110]

15 In the second embodiment, the shape of the first recess 59, the shape of the second recess 69, and the shape of the fourth recess 49 are rectangular recesses opposite the top surface 22 of the substrate 20, and the shape of the third recess 58 is a rectangular recess opposite the bottom surface 24 of the substrate 20, as an example. Similar to the first
20 embodiment, the shapes of the first recess 59, the second recess 69, and the third recess 58 are not limited to the shapes shown here. In addition, the shape of the fourth recess 49 is not limited to the shape shown here. For example, the shapes of the first recess 59, the second recess 69, the third recess 58, and the fourth recess 49 may be recesses having a curved
25 surface facing the top surface 22 of the substrate 20.

[0111]

As described above, the first cover member 78 covers the IC chip 40, the first capacitor 50, and the first inductor 60, and has a function of

protecting the IC chip 40, the first capacitor 50, and the first inductor 60 from the outside.

[0112]

The second cover member 88 integrates the first lower cover member 74 and the second lower cover member 84 and includes the third recess 58. In the second cover member 88 except for the third recess 58, a surface of the substrate 20 facing the bottom surface 24 is in contact with the bottom surface 24. The third recess 58 covers the second electrode 56B of the first capacitor 50.

[0113]

Further, in a plan view, the second cover member 88 has a circular plate shape similar to the contactless information medium 10A. Further, in a plan view, the diameter of the second cover member 88 is greater than the diameter of the substrate 20 and is the same or substantially the same as the first cover member 78.

[0114]

In addition, similar to the first cover member 78, the second cover member 88 has a function of adjusting the capacitance of the contactless information medium 10A, configures the second capacitor 52, and protects the first capacitor 50 from the outside. In addition, similar to the first cover member 78, the second cover member 88 has a function of adjusting the inductance of the contactless information medium 10A, and constitutes the second inductor 62.

[0115]

As shown in FIG. 12A, in a cross-sectional view, a peripheral portion 86 of the second cover member 88 is positioned outside the side surface of the substrate 20. The first through hole 54 and the second through hole 64 according to the first embodiment are not formed in the substrate 20,

and the substrate 20 overlaps the second cover member 88 and the first cover member 78 in a cross-sectional view. The second cover member 88 and the first cover member 78 are assembled to the substrate 20 using a mounting portion 79 of the first cover member 78 at the peripheral portion 86 of the second cover member 88 and at the peripheral portion 76 of the first cover member 78 and sandwich the substrate 20. As a result, the second cover member 88 and the first cover member 78 cover the substrate 20 and have a function of protecting the substrate 20 from the outside.

[0116]

Similar to the first upper cover member 72, the first lower cover member 74, the shape of the second upper cover member 82, and the second lower cover member 84 according to the first embodiment, for example, the first cover member 78 and the second cover member 88 are molded by injection molding using a material similar to the protective member 90.

[0117]

In addition, the first cover member 78 and the second cover member 88 are not limited to the configuration described in the second embodiment. The first cover member 78 and the second cover member 88 may be configured to have a function of adjusting the capacitance and inductance of the contactless information medium 10 and to protect the IC chip 40, the first capacitor 50, and the first inductor 60 from the outside.

[0118]

As described above, the second capacitor 52 according to the second embodiment is configured using at least the first cover member 78 (the first recess 59) and the second cover member 88 (the third recess 58). In addition, the second inductor 62 according to the second embodiment is configured using at least the first cover member 78 (the second recess 69).

The second capacitor 52 and the second inductor 62 according to the second embodiment have the same configuration as the second capacitor 52 and the second inductor 62 according to the first embodiment described in "1-3. Electrical Characteristics of Contactless Information Medium 10".

5 Therefore, descriptions of the second capacitor 52 and the second inductor 62 according to the second embodiment will be omitted.

[0119]

Further, in the contactless information medium 10A, the second capacitor 52 and the second inductor 62 are used to form the resonant
10 circuit 100 (see FIG. 4A). The resonant circuit 100 of the contactless information medium 10A has the same configuration as the resonant circuit 100 of the contactless information medium 10 described in "1-3. Electrical Characteristics of Contactless Information Medium 10". Therefore, descriptions of the resonant circuit 100 of the contactless information
15 medium 10A will be omitted.

[0120]

The metal ring 110 is inscribed in the peripheral portion 76 of the first cover member 78 and the peripheral portion 86 of the second cover member 88, and has a function of closing the portions (connecting portion
20 of the first cover member 78 and the second cover member 88) assembled to the substrate 20 using the mounting portion 79, and can function as a weight member for applying weight to the contactless information medium 10. For example, brass, aluminum, or the like can be used as a material forming the metal ring 110. The shape of the metal ring 110 is annular or
25 generally annular and includes a slit 112 in which part of the metal ring 110 is cut (see FIG. 11). In other words, the shape of the metal ring 110 is C-shaped including the slit 112. Since the metal ring 110 includes the slit 112, generation of eddy currents due to radio waves transmitted from the

reader/writer 202 can be suppressed. As a result, the contactless information medium 10 includes the metal ring 110 including the slit 112, whereby loss of power due to eddy currents can be suppressed, and stable wireless communication with the reader/writer 202 can be performed.

5 [0121]

The inner diameter of the metal ring 110 is the same or substantially the same as the diameter of the first cover member 78 and the second cover member 88. In a plan view, the slit 112 is arranged on an extension line 114 connecting the position where the IC chip 40 is arranged and the
10 position where the second capacitor 52 is arranged, and on the opposite side of the IC chip 40 to the position where the second capacitor 52 is arranged. With this configuration, since the slit 112 is positioned away from the IC chip 40 and the second capacitor and part of the metal ring 110 without the slit 112 is positioned close to the IC chip 40 and the second
15 capacitor, the IC chip 40 and the second capacitor are protected by the side surfaces of the metal ring 110. As a result, even when the contactless information medium 10A is subjected to an external impact, the impact is absorbed by the metal ring 110, so that the impact transmitted to the IC chip 40 and the second capacitor can be reduced. In addition, since the first
20 inductor 60 is arranged in the vicinity of the IC chip 40 and the second capacitor, the first inductor 60 is also protected by the metal ring 110.

[0122]

As described above, in the contactless information medium 10A, the capacitance and the inductance can be adjusted by using the member (the
25 first cover member 78 and the second cover member 88) capable of adjusting both the capacitance C_b of the second capacitor 52 and the inductance L_b of the second inductor 62 at one time. Therefore, in the contactless information medium 10A, the capacitance and the inductance

are more easily adjustable. As a result, in the contactless information medium 10A, the capacitance C_b and the inductance L_b can be adjusted by using the first cover member 78 and the second cover member 88 so as to suppress variations in the properties or performance of both the first capacitor 50 and the first inductor 60.

[0123]

Further, in the contactless information medium 10A, the top surface 22 other than a region where the first recess 59, the second recess 69, and the fourth recess 49 are arranged is in contact with the first cover member 78 and is covered with the first cover member 78. In the bottom surface 24 of the substrate 20, the bottom surface 24 other than a region where the third recess 58 is arranged is in contact with the second cover member 88 and covered with the second cover member 88. Therefore, the first cover member 78 and the second cover member 88 can protect the substrate 20 and reinforce the substrate 20. In addition, the periphery of the first cover member 78 and the second cover member 88 is also protected by the metal ring 110. As a result, the strength of the contactless information medium 10A increases, and the contactless information medium 10A has higher impact resistance.

[0124]

2-2. Method for manufacturing Contactless Information Medium 10A

A method for manufacturing the contactless information medium 10A will be described with reference to FIG. 11, FIG. 13 to FIG. 19. In the method for manufacturing the contactless information medium 10A, the same or similar configurations as those in FIG. 1 to FIG. 10 may be omitted.

[0125]

FIG. 19 is a flowchart showing a method for manufacturing the contactless information medium 10A. The contactless information medium

10A is manufactured by the manufacturing method shown in step S40 to step S44. The method for manufacturing the contactless information medium 10A is not limited to the manufacturing method shown in FIG. 19, and may include another step.

5 [0126]

First, the step S40 shown in FIG. 19 will be described with reference to FIG. 13 and FIG. 14. Since the step S40 is the same as the step S30 shown in FIG. 9, detailed descriptions will be omitted. In addition, in the second embodiment, a contactless information medium 12A, which is in a
10 condition before the first cover member 78 and the second cover member 88 are arranged in the substrate 20, is formed by the step S40.

[0127]

Next, in the step S41 shown in FIG. 19, the resonant frequency is adjusted using the contactless information medium 12A. Since the step
15 S41 is the same as the step S31 shown in FIG. 9, detailed descriptions will be omitted. Further, in the second embodiment, one first cover member 78 and one second cover member 88 are selected from a plurality of first cover members 78 and a plurality of second cover members 88 so as to coincide with or substantially coincide with the frequency f_c of the radio
20 wave transmitted from the reader/writer 202 using the resonant frequency obtained by the step S41.

[0128]

Next, the step S42 shown in FIG. 19 will be described with reference to FIG. 17, FIG. 16A, and FIG. 16B. In the step S42, the first cover
25 member 78 and the second cover member 88 selected in the step S41 are implemented in the contactless information medium 12A. Specifically, in the peripheral portion 86 of the second cover member 88 and the peripheral portion 76 of the first cover member 78, the second cover member 88 and

the first cover member 78 are assembled to and sandwich the substrate 20 using the mounting portion 79 of the first cover member.

[0129]

The first capacitor 50 is sandwiched by the first recess 59 of the first
5 cover member 78 and the third recess 58 of the second cover member 88,
and is covered with the first recess 59 of the first cover member 78 and the
third recess 58 of the first cover member 78. In addition, the first inductor
60 is sandwiched by the second recess 69 of the first cover member 78 and
the second cover member 88, and covered with the first cover member 78.
10 Further, the IC chip 40 is sandwiched by the fourth recess 49 of the first
cover member 78 and the second cover member 88, and covered with the
first cover member 78.

[0130]

As a result, in the step S42, the second capacitor 52 and the second
15 inductor 62 are formed, and the resonant circuit 100 (FIG. 4A) is formed
using the second capacitor 52 and the second inductor 62. In addition, the
second cover member 88 and the first cover member 78 cover the substrate
20, protect the substrate 20 from the outside and protect the IC chip 40.

[0131]

20 Next, the step S43 shown in FIG. 19 will be described with reference
to FIG. 17, FIG. 18A, and FIG. 18B. In the step S43, the metal ring 110 is
implemented. Specifically, the metal ring 110 is arranged so as to be
inscribed on the peripheral portion 76 of the first cover member 78 and the
peripheral portion 86 of the second cover member 88. In this case, the slit
25 112 is arranged on the extension line 114 connecting the position where the
IC chip 40 is arranged and the position where the first capacitor 50 is
arranged.

[0132]

Finally, in the step S44 shown in FIG. 19, injection molding is used to mold the first cover member 78 and the second cover member 88 arranged on the substrate 20 and the protective member 90 that covers the metal ring 110. Specifically, the resin is injected onto the first cover member 78 and the second cover member 88 arranged on the substrate 20 arranged in the mold, and the resin is molded at a predetermined temperature and pressure, so that the protective member 90 covering the first cover member 78 and the second cover member 88 arranged on the substrate 20 and the metal ring 110 is molded.

10 [0133]

In this case, since the portions (the connecting portion of the first cover member 78 and the second cover member 88) assembled to the substrate 20 using the mounting portion 79 are closed by the metal ring 110, members or elements such as the coil antenna 30, the first capacitor 50 and the first inductor 60, the first cover member 78, and the second cover member 88 are protected from the pressure of the resin during injection molding.

[0134]

The contactless information medium 10A is manufactured using the manufacturing method described above. In addition, as described above, the capacitor and the inductor are protected by using the protective member 90, the first cover member 78, and the second cover member 88 in the contactless information medium 10A. Therefore, in the contactless information medium 10A, the capacitance of the capacitor and the inductance of the inductor can be easily adjusted without damaging the capacitor and the inductor. In addition, the contactless information medium 10A has higher impact resistance by including the metal ring 110.

25 [0135]

Each of the contactless information medium, the method for manufacturing the contactless information medium, and the contactless information medium communication system described above as an embodiment of the present invention can be appropriately combined and implemented as long as no contradiction is caused. Further, the addition, deletion, or design change of components as appropriate by those skilled in the art based on each embodiment are also included in the scope of the present invention as long as they are provided with the gist of the present invention.

10 [0136]

Further, it is understood that, even if the effect is different from those provided by each of the above-described embodiments, the effect obvious from the description in the specification or easily predicted by persons ordinarily skilled in the art is apparently derived from the present invention.

15

REFERENCES SIGNS LIST

[0137]

1: contactless information medium, 10A: contactless information medium, 12: contactless information medium, 12A: contactless information medium, 20: substrate, 22: top surface, 24: bottom surface, 30: coil antenna, 40: IC chip, 41: fourth gap, 42: control unit, 44: communication unit, 46: memory unit, 47: fourth member, 49: fourth recess, 50: first capacitor, 51: first gap, 52, second capacitor, 53: third gap, 55: first member, 56A: first electrode, 54: first through hole, 56B: second electrode, 57: third member, 58: third recess, 59: first recess, 60: first inductor, 61: second gap, 62: second inductor, 63: second member, 64: second through hole, 69: second recess, 70: first cover member, 72: first upper cover member, 74: first lower cover member, 76: peripheral portion, 78: first cover member, 79: mounting

portion, 80: second cover member, 82: second upper cover member, 84:
second lower cover member, 86: peripheral portion, 88: second cover
member, 90: protective member, 100: resonant circuit, 100A: resonant
circuit, 102, 104: connecting portion, 110: metal ring, 112: slit, 114:
5 extension line, 120: contactless information medium group, 200:
contactless information medium communication system, 202: reader/writer,
204: input portion, 206: processing portion, 208: output portion, 210:
antenna

CLAIMS

1. A contactless information medium comprising:
 - a substrate including a first surface and a second surface;
 - 5 a coil antenna arranged on the first surface or the second surface;
 - a capacitor electrically connected to the coil antenna, and including
 - a first electrode arranged on the first surface and a second electrode
 - arranged on the second surface facing the first surface; and
 - a first cover member having a first recess covering the first electrode
 - 10 and forming a first gap between the first recess and the first electrode.
2. The contactless information medium according to claim 1, further comprising a protective member covering the first cover member,
 - wherein the protective member is different from the first cover
 - 15 member.
3. The contactless information medium according to claim 2, further comprising:
 - an inductor arranged on the first surface and electrically connected
 - 20 to the coil antenna and the first electrode; and
 - a second cover member including a second recess covering the
 - inductor and forming a second gap between the second recess and the
 - inductor;
 - wherein the protective member is in contact with the substrate
 - 25 between the first cover member and the second cover member.
4. The contactless information medium according to claim 1,
 - wherein a dielectric constant of a material arranged in the first gap

is different from that of the first cover member.

5. The contactless information medium according to claim 3,
wherein a magnetic permeability of a material arranged in the
5 second gap is different from that of the second cover member.

6. The contactless information medium according to claim 3,
wherein a first distance between the first electrode and the first
cover member is different from a second distance between the inductor and
10 the second cover member.

7. The contactless information medium according to claim 6,
wherein the number of turns of the coil antenna is one.

15 8. The contactless information medium according to claim 3, further
comprising an IC chip arranged on the first surface and electrically
connected to the coil antenna, the capacitor, and the inductor.

9. The contactless information medium according to claim 1, further
20 comprising an inductor arranged on the first surface and electrically
connected to the first electrode and the coil antenna;

wherein the first cover member includes a second recess covering
the inductor and forms a second gap between the second recess and the
inductor.

25

10. The contactless information medium according to claim 9, further
comprising:

a third recess covering the second electrode; and

a second cover member forming a third gap between the third recess and the second electrode.

11. The contactless information medium according to claim 9,
5 wherein a dielectric constant of a material arranged in the first gap is different from that of the first cover member.

12. The contactless information medium according to claim 9,
wherein a magnetic permeability of a material arranged in the
10 second gap is different from that of the first cover member.

13. The contactless information medium according to claim 10,
wherein a dielectric constant of a material arranged in the third gap is different that of the second cover member.

15
14. The contactless information medium according to claim 10,
wherein a third distance between the third recess and the second electrode is different from a first distance between the first electrode and the first cover member or a second distance between the inductor and the
20 first cover member.

15. The contactless information medium according to claim 14,
wherein the number of turns of the coil antenna is one.

25 16. The contactless information medium according to claim 14, further comprising an IC chip arranged on the first surface and electrically connected to the coil antenna, the capacitor, and the inductor.

17. The contactless information medium according to claim 16, further comprising a metal ring having a slit;

wherein the first cover member includes a mounting portion at a periphery of the first cover member,

5 the mounting portion contacts a periphery of the second cover member, and

the metal ring contacts the periphery of the first cover member and the periphery of the second cover member.

10 18. The contactless information medium according to claim 17,

wherein, in a plan view, the slit is arranged on an extension line connecting a position where the IC chip is arranged and a position where the capacitor is arranged, and is arranged on the opposite side to the position where the capacitor is arranged with respect to the position where
15 IC chip is arranged.

19. The contactless information medium according to claim 18, further comprising a protective member arranged to cover the first cover member, the second cover member and the metal ring.

20

20. The contactless information medium according to claim 19,

wherein the first cover member includes a fourth recess and forms a fourth gap between the fourth recess and the IC chip.