Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

1. Field of the Invention

[0001] The present invention relates to an antenna device and a communication apparatus including the same, and more specifically, the present invention relates to an antenna device and a communication apparatus including the same for use in mobile communications or the like.

2. Description of the Related Art

[0002] With a recent advance in miniaturization and high performance of mobile communication devices, particularly in those of mobile phones, an antenna device, which is to be mounted therein, has also been required to be further miniaturized and to have higher gain.

[0003] Fig. 5 and Fig. 6 show a conventional surface-mount type antenna and an antenna device incorporating the same, respectively. The basic structure of the surface-mount type antenna 1 shown in Fig. 5 is described in Japanese Unexamined Patent Publication No. 9-98015.

[0004] In Fig. 5, the surface-mount type antenna 1 is arranged by disposing some electrodes on a surface of a base member 2 of a rectangular parallelepiped configuration, which comprises a dielectric material such as ceramic or resin as one of the insulation materials. First, a ground electrode 3 is disposed on substantially the entirety of one major surface 2a of the base member 2. In addition, a strip-shaped radiation electrode 4 is disposed along the length direction of the base member 2 on the other major surface 2b of the base member 2. One end 4a of the radiation electrode 4 extends onto one end surface of the base member 2 to form an open-circuited end and the other end 4b extends onto a major surface 2a and over another end surface of the base member 2 to be connected to the ground electrode 3. Furthermore, a power feeding terminal 5 is disposed in the vicinity of the end 4a of the radiation electrode 4 on the end surface on which the end 4a of the radiation electrode 4 of the base member 2 is disposed. In this arrangement, the power feeding terminal 5 extends over the end surface of the base member 2 to the major surface 2a to be insulated from the ground electrode 3.

[0005] In an antenna device 6 incorporating the surface-mount type antenna 1 shown in Fig. 6, a mounting substrate 7 includes a substrate 8 comprising a dielectric material, i.e., an insulating material, having a major surface 8a, another major surface 8b, a substrate-ground electrode 9 disposed on the other major surface 8b and a power feeding line (not shown) which is insulated from the substrate-ground electrode 9. The surface-mount type antenna 1 is mounted on the substrate-ground electrode 9 in the vicinity of a corner of the mounting substrate 7. In this arrangement, the ground electrode 3 and the power feeding terminal 5 of the surface-mount type antenna 1 are connected to the substrate-ground electrode 9 and the power feeding line, respectively, on the mounting substrate 7 by soldering or the like.

[0006] In order to achieve miniaturization of a communication apparatus in which an antenna device has been mounted, miniaturization of the antenna device, i.e., reduction in the cubic volume taken by the surface-mount type antenna on a mounting substrate, is required.

[0007] Thus, the effort required for making the surface-mount type antenna itself smaller is considerable. When the surface-mount type antenna 1 shown in Fig. 5 is miniaturized, the entire size of the base member 2 of the surface-mount type antenna 1 must be made smaller. However, with a surface-mount type antenna, there is a tendency in which the smaller the size of the base member, the smaller the antenna gain. Accordingly, miniaturization in the size of the base member 2 of the surface-mount type antenna 1 permits the antenna gain of the surface-mount type antenna 1, i.e., the antenna gain of the antenna device 6, to be reduced.

[0008] EP 0 814 535 A discloses a surface-mount antenna including a radiation electrode formed on one or more surfaces of a rectangular parallelepiped base member comprising a dielectric or a magnetic substance so as to have one end as an open end and another end as a first ground electrode, a feeding electrode formed on the surface or surfaces, and a second ground electrode formed in proximity to the open end of said radiation electrode.

[0009] EP 0 872 912 A which is an application in accordance with Article 54(3)(4) EPC provides a low-profile circular-polarization antenna that can be implemented at a reduced mounting cost of components. Two linear-polarization surface-mount antennas are mounted on a mounting substrate such that their planes of polarization are perpendicular to each other in the direction normal to the mounting surface, and an amplification circuit, a shield case for covering the circuit, and a phase circuit for sending signals having the same amplitude and a phase difference of 90 degrees to the two surface-mount antennas are provided on the same mounting surface.

[0010] It is the object of the present invention to provide an antenna device in which miniaturization does not cause the antenna gain to be deteriorated, i.e., antenna gains can be enhanced without increasing in size.

[0011] This object is achieved by an antenna device according to claim 1.

[0012] In accordance with a further aspect, the present invention provides a communication apparatus including the inventive antenna device.

SUMMARY OF THE INVENTION

[0013] To overcome the above described problems, preferred embodiments of the present invention provide an antenna device (and a communication apparatus including the same) in which miniaturization does not cause the antenna gain to be deteriorated, i.e., antenna gains can be enhanced without increasing in size.
[0014] One embodiment of the present invention provides an antenna device comprising a surface-mount type antenna and a mounting substrate on which said surface-mount type antenna is mounted; said surface-mount type antenna comprising: a base member comprising an insulating member and having a first major surface, a second major surface opposite to said first major surface, and a plurality of end surfaces extending between said first and second major surfaces; a ground electrode disposed substantially on said first major surface of said base member; a strip-shaped radiation electrode disposed substantially on said second major surface of said base member and including an open-circuit end and a grounded end; a ground terminal connected to said ground end of the radiation electrode and insulated from said ground electrode; and a power feeding terminal disposed in the vicinity of said open-circuited end of the radiation electrode; said mounting substrate comprising: an insulation substrate comprising a first major surface and a second major surface; a first substrate-ground electrode disposed on said first major surface of said insulation substrate; a second substrate-ground electrode and a connection electrode respectively disposed on said second major surface of said insulation substrate and insulated from each other; and a through-hole connecting said connection electrode to said first substrate-ground electrode and said second substrate-ground electrode; and said ground electrode of said mounting substrate; and said ground terminal of said surface-mount type antenna being connected to said second substrate-ground electrode of said mounting substrate.

[0015] Another embodiment of the present invention provides a communication apparatus including the above described antenna device.

[0016] Such an arrangement permits the antenna gain in the antenna device of the present invention to be increased without increasing in size. That is, since a ground terminal, to which the other end of a radiation electrode of a surface-mount type antenna is connected, is grounded by connecting to a first substrate-ground electrode disposed on a first major surface of a mounting substrate through a connection electrode and through-holes formed on a second major surface of the mounting substrate, the thickness of the base member of the surface-mount type antenna can be substantially increased, leading to improvement of antenna gains.

[0017] Furthermore, in the communication apparatus of the present invention, use of the antenna device above permits communication quality to be enhanced and permits cost reduction to be achieved.

[0018] Other features and advantages of the present invention will become apparent from the following description of preferred embodiments of the invention which refers to the accompanying drawings, wherein like reference numerals indicate like elements to avoid duplicative description.
electrode 4 of the surface-mount type antenna 10 and the through-hole 17 of the mounting substrate 13.

As is clear from Fig. 3, in the antenna device 12, the other end 4b of the radiation electrode 4 of the surface-mount type antenna 10 is grounded by connecting to the first substrate-ground electrode 14 through the ground terminal 11, the connection electrode 16 of the mounting substrate 13, and the through-holes 17.

The power feeding terminal 5 of the surface-mount type antenna 10 is connected to a power feeding line 18 disposed on the mounting substrate 13, although this is not shown in Fig. 2.

In such an arrangement of the antenna device 12 of the present invention, the grounded position on the end 4b of the radiation electrode 4 of the surface-mount type antenna 10 is substantially different from that of the prior art. Indeed, the position of the substrate-ground electrode 9 (Fig. 6) disposed on the second major surface 8b of the substrate 8 in the prior art antenna device 6 is quite different from the position of the first substrate-ground electrode 14 formed on a first major surface 8a of the substrate 8 of the invention. Thus, the thickness of the surface-mount type antenna 10 of the invention is greater than the thickness of the base member 2 alone as is the case in the prior art. Indeed, the thickness of the antenna 10 of the invention is obtained by adding the thickness of the mounting substrate 8 with the thickness of the base member 2. Advantageously, although the actual size of the surface-mount type antenna 10 is not increased, the effective thickness of the surface-mount type antenna 10 is increased, and antenna gains of the antenna device 12 can be enhanced.

An experiment was conducted by the inventor of this application on the conventional antenna device 6 in which the bandwidth was 34.0 MHz, the VSWR (Voltage Standing Wave Ratio), obtained when the antenna is viewed from the power feeding terminal side, was the bandwidth of 3.5 or less, the average of the YZ-sided face gain was -9.14 dBd (obtained in a direction horizontal to the YZ-sided face while putting the antenna device at the center), and the average of the ZX-sided face gain was -9.96 dBd (obtained in a direction horizontal to the ZX-sided face while putting the antenna device at the center). In the antenna device 12 of the present invention, experiments revealed that the bandwidth was 33.2 MHz, the average of the YZ-sided face gain was -8.33 dBd, and the average of the ZX-sided face gain was -9.09 dBd. The antenna gain of the invention improved although the bandwidth did not substantially change.

Generally, the larger the antenna gain, the narrower the bandwidth of a surface-mount type antenna, and the wider the bandwidth, the smaller the antenna gain. In the antenna device of the present invention, there is an advantage in which the antenna gain is improved without sacrificing the bandwidth. In this arrangement, the antenna device is formed by using a surface-mount type antenna which is designed with a slightly smaller gain and a wider bandwidth such that the antenna gain of the antenna device is substantially the same value as that of the conventional antenna device.

In the above described embodiment, the configuration of the radiation electrode of the surface-mount type antenna is made substantially into a straight-line form. However, other configurations such as an L-shaped form, a U-shaped form, or a meandering (e.g., S-shaped) form can be used. Furthermore, the number of the through-holes disposed on the mounting substrate is not restricted to three. Indeed, in order to reduce the inductance of the through-hole part, one or any number of through-holes can be employed. In addition, although the base member of the surface-mount type antenna comprises a dielectric member such as ceramics or resin, a magnetic material can also be used.

Fig. 4 shows a preferred embodiment of a communication apparatus including the antenna device of the present invention. In Fig. 4, the communication apparatus 20 includes an antenna device 12 disposed in a case 21. The antenna device 12 comprises a surface-mount type antenna 10 and a mounting substrate 13. Additionally, a first substrate-ground electrode (not shown) is disposed on a major surface of a substrate 8 comprising the mounting substrate 13. A second substrate-ground electrode 15, a connection electrode 16, and a power feeding line 18 are also formed on the substrate 13. In this arrangement, the connection electrode 16 is connected to the first substrate-ground electrode through through-holes 17. The surface-mount type antenna 10 is mounted at a corner of the mounting substrate 13. The ground electrode (not shown) of the surface-mount type antenna 10 is connected to the second substrate-ground electrode 15 of the mounting substrate 13, the ground terminal (not shown) is connected to the connection electrode 16, and the power feeding line 18 is connected to the power feeding line 18. Furthermore, the power feeding line 18 is connected to a transmission circuit 23 and a reception circuit 24 formed on the mounting substrate 13 through a switching circuit 22 similarly formed on the mounting substrate 13.

As described above, use of the antenna device 12 of the present invention permits the antenna gain of the antenna device 12 to be improved and thereby permits the antenna gain of the communication apparatus 20 itself to be improved, resulting in improvement of the communication quality of the communication apparatus 20. Moreover, improvement of the antenna gain allows for a relaxation of the specifications of peripheral circuits and components such as a filter, amplifier, mixer, and a resonator included in the transmission circuit 23 and the reception circuit 24 of the communication apparatus 20. This leads to cost reductions of the peripheral circuits and components, and results in cost reductions of the communication apparatus itself.
Claims

1. An antenna device (12), comprising:

   a surface mount antenna (10), comprising:

   a base (2) having opposing first and second surfaces (2a; 2b) and opposing end surfaces;
   a radiation electrode (4) covering at least a portion of the first major surface (2b) of the base (2), the radiation electrode (4) extending over the length of the base (2), over a first end surface of the base (2), and at least partially onto the second major surface (2a) of the base (2);
   a power terminal (5) disposed on the base (2) near an open-circuited end of the radiation electrode (4) and operable to conduct signal power which is at least one of received and transmitted by the antenna; and
   a first ground electrode (3) covering at least a portion of the second major surface (2a) of the base (2) and being electrically insulated from the radiation electrode (4) and the power terminal (5);

   a mounting substrate (8), comprising spaced apart first and second major surfaces (8a, 8b);

   characterized in that

   the mounting substrate (8) comprises a connection electrode (16) disposed on the first major (8b) surface of the mounting substrate (8), a second ground electrode (15) covering at least a portion of the first major surface (8a) of the mounting substrate (8) and terminating proximate to the connection electrode (16) such that the connection electrode (16) and the second ground electrode (15) are not connected,
   a further ground electrode (14) covering at least a portion of the second major surface (8a) of the mounting substrate (8),
   at least one first conductive through-hole (17), and
   at least one second conductive through-hole (19);

   wherein the connection electrode (16) is electrically coupled to the further ground electrode (14) via the at least one first through hole (17);

   wherein the further ground electrode (14) is connected to the second ground electrode (15) of the mounting substrate (8) via the at least one second through hole (19);

   wherein the base (2) is disposed on the mounting substrate (8) such that the second major surface (2a) of the base (2) is electrically coupled to the connection electrode (16), any wherein the first ground electrode (3) is connected to the second ground electrode (15) such that the radiation electrode (4) is electrically coupled to the first aground electrode (3).

2. the antenna device (12) of claim 1, wherein the first and second major surfaces (2a, 2b) and the opposing ends define a parallelepiped.

3. The antenna device (12) of claim 1 or 2, wherein the radiation electrode (4) includes a shape taken from the group consisting of a substantially linear shape, an L-shape, a U-shape, an S-shape, and a curvilinear shape.

4. The antenna device (12) of one of claims 1 to 3, wherein the base (2) is formed from at least one material taken from the group consisting of a dielectric ceramic, a dielectric resin, and a magnetic material.

5. A communications device (20), comprising:

   at least one of a transmitter and receiver circuit (23, 24); and
   an antenna device (12) according to one of claims 1 to 4, the antenna device (12) coupled to the at least one of a transmitter and receiver circuit (23, 24).

Patentansprüche

1. Eine Antennenvorrichtung (12), die folgende Merkmale aufweist:

   eine Antenne für Oberflächenmontage (10), die folgende Merkmale aufweist:

   eine Basis (2), die eine gegenüberliegende erste und zweite Oberfläche (2a; 2b) und gegenüberliegende Endoberflächen aufweist;

   eine Strahlungselektrode (4), die zumindest einen Teil der ersten Hauptoberfläche (2b) der Basis (2) bedeckt, wobei sich die Strahlungselektrode (4) über die Länge der Basis (2), über eine erste Endoberfläche der Basis (2) und zumindest teilweise auf die zweite Hauptoberfläche (2a) der Basis (2) erstreckt;

   einen Leistungsanschluss (5), der auf der Basis (2) in der Nähe eines Leerlaufendes der Strahlungselektrode (4) angeordnet ist und wirksam ist, um Signalleistung, die von der Antenne zumindest empfangen oder übertragen wird, zu leiten; und

   eine erste Masselektrode (3), die zumin-
dest einen Teil der zweiten Hauptoberfläche (2a) der Basis (2) bedeckt und von der Strahlungselektrode (4) und dem Leistungsanschluss (5) elektrisch getrennt ist;

ein Befestigungssubstrat (8), das eine beaustandete erste und zweite Hauptoberfläche (8a, 8b) aufweist;

gekennzeichnet dadurch, dass das Befestigungssubstrat (8) Folgendes aufweist:

eine Verbindungselektrode (16), die auf der ersten Hauptoberfläche (8b) des Befestigungssubstrats (8) angeordnet ist,
eine zweite Masselektrode (15), die zumindest einen Teil der ersten Hauptoberfläche (8b) des Befestigungssubstrats (8) bedeckt und nahe der Verbindungselektrode (16) endet, derart dass die Verbindungselektrode (16) und die zweite Masselektrode (15) nicht verbunden sind,
eine weitere Masselektrode (14), die zumindest einen Teil der zweiten Hauptoberfläche (8a) des Befestigungssubstrats (8) bedeckt, mindestens ein erstes leitfähiges Durchgangsloch (17), und
mindestens ein zweites leitfähiges Durchgangsloch (19);

wobei die Verbindungselektrode (16) mit der weiteren Masselektrode (14) über das mindestens eine Durchgangsloch (17) elektrisch gekoppelt ist;
wobei die weitere Masselektrode (14) mit der zweiten Masselektrode (15) des Befestigungssubstrats (8) über das mindestens eine zweite Durchgangsloch (19) verbunden ist;
wobei die Basis (2) auf dem Befestigungssubstrat (8) angeordnet ist, derart dass die zweite Hauptoberfläche (2a) der Basis (2) mit der ersten Hauptoberfläche (8b) des Befestigungssubstrats (8) gekoppelt ist;
wobei das Ende (4b) der Strahlungselektrode (4), die auf der zweiten Hauptoberfläche (2a) der Basis (2) angeordnet ist, mit der Verbindungselektrode (16) elektrisch gekoppelt ist, und wobei die erste Masselektrode (3) mit der zweiten Masselektrode (15) verbunden ist, derart dass die Strahlungselektrode (4) mit der ersten Masselektrode (3) elektrisch gekoppelt ist.

2. Die Antennenvorrichtung (12) gemäß Anspruch 1, wobei die erste und die zweite Hauptoberfläche (2a, 2b) und die gegenüberliegenden Enden ein Parallelepiped definieren.

3. Die Antennenvorrichtung (12) gemäß Anspruch 1 oder 2, bei der die Strahlungselektrode (4) eine Form aus der Gruppe, die aus einer im Wesentlichen li-

nearen Form, einer L-Form, einer U-Form, einer S-Form und einer krummlinigen Form besteht, umfasst.

4. Die Antennenvorrichtung (12) gemäß einem der Ansprüche 1 bis 3, bei der die Basis (2) aus mindestens einem Material aus der Gruppe, die aus einer dielektrischen Keramik, einem dielektrischen Harz und einem magnetischen Material besteht, gebildet ist.

5. Eine Kommunikationsvorrichtung (20), die folgende Merkmale aufweist:

mindestens eine einer Übertragungs- und Empfangsschaltung (23, 24); und

eine Antennenvorrichtung (12) gemäß einem der Ansprüche 1 bis 4, wobei die Antennennvorrichtung (12) mit der zumindest einer einer Übertragungs- und Empfangsschaltung (23, 24) gekoppelt ist.

Revendications

1. Dispositif d’antenne (12) comprenant :

une antenne à montage en surface (10), comprenant :

une base (2) ayant des première et seconde surfaces opposées (2a ; 2b) et des surfaces d’extrémité opposées,
une électrode de rayonnement (4) recouvrant au moins une partie de la première surface principale (2b) de la base (2), l’électrode de rayonnement (4) s’étendant sur la longueur de la base (2), sur une première surface d’extrémité de la base (2), et au moins partiellement sur la seconde surface principale (2a) de la base (2),
une borne d’alimentation (5) disposée sur la base (2) à proximité d’une extrémité en circuit ouvert de l’électrode de rayonnement (4) et pouvant être mise en oeuvre pour conduire une puissance de signal qui est au moins l’une d’une puissance reçue et émise par l’antenne, et
une première électrode de masse (3) recouvrant au moins une partie de la seconde surface principale (2a) de la base (2) et qui est électriquement isolée de l’électrode de rayonnement (4) et de la borne d’alimentation (5),

un substrat de montage (8), comprenant des première et seconde surfaces principales espa-
cées (8a, 8b),
caractérisé en ce que
le substrat de montage (8) comprend
une électrode de connexion (16) disposée sur la première surface principale (8b) du substrat de montage (8),
une seconde électrode de masse (15) recouvrant au moins une partie de la première surface principale (8b) du substrat de montage (8) et se terminant à proximité de l'électrode de connexion (16) de sorte que l'électrode de connexion (16) et la seconde électrode masse (15) ne sont pas connectées,
une autre électrode de masse (14) recouvrant au moins une partie de la seconde surface principale (8a) du substrat de montage (8),
au moins un premier trou traversant conducteur (17),
et
au moins un second trou traversant conducteur (19),
où l'électrode de connexion (16) est électriquement couplée à l'autre électrode de masse (14) par l'intermédiaire du au moins un premier trou traversant (17),
où l'autre électrode de masse (14) est connectée à la seconde électrode de masse (15) du substrat de montage (8) par l'intermédiaire du au moins un second trou traversant (19),
où la base (2) est disposée sur le substrat de montage (8) de sorte que la seconde surface principale (2a) de la base (2) est couplée à la première surface principale (8b) du substrat de montage (8), et
où l'extrémité (4b) de l'électrode de rayonnement (4) qui est située sur la seconde surface principale (2a) de la base (2) est électriquement couplée à l'électrode de connexion (16), et où la première électrode de masse (3) est connectée à la seconde électrode de masse (15) de sorte que l'électrode de rayonnement (4) est électriquement couplée à la première électrode de masse (3).

2. Dispositif d'antenne (12) selon la revendication 1,
dauf au moins l’un d’un circuit émetteur et récepteur (23, 24), et
d’un dispositif d’antenne (12) selon l’une des revendications 1 à 4, le dispositif d’antenne (12) étant couplé au au moins l’un d’un circuit émetteur et récepteur (23, 24).

3. Dispositif d’antenne (12) selon la revendication 1 ou 2, dans lequel l’électrode de rayonnement (4) comprend une forme prise à partir du groupe constitué d’une forme pratiquement linéaire, d’une forme en L, d’une forme en U, d’une forme en S, et d’une forme curviligne.

4. Dispositif d’antenne (12) selon l’une des revendications 1 à 3, dans lequel la base (2) est formée à partir d’au moins un matériau pris à partir du groupe constitué d’une céramique de diélectrique, d’une résine de diélectrique et d’un matériau magnétique.

5. Dispositif de communication (20), comprenant :