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(54) **ANTENNA MODULE AND MAGNETIC SHEET WITH COIL PATTERN**

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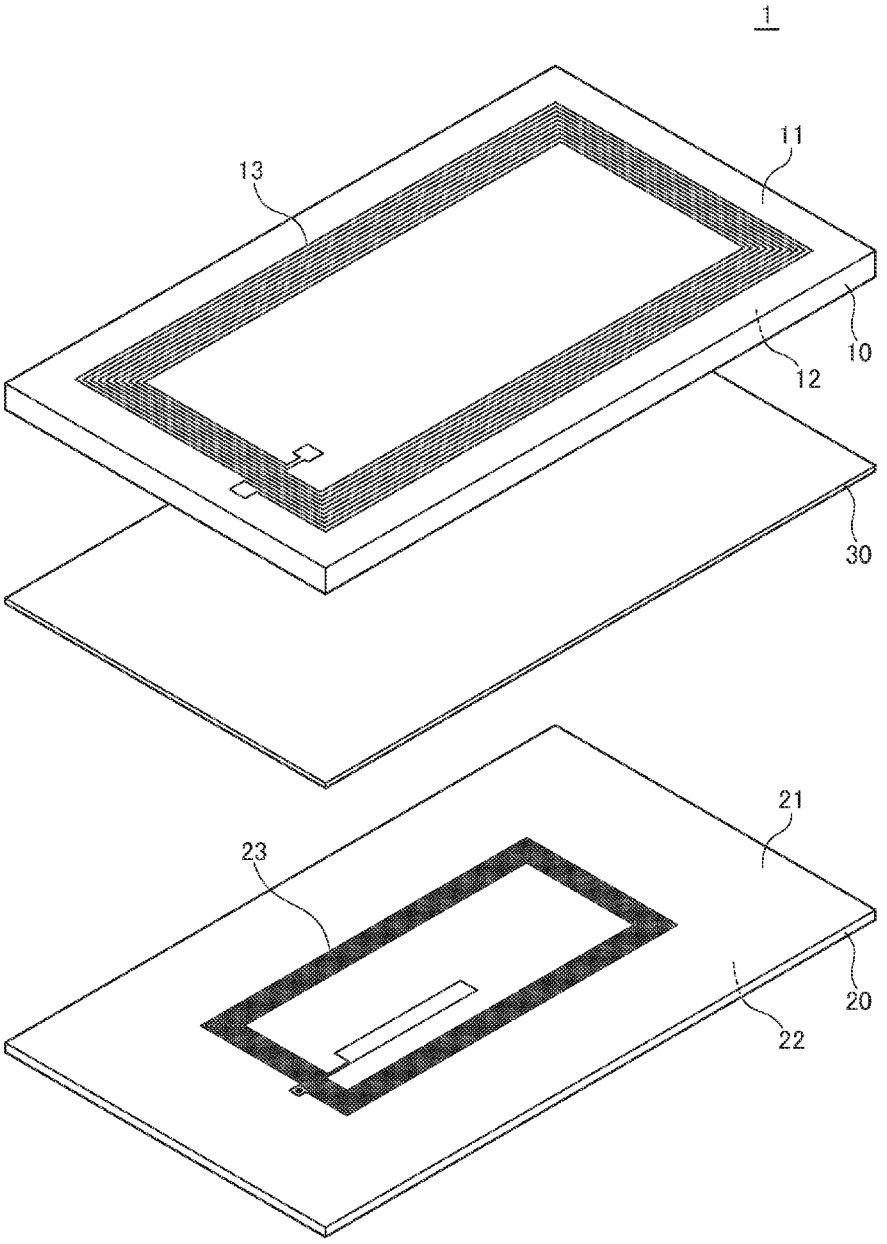
(57) **ABSTRACT**

Disclosed herein is an antenna module that includes a substrate on which a first coil is provided, a base material on which a second coil and a magnetic sheet overlapping the second coil are provided, and an adhesive layer bonding the substrate and the base material such that the first coil and the magnetic sheet overlap each other.



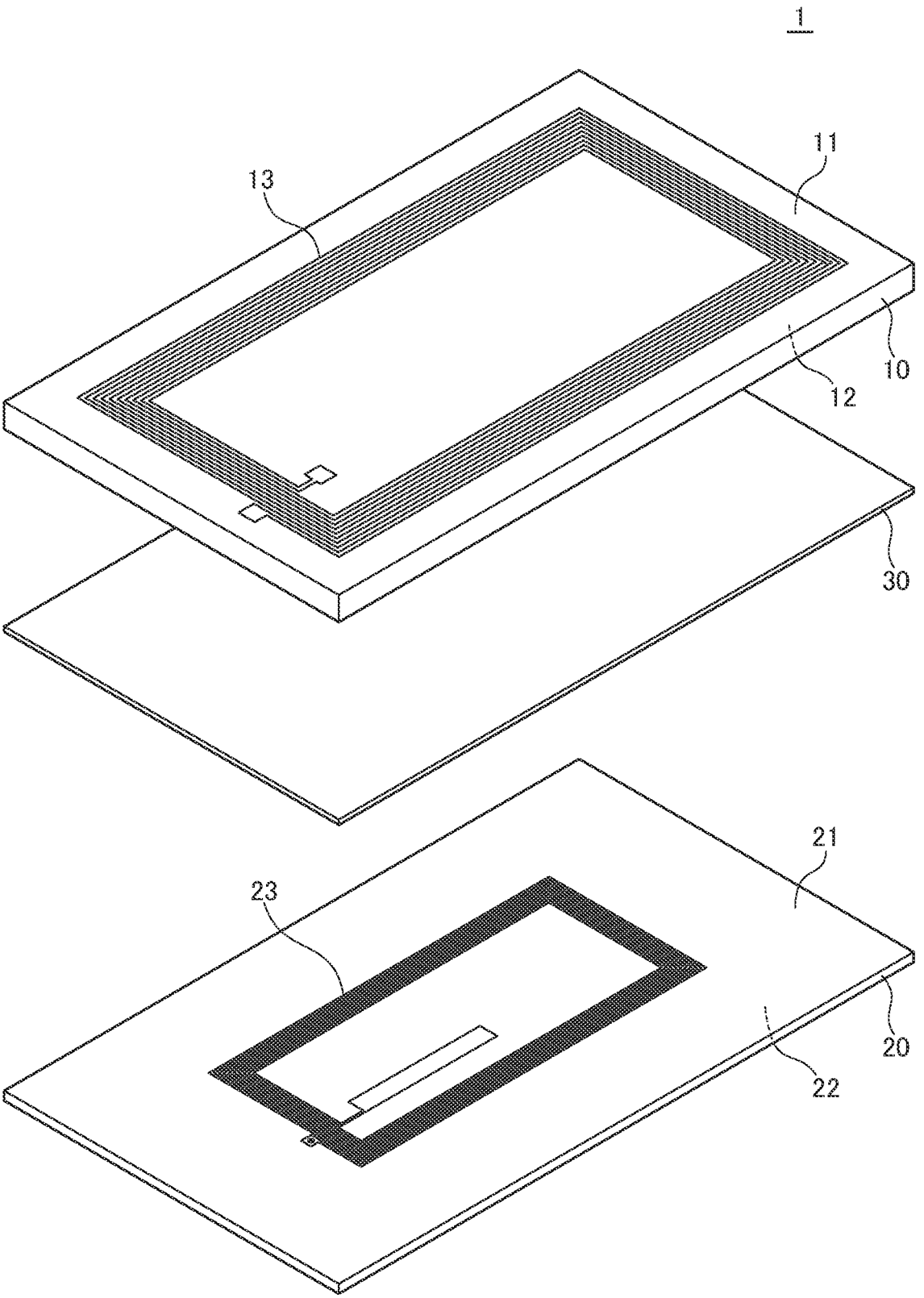


FIG. 1

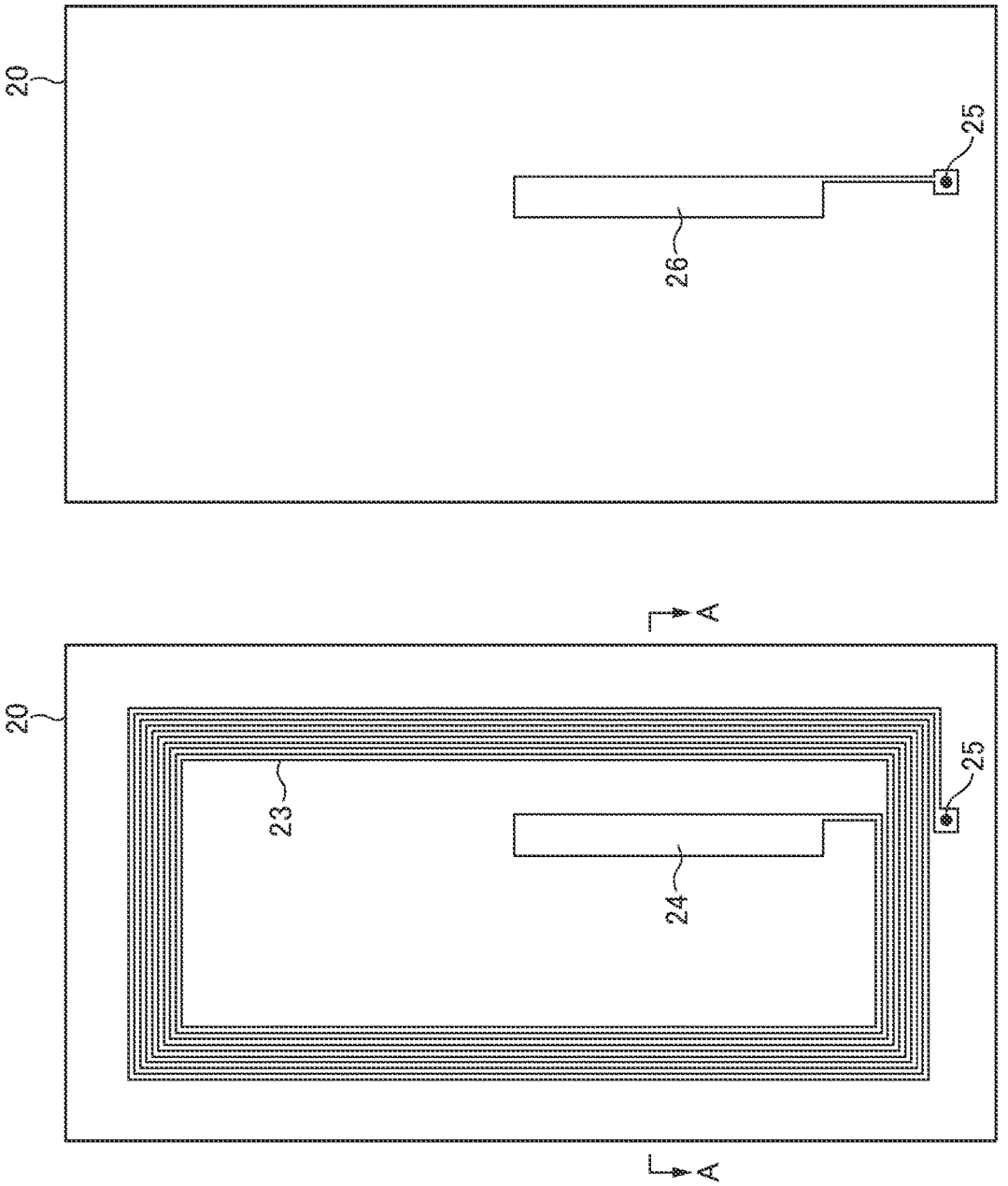


FIG. 2B

FIG. 2A

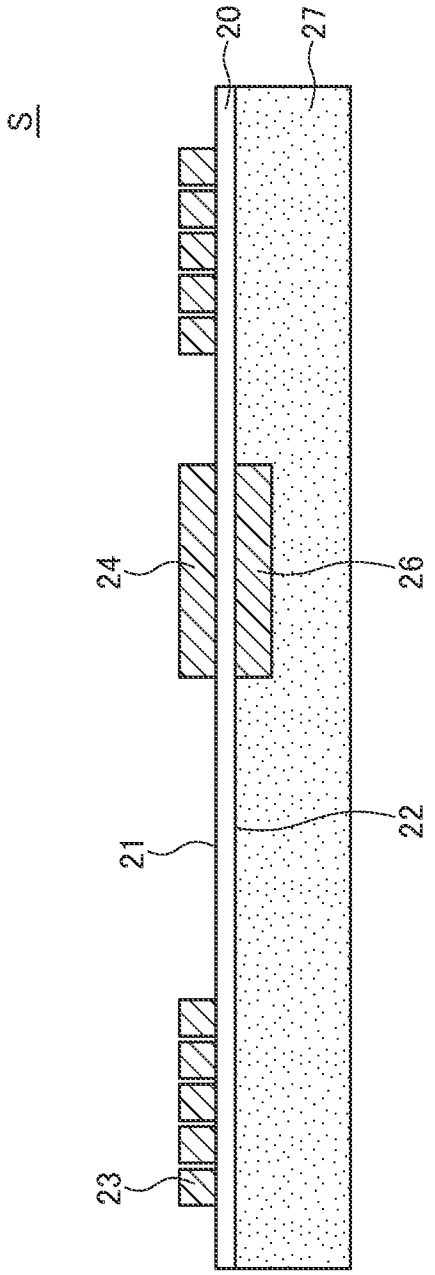


FIG. 3

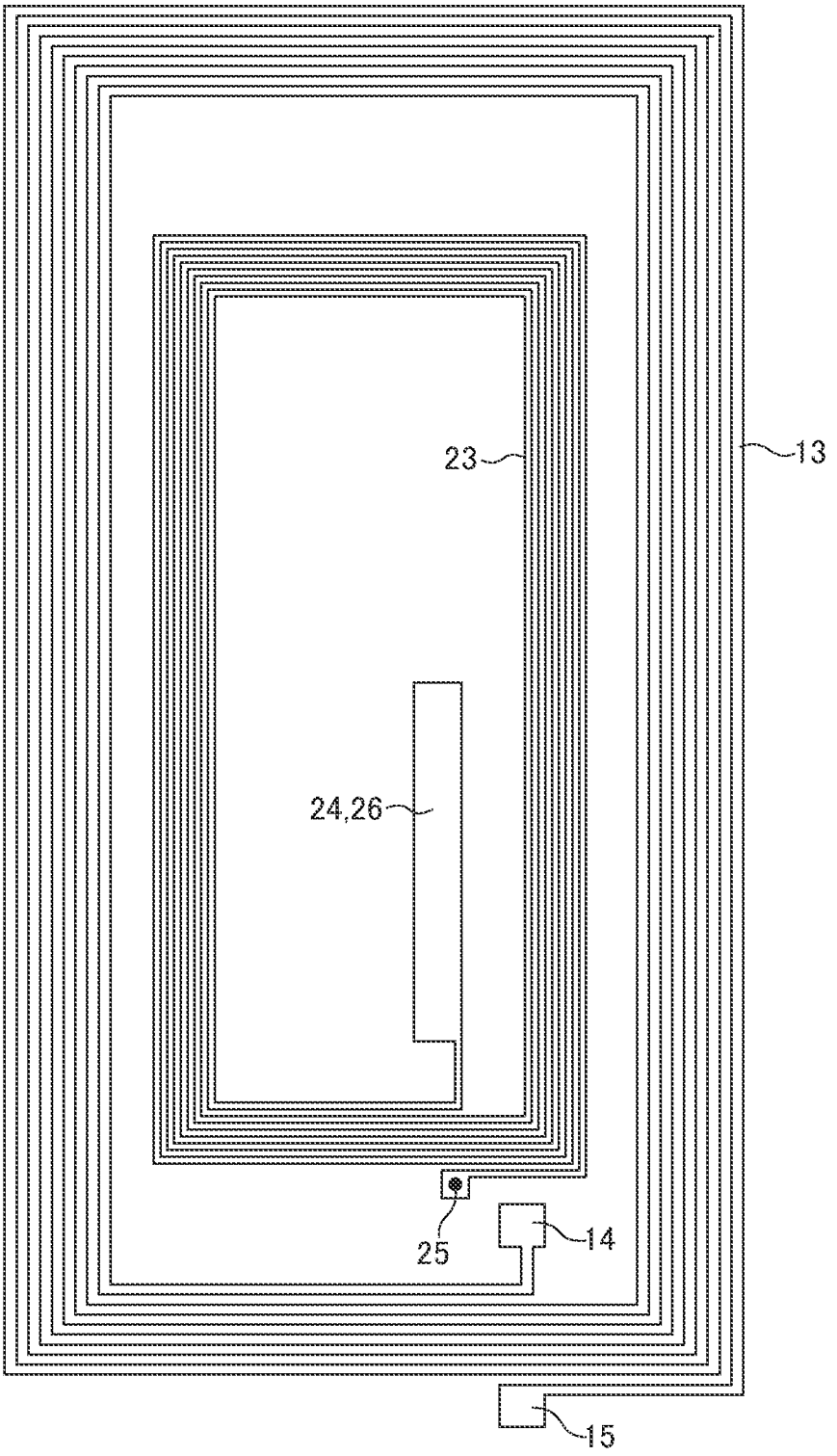


FIG. 4

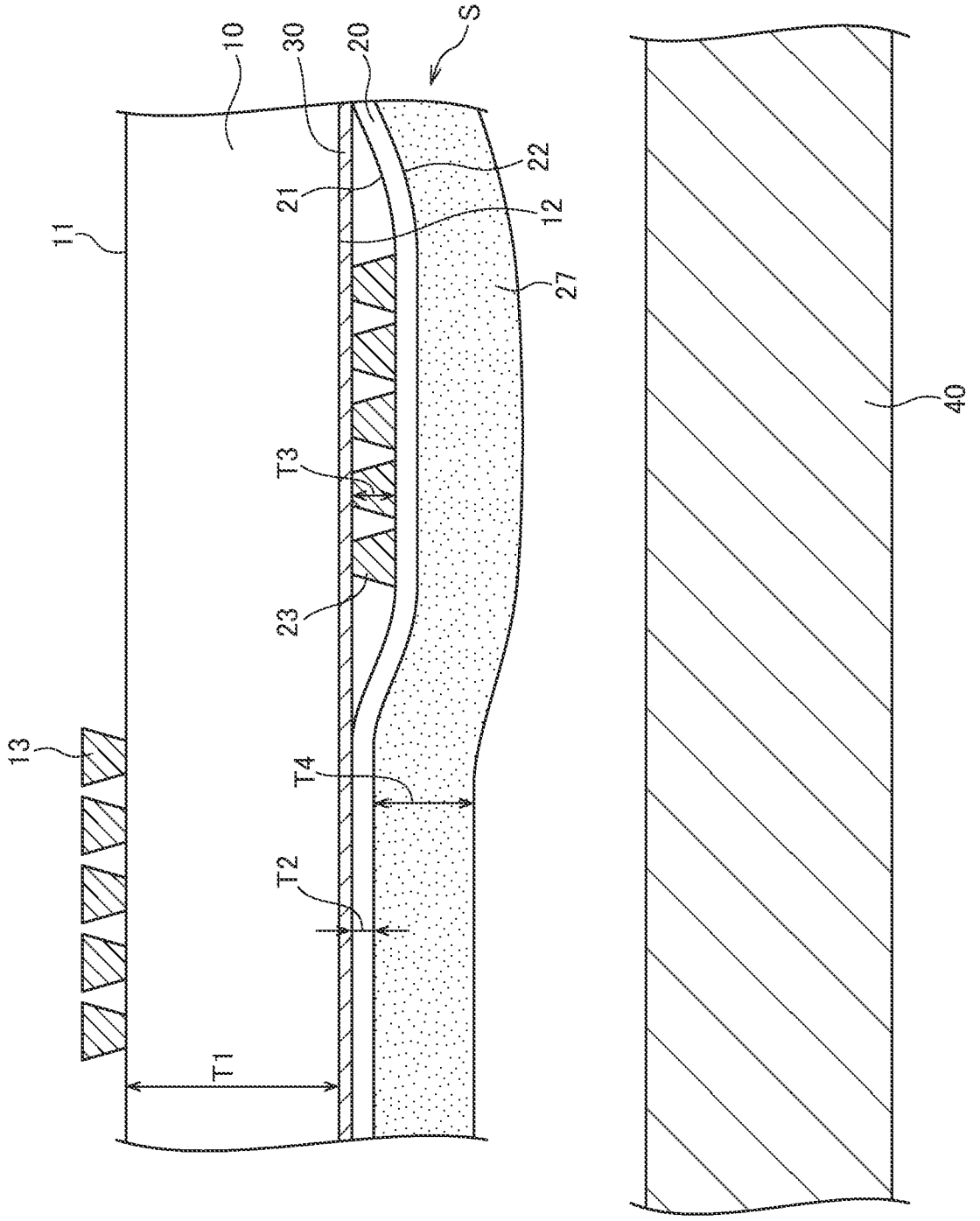


FIG. 5

ANTENNA MODULE AND MAGNETIC SHEET WITH COIL PATTERN

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Japanese Patent Application No. 2021-083624, filed on May 18, 2021, the entire disclosure of which is incorporated by reference herein.

BACKGROUND

Field

[0002] The present disclosure relates to an antenna module and a magnetic sheet with a coil pattern.

Description of Related Art

[0003] The antenna module described in JP 2011-066759A has a structure in which an antenna coil and a booster coil are formed on the front and back surfaces of a substrate, respectively.

[0004] However, when a booster coil is formed on the back surface of a substrate on the front surface of which an antenna coil is formed like the antenna module described in JP 2011-066759A, the booster coil cannot be changed in design afterward. Thus, in conventional antenna coils having a plurality of coils, it is difficult to change the design of some coils afterward.

SUMMARY

[0005] It is therefore an object of the present disclosure to provide an antenna module in which a design change of some coils can be made afterward.

[0006] An antenna module according to an embodiment of the present disclosure includes: a substrate on which a first coil is provided; a base material on which a second coil and a magnetic sheet overlapping the second coil are provided; and an adhesive layer bonding the substrate and base material such that the first coil and the magnetic sheet overlap each other. This allows the design of the second coil to be changed afterward.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above features and advantages of the present disclosure will be more apparent from the following description of certain preferred embodiments taken in conjunction with the accompanying drawings, in which:

[0008] FIG. **1** is a schematic exploded perspective view illustrating the outer appearance of an antenna module **1** according to an embodiment;

[0009] FIGS. **2**A and **2**B are schematic plan views illustrating a pattern shape as viewed from the surface **21** of the base material **20**, where FIG. **2**A illustrates a pattern formed on the surface **21** of the base material **20**, and FIG. **2**B illustrates a pattern formed on a surface **22** of the base material **20**;

[0010] FIG. **3** is a schematic cross-sectional view taken along the line A-A in FIG. **2**A;

[0011] FIG. **4** is a schematic plan views for explaining a positional relationship between the antenna coil **13** and the booster coil **23**; and

[0012] FIG. **5** is a partial cross-sectional view of the antenna module **1**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0013] Preferred embodiments of the present disclosure will be explained below in detail with reference to the accompanying drawings.

[0014] FIG. **1** is a schematic exploded perspective view illustrating the outer appearance of an antenna module **1** according to an embodiment.

[0015] As illustrated in FIG. **1**, the antenna module **1** according to the present embodiment includes a rigid substrate **10** made of, for example, epoxy resin, a flexible base material **20** made of, for example, PET resin, and an adhesive layer **30** that bonds the substrate **10** and base material **20**. An antenna coil **13** as an example of a first coil used for NFC (Near Field Communication), is formed on one surface **11** of the substrate **10**. A booster coil **23** as an example of a second coil, which is a coil pattern for extending communication distance, is formed on one surface **21** of the base material **20**.

[0016] FIGS. **2**A and **2**B are schematic plan views illustrating a pattern shape as viewed from the surface **21** of the base material **20**. FIG. **2**A illustrates a pattern formed on the surface **21** of the base material **20**, and FIG. **2**B illustrates a pattern formed on a surface **22** of the base material **20**. FIG. **3** is a schematic cross-sectional view taken along the line A-A in FIG. **2**A.

[0017] As illustrated in FIG. **2**A, the booster coil **23** is wound around in a plurality of turns on the surface **21** of the base material **20**. In the example illustrated in FIG. **2**A, the booster coil **23** is wound in five turns and has a rectangular outer shape; however, the number of turns of the booster coil **23** and the outer shape thereof are not limited thereto. Further, in the example illustrated in FIG. **2**A, although the booster coil **23** is formed on the surface **21** of the base material **20**, it may be formed on the surface **22** of the base material **20**, or may be formed on both the surfaces **21** and **22** of the base material **20**. The inner peripheral end of the booster coil **23** is connected to a capacitor electrode pattern **24**. The outer peripheral end of the booster coil **23** is connected to a capacitor electrode pattern **26** illustrated in FIG. **2**B through a via conductor **25** that runs through the base material **20**. As illustrated in FIG. **3**, the capacitor electrode patterns **24** and **26** face each other through the base material **20** to thereby constitute a capacitor. Thus, both ends of the booster coil **23** are connected respectively to the capacitor electrode patterns **24** and **26** of the capacitor, whereby the booster coil **23** constitutes a closed circuit connected to no external circuit.

[0018] As illustrated in FIG. **3**, a magnetic sheet **27** is formed on the surface **22** of the base material **20**, thereby constituting a magnetic sheet S with coil pattern. The magnetic sheet **27** is made of a composite magnetic material obtained by mixing metal magnetic powder such as permalloy and resin and has flexibility. Since the base material **20** itself has flexibility, the magnetic sheet S with coil pattern has flexibility as a whole. The magnetic sheet **27** is formed entirely on the surface **22** of the base material **20** so as to overlap the booster coil **23** in a plan view and covers the upper and side surfaces of the capacitor electrode pattern **26** so as to embed therein the capacitor electrode pattern **26**. An insulating film may be provided between the capacitor

electrode pattern **26** and the magnetic sheet **27** so as to ensure insulation. Alternatively, in place of the magnetic sheet **27** made of a composite magnetic material, a film-like magnetic sheet **27** having flexibility may be attached to the surface **22** of the base material **20** by a double-sided tape or the like.

[0019] The surface **21** of the thus configured magnetic sheet S with coil pattern is attached to the surface **12** of the substrate **10** through the adhesive layer **30**. In this state, the antenna coil **13** and the magnetic sheet **27** overlap each other in a plan view and, as illustrated in FIG. **4**, the opening area of the antenna coil **13** and the booster coil **23** overlap each other in a plan view. An inner peripheral end **14** and an outer peripheral end **15** of the antenna coil are connected to a not-shown NFC circuit. The NFC circuit may be mounted on the substrate **10** itself or on another substrate.

[0020] As described above, the antenna module **1** according to the present embodiment has, as separate members, the substrate **10** on which the antenna coil **13** is formed and the base material **20** on which the booster coil **23** is formed, thus allowing the booster coil **23** to be designed and manufactured independently of the antenna coil **13**. This allows the design of the booster coil **23** to be changed after manufacturing the antenna coil **13**. In addition, the magnetic sheet S with coil pattern has flexibility as a whole, so that even when unevenness is present on the surface **12** of the substrate **10**, the magnetic sheet S with coil pattern can be tightly attached to the substrate **10**.

[0021] FIG. **5** is a partial cross-sectional view of the antenna module **1** according to the present embodiment.

[0022] As illustrated in FIG. **5**, when the magnetic sheet S with coil pattern is attached to the substrate **10**, the base material **20** and magnetic sheet **27** are deformed due to flexibility thereof at a region where the booster coil **23** is formed. That is, the surface **21** of the base material is in direct contact with the adhesive layer **30** at a region where the booster coil **23** is not formed, whereas the booster coil **23** is interposed between the base material **20** and the adhesive layer **30** at the region where the booster coil **23** is formed. Accordingly, the distance between the magnetic sheet **27** and the surface **12** of the substrate **10** is smaller at the region absent of the booster coil **23** than at the formation region of the booster coil **23**. As a result, the distance between the antenna coil **13** and the magnetic sheet **27** becomes small, making it possible to extend communication distance.

[0023] Further, in the present embodiment, a thickness T**2** (e.g., about 23 μm) of the base material **20** is smaller than a thickness T**1** (e.g., about 0.8 mm) of the substrate **10**. Accordingly, the distance between the booster coil **23** and the antenna coil **13** is larger than the distance between the booster coil **23** and the magnetic sheet **27**, so that it is possible to reduce influence that a metal member **40** such as a battery disposed to face the magnetic sheet **27** has on the antenna coil **13**. In addition, the thickness T**2** of the base material **20** is smaller than a thickness T**3** of the booster coil **23**, whereby the booster coil **23** is partly radially covered with the magnetic sheet **27**. This can further enhance the communication distance extension effect by the booster coil **23**. The thickness T**3** of the booster coil **23** is, for example, about 35 μm. A thickness T**4** of the magnetic sheet **27** needs to be set to a value that can provide sufficient magnetic characteristics and flexibility and is, for example, about 100 μm. By thus making the thickness T**2** of the base material **20** smaller than the thickness T**3** of the booster coil **23** and the thickness T**4** of the magnetic sheet **27**, sufficient flexibility can be ensured.

[0024] Further, the antenna coil **13** formed on the surface **11** of the substrate **10** has a sectional shape in which the pattern width thereof becomes larger with increasing distance from the surface **11** of the substrate **10**; on the other hand, the booster coil **23** formed on the surface **21** of the base material **20** has a sectional shape in which the pattern width thereof becomes smaller with increasing distance from the surface **21** of the base material **20**. This reduces a stray capacitance occurring between the antenna coil **13** and the booster coil **23**, making it possible to reduce a change in characteristics ascribable to the stray capacitance.

[0025] While the preferred embodiment of the present disclosure has been described, the present disclosure is not limited to the above embodiment, and various modifications may be made within the scope of the present disclosure, and all such modifications are included in the present disclosure.

[0026] The technology according to the present disclosure includes the following configuration examples, but not limited thereto.

[0027] An antenna module according to an embodiment of the present disclosure includes: a substrate on which a first coil is provided; a base material on which a second coil and a magnetic sheet overlapping the second coil are provided; and an adhesive layer bonding the substrate and base material such that the first coil and the magnetic sheet overlap each other. This allows the design of the second coil to be changed afterward.

[0028] Each of the base material and the magnetic sheet may have flexibility. This allows the base material to be tightly attached to the substrate even when the substrate has surface unevenness.

[0029] The first coil may be provided on a first surface of the substrate, the second coil may be provided on a first surface of the base material, the magnetic sheet may be provided on a second surface of the base material, the adhesive layer may bond a second surface of the substrate and the first surface of the base material, and the distance between the magnetic sheet and the second surface of the substrate may be smaller at a region where the second coil is not provided than at a region where the second coil is provided. This can reduce the distance between the first coil and the magnetic sheet.

[0030] The base material may be thinner than the substrate, whereby the distance between the second coil and the first coil may be larger than the distance between the second coil and the magnetic sheet. This can reduce the influence of a metal member disposed so as to face the magnetic sheet.

[0031] The base material may be thinner than the second coil, and the second coil may be partly radially covered with the magnetic sheet. This can further enhance a communication distance extension effect by the second coil.

[0032] The antenna module may further include a pair of capacitor electrode patterns provided respectively on the first and second surfaces of the base material so as to face each other through the base material, and the inner and outer peripheral ends of the second coil may be connected respectively to the pair of capacitor electrode patterns. This allows the adjustment of a resonance frequency without using a chip capacitor or the like.

[0033] The first coil may have a sectional shape in which the pattern width thereof becomes larger with increasing

distance from the first surface of the substrate, and the second coil may have a sectional shape in which the pattern width thereof becomes smaller with increasing distance from the first surface of the base material. This can reduce a change in characteristics ascribable to a stray capacitance.

[0034] A magnetic sheet with a coil pattern according to an embodiment of the present disclosure includes: a flexible base material; a coil pattern provided on any surface of the base material and constituting a closed circuit; and a flexible magnetic sheet provided on any surface of the base material so as to overlap the coil pattern, wherein the base material is thinner than the magnetic sheet and the conductor thickness of the coil pattern. Attaching the thus configured magnetic sheet with coil pattern to a substrate having an antenna coil allows communication distance to be extended.

What is claimed is:

1. An antenna module comprising:

a substrate on which a first coil is provided;

a base material on which a second coil and a magnetic sheet overlapping the second coil are provided; and

an adhesive layer bonding the substrate and the base material such that the first coil and the magnetic sheet overlap each other.

2. The antenna module as claimed in claim **1**, wherein each of the base material and the magnetic sheet has flexibility.

3. The antenna module as claimed in claim **2**,

wherein the first coil is provided on a first surface of the substrate,

wherein the second coil is provided on a first surface of the base material,

wherein the magnetic sheet is provided on a second surface of the base material,

wherein the adhesive layer bonds a second surface of the substrate and the first surface of the base material, and

wherein a distance between the magnetic sheet and the second surface of the substrate is smaller at a region where the second coil is not provided than at a region where the second coil is provided.

4. The antenna module as claimed in claim **3**, wherein the base material is thinner than the substrate, whereby a distance between the second coil and the first coil is larger than a distance between the second coil and the magnetic sheet.

5. The antenna module as claimed in claim **4**,

wherein the base material is thinner than the second coil, and

wherein the second coil is partly radially covered with the magnetic sheet.

6. The antenna module as claimed in claim **3**, further comprising a pair of capacitor electrode patterns provided respectively on the first and second surfaces of the base material so as to face each other through the base material,

wherein inner and outer peripheral ends of the second coil are connected respectively to the pair of capacitor electrode patterns.

7. The antenna module as claimed in claim **3**,

wherein the first coil has a sectional shape in which a pattern width thereof becomes larger with increasing distance from the first surface of the substrate, and

wherein the second coil has a sectional shape in which a pattern width thereof becomes smaller with increasing distance from the first surface of the base material.

8. A magnetic sheet with a coil pattern comprising:

a flexible base material;

a coil pattern provided on any surface of the base material and constituting a closed circuit; and

a flexible magnetic sheet provided on any surface of the base material so as to overlap the coil pattern,

wherein the base material is thinner than the magnetic sheet and the conductor thickness of the coil pattern.

* * * * *