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(54) **Transparent planar antenna structure**

Transparente planare Antennenstruktur

Structure d'antenne plane transparente

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Description

FIELD OF THE INVENTION

[0001] The present invention relates generally to a portable wireless communications device and, more particularly, to a transparent planar antenna structure overlying the device's liquid crystal display (LCD).

BACKGROUND OF THE INVENTION

[0002] The size of wireless communications devices continues to shrink, as the use for such devices expands in both well established, and new communication technologies. These communication technologies include pagers, telephones, televisions, GPS and other satellite receivers, and wireless LAN. One of the key elements in the performance of a wireless unit is the unit's antenna. At the same time, the antenna size is a limiting factor in further reducing the size of wireless devices. Whip type antennas are relatively large, and recently, concerns have surfaced regarding the harmful effects of an omni-directional radiation of hand-held transmitters. Further, the whip antenna extends from the chassis and is easily damaged.

[0003] Antennas can be incorporated into, or on the device chassis. One obvious choice of antenna is the so-called patch design. As the name suggests this antenna is built as a thin sheet that can be layered over an existing structure.

[0004] Fig. 13 illustrates the coplanar layout of a panel antenna 10 (prior art). The design of such antennas is well known to consist of a conductive radiating element 12 surrounded by a conductive ground plane 14. The panel antenna 10 can be fabricated, for example, on a PC board with the conductor being a thin film of copper overlying a sheet of dielectric material. The radiating element 12 is patterned to be electrically isolated from the ground plane 14. The radiating element 12 and the ground plane 14 (conductors) are isolated by etching through the copper until a portion 16 of the underlying dielectric material, represented by cross-hatched lines, is exposed.

[0005] Fig. 14 is a partial cross-sectional view of the panel antenna 10 of Fig. 13 (prior art). The radiating element 12 and the ground plane 14 (conductive regions), overlying dielectric layer 18, are represented with cross-hatched lines. The design of an antenna for a coplanar arrangement of the radiating element 12 (radiator) and the ground plane 14 is based on well understood relationships such as the separation between ground planes (b), conductor width (a), the dielectric constant (ϵ_r) of the dielectric layer 18, thickness (t) of the ground plane 14 (radiator), the thickness (h) of the dielectric layer 18, and the effective wavelength of the intended resonant frequency.

[0006] However, designs which conform to size constraints, often deliver inadequate gain, or highly direction-

al gain. With inadequate gain, the electrical performance of the associated wireless unit is compromised, and information transfer becomes unsure. Even when antennas can be mounted on a chassis, the continuing reduction of chassis sizes makes the placement of antennas, which provide adequate coverage, difficult.

[0007] The design of a cellular telephone illustrates the difficulties of antenna design. Typically, half of the surface area of the phone is occupied with user-operated switches, such as a keypad, and an electronic display for viewing. Usually, the keypad and LCD display are co-located on the same "side" of the phone so that the operator can see the results of keypad manipulations. It is difficult to locate an antenna on this user-interface side of the telephone. Consumer preference for larger displays and improvements in technology increasing the size of LCDs act to further limit the area available for the placement of conventional or patch antennas.

[0008] Even if an antenna can be placed on the opposite side of the phone from the display, the antenna will likely only provide hemispheric, or kidney shaped coverage, in the direction in which the antenna faces. Wireless units with directional antenna gain frequently lose contact with base stations or communicating wireless units as the phone operator changes positions. In the least, communicating base stations must be frequently changed, making communications difficult, and using large amounts of communication overhead to support base station selections. It is possible to use multiple directional antennas in a system to provide combined omni-directional coverage. However, the placement of two antennas on a wireless unit is even more difficult than mounting one antenna, especially when a considerable surface area is occupied by the electronic display and keypad.

[0009] Many communications devices have both a receiver and a transmitter section, operating at the same, or different frequencies. Other devices have multiple receivers and transmitters. Because of the difficulties in mounting multiple antennas on a wireless unit, the single antenna must be designated to interface to all the various transmitters and receivers, and so must operate over a number of frequency bands. To interface a single antenna to multiple wireless sections requires duplexer circuits, or time multiplexed antenna switches. These circuits degrade antenna performance, add considerable cost to the manufacture of the device, and occupy valuable space inside the chassis.

[0010] Antennas have been constructed to overlie the electronic display sections of small wireless units. Woo et al., U.S. Patent No. 5,627,548 disclose a transparent indium-tin oxide patch antenna overlying an LCD. However, the conductivity of indium-tin oxide is poor, so that the antenna gain resulting from the use of such a conductant is poor. The poor gain, high current loss, and resulting IR (current x resistance) heating makes such a material an even poorer choice for a transmitter antenna.

[0011] EP-A-0 331 201 discloses an amorphous oxide

film and articles having such a film thereon. The amorphous oxide film is essentially composed of an oxide containing at least one member selected from the group consisting of Zr, Ti, Hf, Sn, Ta and In and at least one member selected from the group consisting of B and Si. As articles comprising said amorphous oxide film this document describes surface-coated mirrors, low-reflective glass, heat radiation shielding glass, metal diffusion barrier layers, scratch-resistant protective film provided on a transparent sheet and the like. This document does not describe to use the amorphous oxide film for providing a transparent planar antenna.

SUMMARY OF THE INVENTION

[0012] It would be advantageous to eliminate the whip antenna from hand-held devices, and provide an antenna that is more rugged and less likely to radiate energy harmful to the user.

[0013] It would be advantageous if a system of chassis mounted antennas could be provided to provide high gain in an omni-directional radiation pattern.

[0014] It would be advantageous if an antenna could be placed on a chassis in the area of the user-operated functions. Specifically, it would be advantageous if an antenna could be designed to co-exist with the relatively large, planar surface of the visual display panel.

[0015] It would be advantageous if multiple antennas could be mounted on a wireless device to eliminate the need for duplexers and antenna switching circuits.

[0016] Accordingly, the present invention comprises a transparent antenna, comprising a first transparent sheet of thin film and a first transparent planar radiating element having a first operating frequency and overlying said first transparent sheet of thin film, whereby structures underlying said first transparent sheet of thin film are visible, and a first transparent planar ground plane, characterized in that said transparent planar radiating element and said first transparent planar ground plane include highly conductive metal film structures selected from the group consisting of a grid of parallel oriented metal lines and a mesh of orthogonal and parallel oriented metal lines.

[0017] The present invention further comprises a wireless communication's device which includes a flat panel electronic visual display and at least a first transparent planar antenna having a construction mentioned immediately before, wherein said first transparent planar antenna is located overlying said flat panel electronic visual display.

[0018] The first antenna includes the radiating element and ground plane being located coplanar overlying the first transparent sheet of thin film. The thin film is selected from the group of materials consisting of polyethylene terephthalate (PET), polyethylenesulfone (PES), polyetherimide (PEI), polycarbonate, polyimide, polytetrafluoroethylene, acrylic, glass, and combinations of the above mentioned materials.

[0019] The first antenna radiator (first transparent pla-

nar radiating element) and the ground plane include a metal film structure overlying the first thin film patterned to electrically isolate the radiator from the ground plane. The metal film structure is selected from the group consisting of a grid of parallel oriented metal lines and a mesh of orthogonal and parallel oriented metal lines. The material of the metal film structure is selected from the group of materials consisting of copper, aluminum, gold, silver, nickel, chromium, titanium, molybdenum, tin, tantalum, magnesium, cobalt, platinum, tungsten, manganese, silicon, zirconium, vanadium, niobium, hafnium, indium and other alloys of the above mentioned materials. The grid-like structure of the conductors permit the first antenna to be greater than 65 percent transmissive in the band of visible light wavelengths.

[0020] In some aspects of the invention, a second transparent antenna having a second operating frequency, has a radiating element located coplanar to the first transparent planar radiating element. The first and second antenna radiating elements are located coplanar to a shared ground plane. Alternately, the second antenna has a radiating element located on a second thin film, overlying the first thin film, and the first and second antenna radiating elements share the first transparent planar ground plane. The second transparent antenna operates either at the same frequency as the first antenna, or at a different frequency.

[0021] Another alternate design includes a first transparent sheet of thin film on which the first radiating element is mounted, and a second transparent sheet of thin film, underlying the first transparent sheet of thin film, on which the first transparent planar ground plane is mounted. With this planar design the antenna is located in two sheets of overlying thin film.

[0022] In the preferred embodiment, the radiating element is a planar rectangle, or oval shape, as is typical in the design of patch antennas. Alternately, the radiating elements are configured inter-digitally using either a grid of parallel oriented metal lines, or a mesh of orthogonal and parallel oriented metal lines.

[0023] A wireless device having a plurality of receivers and transmitters, each operatively connected to an independent transparent antenna, is also provided. The transparent antennas are as described above. The low cost and low profile of the transparent antennas permit each radio frequency (RF) section of the wireless device to have its own antenna, unlike many prior art wireless devices where RF sections must share a single antenna. In this manner, the necessity of a duplexer circuit is eliminated.

[0024] For a fuller understanding of the nature and advantages of the invention, reference should be made to the ensuing detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

Fig. 1 is a cross-sectional view of the transparent panel antenna section of a wireless communications device.

Fig. 2 illustrates, in greater detail, the antenna of Fig. 1.

Fig. 3 illustrates the grid metal film structure.

Fig. 4 illustrates the mesh metal film structure.

Fig. 5 is microscope picture illustrating a detailed section of the grid of Fig. 3.

Fig. 6 illustrates a plurality of transparent antennas.

Fig. 7 illustrates a plurality of non-coplanar transparent antennas.

Fig. 8 illustrates a touch panel in use with the present invention.

Fig. 9 illustrates a non-coplanar embodiment of the present invention.

Fig. 10 depicts an inter-digital antenna embodiment of the transparent antenna of the present invention.

Fig. 11 illustrates non-conductive, or dummy sections of grid and mesh metal structures in use with the transparent antenna of the present invention.

Fig. 12 is a schematic block diagram of a wireless device communicating information at a plurality frequencies.

Fig. 13 illustrates the coplanar layout of a panel antenna.

Fig. 14 is a partial cross-sectional view of the antenna of Fig. 13.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0026] Fig. 1 is a cross-sectional view of the transparent panel antenna section of a wireless communications device 30. The wireless communications device 30 comprises a flat panel electronic visual display 32. In the preferred embodiment of the invention, the flat panel electronic visual display 32 is a liquid crystal display (LCD). The wireless communications device 30 also comprises at least a first transparent planar antenna 34, having a first operating frequency, a highly conductive planar radiating element 36, and a highly conductive first transparent planar ground plane 38. The first transparent planar antenna 34 overlies the flat panel electronic visual display 32 so that the display 32 is viewed through the first transparent planar antenna 34.

[0027] Fig. 2 illustrates, in greater detail, the first transparent planar antenna 34 of Fig. 1. The wireless communications device 30 further comprises a first transparent sheet of thin film 40. The first transparent planar antenna 34 includes the first transparent planar radiating element 36 and the first transparent planar ground plane 38 being located coplanar and overlying the first transparent sheet of thin film 40, whereby the first transparent planar antenna 34 is located on the single transparent sheet of thin film 40. Alternately, the first transparent planar radiating element 36 and the first transparent planar ground plane 38 are mounted under the first transparent sheet

of thin film 40, so that the first transparent sheet of thin film 40 overlies the first transparent planar radiating element 36, the first transparent planar ground plane 38, and the flat panel electronic visual display 32.

[0028] The first transparent sheet of thin film 40 is selected from the group of materials consisting of polyethylene terephthalate (PET), polyethylenesulfone (PES), polyetherimide (PEI), polycarbonate, polyimide, polytetrafluoroethylene, acrylic, glass, and combinations of the above mentioned materials. The first transparent sheet of thin film 40 has a thickness t_{42} in the range between 100 and 400 microns.

[0029] The first transparent planar radiating element 36 and the first transparent planar ground plane 38 include a metal film structure 44 overlying the first transparent sheet of thin film 40 patterned to electrically isolate the first transparent planar radiating element 36 (radiator) from the first transparent planar ground plane 38, whereby the metal permits high electrical conductivity in the first transparent planar antenna 34. Typically, the metal film structure 44 is fabricated by depositing a sheet of the metal film material overlying the first transparent sheet of thin film 40. Then, the metal film structure 44 is etched with a variety of processes that are well known in the art of integrated circuit (IC) processing, such as using a patterned photo-resist profile as an etch mask. These processes remove metal material to form the shape of the metal film structure 44, and to electrically isolate the first transparent planar radiating element 36 from the first transparent planar ground plane 38. The metal film structure 44 is selected from the group consisting of a grid of parallel oriented metal lines and a mesh of orthogonal and parallel oriented metal lines. Fig. 3 illustrates the grid metal film structure 44. The conductive lines appear as parallel bars. Fig. 4 illustrates the mesh metal film structure 44. The conductive lines appear as a screen.

[0030] The material of the metal film structure 44 is selected from the group of materials consisting of copper, aluminum, gold, silver, nickel, chromium, titanium, molybdenum, tin, tantalum, magnesium, cobalt, platinum, tungsten, manganese, silicon, zirconium, vanadium, niobium, hafnium, indium and other alloys of the above mentioned materials.

[0031] Fig. 5 is a microscope picture illustrating a detailed section of the grid of Fig. 3. The metal lines have a width in the range between 1 and 30 microns (μm). Specifically, Fig. 5 shows a line width of 10 microns. The parallel oriented metal lines are separated by a distance, or gap in the range between 30 microns and 1 mm. Specifically, Fig. 5 shows a gap of 40 microns. The gap between conductive lines is calculated in response to the operating, or resonant first frequency of the first transparent planar antenna 34. In some cases, the gap is chosen, at least partially, in response to pitch, or the spacing between electrical elements of underlying LCD 32 (not shown). Specifically, by forming each metal line of the metal film structure 44 so as to correspond to a pixel pitch of the flat panel electric visual display 32 (the metal lines

which are the non-transparent section of the metal film structure are formed in the non-display area between pixels of the flat panel display section), an improved visibility of the flat panel display section can be achieved. The non-display area between adjacent pixels of the flat panel electric visual display 32 indicates, for example, a space between pixel electrodes of the liquid crystal display, where a black matrix is formed.

[0032] Generally, the gap is chosen to be no greater than one-tenth of the effective first wavelength. The effective wavelength is calculated in response to the thickness t_{46} of the metal film structure 44, and the dielectric constant (ϵ_r) and thickness t_{42} of the first transparent sheet of thin film 40 (Fig. 2). Because the above-mentioned metal materials are good conductors, and the shape of the metal film structure 44 insures good conductivity, the metal film structure 44 remains very conductive when the metal film thickness t_{46} is thin. The metal film thickness t_{46} is in the range between 300 and 100,000 Å.

[0033] The line widths and gaps forming the metal film structure 44 are also shaped to provide optical transparency. The minimum gap which provides transparency is approximately 30 microns, which is about the width of 1 pixel in an LCD, and the minimum line width is approximately 1 micron. Generally, line widths and gaps between lines are chosen so that the first transparent planar antenna 34 is greater than 65 percent transmissive in the band of visible light wavelengths.

[0034] When the metal film structure 44 is a mesh, as shown in Fig. 4, the gap between parallel and intersecting lines varies from a square shape to a rectangular shape. The square shape has gap dimensions from 30 microns to 1 mm between the parallel lines oriented in a first direction. Alternately, the gap between one set of parallel lines differs from the gap between the set of parallel lines oriented orthogonal to the first direction so that a rectangle is formed. The present invention is not limited to any particular pattern of metal lines, although regularly placed lines and gaps are easier to fabricate. The key feature of the present invention is that the metal film structure 44 be both highly conductive and transparent.

[0035] In some aspects of the invention, the metal film structure 44 is selected from the group of materials consisting of indium-tin, indium-tin oxide, and tin oxide. These materials are not as conductive as the metal, named above. Therefore, the thickness t_{46} (Fig. 2) must be greater to provide equivalent conductance to the metals. Then, the metal film structure 44 has a metal film thickness t_{46} in the range between 0.1 and 10 microns.

[0036] Fig. 6 illustrates a plurality of transparent antennas. In some aspects of the invention, the wireless communications device 30 further comprises a second transparent planar antenna 50 having a second operating frequency, different than the first operating frequency. The second transparent planar antenna 50 has a second transparent planar radiating element 52 located coplanar to the first transparent antenna radiating element 36. The

first and second transparent planar radiating elements 36, 52 are located coplanar to a shared first transparent planar ground plane 38. Alternately, the second transparent planar antenna 50 has an operating frequency the same as the first operating frequency. The second transparent planar antenna 50 has the second transparent planar radiating element 52 located coplanar to the first transparent antenna radiating element 36, and the first and second transparent planar radiating elements 36, 52 are located coplanar to the shared first transparent planar ground plane 38.

[0037] The wireless communications device 30 further comprises a plurality of transparent antennas, including at least third and fourth transparent planar antennas 54 and 56. It can be seen from Fig. 6 that the size of the metal film structure 44 is variable to provide enough space for several antennas. For simplicity, only four antennas are shown. Each of the plurality of transparent planar antennas 50, 54, and 56 have a transparent planar radiating element (52, 58 and 60) located coplanar to the first transparent antenna radiating element 36. The plurality of transparent planar radiating elements 36, 52, 58 and 60 are located coplanar to the first transparent planar ground plane 38.

[0038] Fig. 7 illustrates a plurality of non-coplanar transparent antennas. The wireless communications device 30 further comprises a second transparent sheet of thin film 62 overlying the first transparent sheet of thin film 40. The wireless communications device 30 also comprises a second transparent planar antenna 50 having a second operating frequency different than the first operating frequency. The second transparent planar antenna 50 has the second transparent planar radiating element 52 located overlying the second transparent sheet of thin film 62. The first and second transparent planar radiating elements 36 and 52 share the first transparent planar ground plane 38. Alternately, the second transparent planar antenna 50 has an operating frequency the same as the first operating frequency.

[0039] In some aspects of the invention, the wireless communications device 30 further comprises a plurality of sheets of thin film overlying the first transparent sheet of thin film 40, and a plurality of transparent antennas having a plurality of corresponding radiating elements. Each one of the plurality of transparent planar radiating elements overlies a corresponding one of the plurality of sheets of thin film, and each radiating element shares the first transparent planar ground plane 38. For simplicity and clarity, only a third transparent planar antenna 54, including a third transparent sheet of thin film 70 and a third transparent planar radiating element 58, are shown in Fig. 7. However, it can be seen that additional antennas are stackable overlying the third transparent planar antenna 54. A cross-section of the third transparent planar antenna 54 is shown removed to provide a clear view of the second transparent planar antenna 50.

[0040] Fig. 8 illustrates a touch panel in use with the present invention. The wireless communications device

30 further comprises a transparent user-activated touch panel 74 overlying the flat panel electronic visual display 32. The use of touch panels, such as touch panel 74, overlying computer screens and electronic displays is a well known computer interface for use either without, or in addition to, a keypad. The touch panel 74 including user-activated sensors 75 corresponding to visual prompts represented on the flat panel electronic visual display 32 visible through the first transparent planar antenna 34 and the transparent touch panel 74. The thin film materials and thicknesses of the touch panel 74 are similar to the first transparent sheet of thin film 40 of the first transparent planar antenna 34. Alternately, the touch panel 74 is placed between the first transparent planar antenna 34 and the flat panel electronic visual display 32. In one aspect of the invention, the transparent touch panel 74 and the first transparent planar antenna 34 are both mounted on the first transparent sheet of thin film 40. For example, the first transparent planar antenna 34 and the touch panel 74 are fabricated on the same transparent sheet of thin film 40 with the conductive regions of the first transparent planar antenna 34 and the touch panel 74 on opposite sides of the first transparent sheet of thin film 40.

[0041] Fig. 9 illustrates a non-coplanar embodiment of the present invention. The wireless communications device 30 comprises a fourth transparent sheet of the thin film 76 on which the first transparent radiating element 36 is mounted, and a fifth transparent sheet of thin film 78, underlying the fourth transparent sheet of thin film 76, on which the first transparent planar ground plane 38 is mounted. The first transparent planar antenna 34 is located on two sheets of overlying sheets of thin film 76 and 78.

[0042] Fig. 10 depicts an inter-digital antenna embodiment of the transparent antenna of the present invention. The wireless communications device 30 of Fig. 1 further comprises a second transparent planar antenna 50 having a second operating frequency. The second transparent planar radiating element 52 is located coplanar to the first transparent antenna radiating element 36. The first and second transparent planar radiating elements 36 and 52 are co-located in the inter-digital metal film structure 44. The first and second transparent planar antennas 34 and 50 are located with a coplanar ground plane (not shown, see Fig. 1). Alternately, the ground is on a different plane (not shown, see Fig. 9) from the transparent planar radiating elements (36, 52). The spacing between the digits of the first and second transparent planar radiating elements 36 and 52 is dependent on the operating frequencies of the first and second transparent planar antennas 34 and 50, the effective wavelengths, and the mutual parasitic effects of antennas being closely located.

[0043] Fig. 10 is not drawn to scale. The digits, as drawn, appear visible with respect to the overall panel only for the purpose of showing the alternating digits of the first and second transparent planar antennas 34 and

50. Since the grid and mesh line widths and gaps are actually on the order of microns, they are not typically visible to the human eye. As explained above and shown in Figs. 3 through 5, the inter-digital metal structure 44 is selected from the group consisting of a grid of parallel oriented lines and a mesh of orthogonal and parallel oriented metal lines. The metal lines have a width in the range between 1 and 30 microns, with a spacing between parallel oriented metal lines in the range between 30 microns and 1 mm. As shown in Fig. 10, the space between lines or sections of mesh include the digits of another antenna. A mesh version of the second transparent planar radiating element 52 is shown in Section A, and the grid versions of the transparent planar radiating elements 36 and 52 are shown in Section B of Fig. 10.

[0044] Fig. 11 illustrates non-conductive, or dummy sections of grid and mesh metal structures 80 in use with the first transparent planar antenna 34 of the present invention. The non-conductive metal film structure 80 overlies the first transparent sheet of thin film 40 (not shown) and is patterned to be an electrical isolator. The non-conductive metal film structure 80 is selected from the group consisting of a grid of parallel oriented non-conductive metal lines and a mesh of orthogonal and parallel oriented non-conductive metal lines. The non-conductive grid, Section A of Fig. 11, and the non-conductive mesh, Section B of Fig. 11, are similar to the conductive grid and mesh metal structures 44, discussed above and shown in Figs. 3, 4 and 5. However, there are breaks in the grid and mesh patterns so that they do not conduct electrically. Typically, the non-conductive grid and mesh structures 80 are used in the same antenna as conductive grid and mesh structures 44 to normalize transparency. That is, to make the transparency through the non-conductive areas surrounding the first transparent radiating element 36 and the first transparent planar ground plane 38 the same as the first transparent planar radiating element 36 and the first transparent planar ground plane 38.

[0045] Fig. 12 is a schematic block diagram of the wireless communications device 30 communicating information at a plurality of frequencies. The wireless communications device 30 comprises at least a first receiver 90 (first communicating section) having an input operatively connected to a line 92 to receive information at a first operating frequency. The wireless communications device 30 further comprises at least a second receiver 94 (second communicating section) having an input operatively connected to a line 96 to receive information at a second operating frequency, different than the first operating frequency. The wireless communications device 30 comprises the first transparent planar antenna 34 including a highly conductive first transparent planar radiating element 36 and the first transparent planar ground plane 38, as described above and shown in Figs. 1-5 and 8-11. The first transparent planar antenna 34 is operatively connected to the first receiver 90 without any operative connection to the second receiver 94. The wire-

less communications device 30 comprises the second transparent planar antenna 50 as described above and shown in Figs. 6 and 7. The second transparent planar antenna 50 includes the highly conductive second transparent planar radiating element 52 and the first transparent planar ground plane 38. The first transparent planar ground plane 38 is coplanar with the second transparent planar radiating element 52 as shown in Fig. 6. Alternately, the first transparent planar ground plane 38 is on a different plane than the second transparent planar radiating element 52, as shown in Fig. 7. The second transparent planar antenna 50 is operatively connected to the second receiver 94 without any operative connection to the first receiver 90.

[0046] The first and second transparent planar radiating elements 36 and 52 and the first transparent planar ground plane 38 are the metal film structures 44 selected from the group consisting of a grid of parallel oriented metal lines and a mesh of orthogonal and parallel oriented metal lines, as described above and shown in Figs. 3-5. The use of two antennas eliminates the need for a duplexer circuit as is needed in many wireless communications devices to de-couple multiple receivers when they share only one antenna.

[0047] Alternately, the second receiver 94 is replaced with at least a transmitter 98 (second communicating section) having a second operating frequency, different than the first operating frequency. In another aspect of the invention, the second operating frequency is the same as the first operating frequency. The wireless communications device 30 has separate antennas, the first transparent planar antenna 34 operatively connected to the first receiver 90, and the second transparent planar antenna 50 operatively connected to the transmitter 98. As described above, the use of two antennas eliminates the need for a duplexer circuit. Because of the low cost and low profile of the present invention transparent antenna, the wireless communications device 30 is able to provide a separate antenna for each radio frequency section of the communications device without the use of either duplexers or antenna switches. The use of independent transparent antennas for each of a plurality of receiver and transmitter sections is also an application of the present invention.

[0048] Typically, additional circuitry such as amplifiers and filters interface between the first and second transparent planar antennas 34 and 50, and receivers 90 and 94, and transmitter 98, as is well known in the art. Further, the above mentioned devices must be interfaced with conductive lines having precisely defined impedances. The conductive lines interfacing the first and second transparent planar radiating elements 36 and 52 are transparent when mounted on the thin film, and fabricated with conductive grid and mesh metal structures 44. In some aspects of the invention, amplifiers, filters, and other circuit components are mounted on thin film, even though these elements are not transparent. The non-transparent structures are placed where visibility of

underlying the flat panel electronic visual display 32 is not critical.

[0049] The present invention allows one of the largest surface areas of a wireless communications device, the flat panel LCD, to be used for a second purpose, as a surface to mount an antenna. The fabrication of an antenna from thin films of conductive material on a transparent thin film permits the antenna of the present invention to have the performance characteristics of prior art patch antennas, while being transparent enough to allow the user to view the display through the antenna.

[0050] The small profile of the transparent antennas makes it relatively easy to design an antenna system of transparent panel antennas with a summing network to add the direction gain of several antennas, yielding an omni-directional antennas gain pattern. Alternately, the use of just a single transparent antenna, providing essentially hemispherical coverage, to minimize RF output in the direction of the wireless device user, is desirable when RF emissions are a health concern. Other embodiments of the present invention will occur to those skilled in the art.

Claims

1. A transparent antenna, comprising:

- a first transparent sheet of thin film (40); and
- a first transparent planar radiating element (36) having a first operating frequency and overlying said first transparent sheet of thin film (40), whereby structures underlying said first transparent sheet of thin film (40) are visible, and
- a first transparent planar ground plane (38),

characterized in that:

said transparent planar radiating element (36) and said first transparent planar ground plane (38) include highly conductive metal film structures (44) selected from the group consisting of a grid of parallel oriented metal lines and a mesh of orthogonal and parallel oriented metal lines.

2. The transparent antenna as in claim 1, **characterized in that:**

said first transparent planar ground plane (38) overlies said first transparent sheet of thin film (40), whereby said first transparent planar radiating element (36) and said first transparent planar ground plane (38) are located coplanar to each other.

3. The transparent antenna as in claims 1 or 2, **characterized in that:**

said first transparent sheet of thin film (40) has a thickness in the range between 100 and 400 μm .

4. The transparent antenna as in claim 1, **characterized by** further comprising:

a second transparent sheet of thin film (62) overlying said first transparent sheet of thin film (40);

in which said first transparent ground plane (38) is mounted on said second transparent sheet of thin film (62), whereby the first transparent planar antenna (34) is located on two transparent sheets of overlying thin films (40, 62).

5. The transparent antenna as in claim 1, **characterized in that:**

said metal film structures (44) are selected from the group of materials consisting of copper, aluminum, gold, silver, nickel, chromium, titanium, molybdenum, tin, tantalum, magnesium, cobalt, platinum, tungsten, manganese, silicon, zirconium, vanadium, niobium, hafnium, indium and other alloys of the above mentioned materials.

6. The transparent antenna as in claims 1 or 5, **characterized in that:**

said metal lines have a width in the range between 1 and 30 μm , and in which parallel oriented metal lines are separated by a distance in the range between 30 μm and 1 mm.

7. The transparent antenna as in any of claims 1 through 6, **characterized in that:**

said metal film structures (44) overlying said first transparent sheet of thin film (40) have a metal film thickness in the range between 0,03 μm and 10 μm .

8. The transparent antenna as in claim 1, **characterized in that:**

the material of said metal film structures (44) is selected from the group of materials consisting of indium-tin, indium-tin oxide, tin oxide, and in which said metal film has a metal film thickness in the range between 0.1 and 10 μm .

9. The transparent antenna as in any of claims 1 through 8, **characterized in that:**

the transparent antenna is greater than 65 percent transmissive in the band of visible light wavelengths.

10. The transparent antenna as in claim 2, **characterized by** further comprising:

a second transparent planar radiating element (52), in which said second transparent planar radiating element (52) is located coplanar to said first transparent planar radiating element (38), whereby said first and second transparent planar radiating elements (38, 52) are located coplanar to said first transparent planar ground plane (38).

11. The transparent antenna as in claim 2, **characterized by** further comprising:

a plurality of transparent planar radiating elements (52, 58, 60), in which said plurality of transparent planar radiating elements (52, 58, 60) are located coplanar to said first transparent planar radiating element (36) and said first transparent planar ground plane (38).

12. A wireless communications device which includes a flat panel electronic visual display (32), and at least a first transparent planar antenna (34) in accordance with one of the claims 1 to 9, wherein said first transparent planar antenna (34) is located overlying said flat panel electronic visual display (32).

13. The wireless communications device as in claim 12, **characterized in that:**

said first transparent sheet of thin film (40) is selected from the group of materials consisting of polyethylene terephthalate (PET), polyethylenesulfone (PES), polyetherimide (PEI), polycarbonate, polyimide, polytetrafluoroethylene, acrylic, glass, and combinations of the above-mentioned materials.

14. The wireless communications device as of claims 12 or 13, **characterized by** further comprising:

a dummy section of a non-conductive metal film structure (80) having the same transparency as that of said metal film structure (44), wherein said dummy section (80) includes the same metal lines as the plurality of metal lines of said metal film structure (44), and said dummy section (80) has a non-conductive film structure by cutting a part of each of said metal lines.

15. The wireless communications device as in any of claims 12 through 14, **characterized in that:**

said flat panel electronic visual display (32) is a

liquid crystal display (LCD).

16. The wireless communications device as in claim 12, **characterized by** further comprising:

a second transparent planar antenna (50) having a second operating frequency, different than the first operating frequency, in which said second transparent planar antenna (50) has a second transparent planar radiating element located coplanar to said first transparent planar radiating element (36), and in which said first and second transparent planar radiating elements (36, 52) are located coplanar to the shared first transparent planar ground plane (38).

17. The wireless communications device as in claim 12, **characterized by** further comprising:

a second transparent planar antenna (50) having a second operating frequency, the same as the first operating frequency, in which said second transparent planar antenna (50) has a second transparent planar radiating element (52) located coplanar to said first transparent antenna radiating element (36), and in which said first and second transparent planar radiating elements (36, 52) are located coplanar to the shared first transparent planar ground plane (38).

18. The wireless communications device as in claim 12, further comprising:

a second transparent sheet of thin film (62) overlying said first transparent sheet of thin film (40); and
a second transparent planar antenna (50) having a second operating frequency different than the first operating frequency, in which said second transparent planar antenna (50) has a second transparent planar radiating element (52) located overlying said second transparent sheet of thin film (62), and in which said first and second transparent planar radiating elements (36, 52) share said first transparent planar ground plane (38).

19. The wireless communications device as in claim 12, **characterized by** further comprising:

a second transparent sheet of thin film (62) overlying said first transparent sheet of thin film (40); and
a second transparent planar antenna (50) having a second operating frequency the same as the first operating frequency,

wherein said second transparent planar antenna (50) includes a first transparent planar radiating element (52) is located overlying said second transparent sheet of thin film (62), and
said first transparent planar radiating element (36) and said second transparent planar radiating element (52) share said first transparent planar ground plane (38).

20. The wireless communications device as in claim 12, **characterized by** further comprising:

a plurality of transparent planar antennas (50, 54, 56), in which said plurality of antennas each have a transparent planar radiating element (52, 58, 60) located coplanar to said first transparent planar radiating element (36), and in which each of said plurality of transparent planar radiating elements (52, 58, 60) is located coplanar to said first transparent planar ground plane (38).

21. The wireless communications device as in claim 12, **characterized by** further comprising:

a plurality of transparent sheets of thin film (62, 70) of a laminated structure,
a plurality of transparent planar antennas (50, 54, 60), said plurality of transparent planar antennas including transparent planar radiating elements (52, 58 and 60) respectively, and sharing said first transparent planar ground plane (38), and
said plurality of transparent planar antennas (50, 54, 56), with each one of said plurality of transparent planar radiating elements (52, 58, 60) overlying a corresponding one of said plurality of sheets of thin film (62, 70, 76).

22. The wireless communications device as defined in claim 12, **characterized by** further comprising:

a transparent user-activated touch panel (74) overlying said planar panel electronic display (32), said transparent user-activated touch panel including user-activated sensors (75) corresponding to visual prompts displayed on said planar panel electric display visible through said first transparent planar antenna (34) and said transparent touch panel (74).

23. The wireless communications device as in claim 22, **characterized in that:**

said transparent touch panel (74) and said first transparent planar antenna (34) are both mounted on said first transparent sheet of thin film (40).

24. The wireless communications device as in claim 12,

characterized by further comprising:

a second transparent planar antenna (50) having a second operating frequency, said second transparent planar radiating element (52) being located coplanar to said first transparent planar radiating element (36);
 in which said first and second transparent planar radiating elements (36, 38) are co-located in an inter-digital metal film structure (44);
 in which said inter-digital metal film structure (44) is selected from the group consisting of a grid of parallel oriented metal lines and a mesh of orthogonal and parallel oriented metal lines; and
 in which said metal lines have a width in the range between 1 and 30 μm , with a spacing between parallel oriented metal lines in the range between 30 μm and 1 mm.

25. The wireless communications device as in claim 12 or claim 24, **characterized in that:**

each metal line of said metal film structure (44) is formed in a non-display part between pixels of said planar panel electric visual display (32).

26. The wireless communications device as in claim 14, **characterized by** further comprising:

a first communicating section (90) for communicating information at the first operating frequency;
 a second communicating section (94, 98) for communicating information at the second operating frequency, wherein

said first transparent planar antenna (34) is operatively connected to said first communicating section (90) without any operative connection to said second communicating section (94, 98); and
 said second transparent planar antenna (50) is operatively connected to said second communicating section (94, 98) without any operative connection to said first communicating section (90), and
 whereby the use of the two transparent planar antennas (34, 50) eliminates the need for a duplexer circuit.

27. The wireless communications device as in claim 26, **characterized in that:**

said first communicating section (90) is a first receiving section (90) provided with an input section for receiving information at the first operating frequency, and
 said second communicating section (94, 98) is a second receiving section (94) provided with

an input section for receiving information at the second operating frequency.

28. The wireless communications device as in claim 26, **characterized in that:**

said first communicating section (90) is a receiving section (90) provided with an input section for receiving information at the first operating frequency, and
 said second communicating section (94, 98) is a transmitting section (98) provided with an output section for transmitting information at the second operating frequency.

Revendications

1. Antenne transparente, comprenant:

- une première feuille transparente de film mince (40); et
- un premier élément rayonnant plan transparent (36) présentant une première fréquence de fonctionnement et recouvrant ladite première feuille transparente de film mince (40), les structures sous-jacentes à ladite feuille transparente de film mince (40) étant de ce fait visibles; et
- un premier plan de masse plan transparent (38),

caractérisée en ce que ledit élément rayonnant plan transparent (36) et ledit premier plan de masse plan transparent (38) comprennent des structures de film métallique hautement conductrices (44) sélectionnées parmi le groupe composé d'une grille de lignes métalliques orientées parallèlement et d'une trame de lignes métalliques orientées parallèlement et orthogonalement.

2. Antenne transparente selon la revendication 1, **caractérisée en ce que** ledit premier plan de masse plan transparent (38) recouvre ladite première feuille transparente de film mince (40), ledit premier élément rayonnant plan transparent (36) et ledit premier plan de masse plan transparent (38) étant de ce fait situés dans le même plan l'un et l'autre.

3. Antenne transparente selon la revendication 1 ou 2, **caractérisée en ce que** ladite première feuille transparente de film mince (40) a une épaisseur dans la gamme comprise entre 100 et 400 μm .

4. Antenne transparente selon la revendication 1, **caractérisée en ce qu'elle** comprend en outre une deuxième feuille transparente de film mince (62) recouvrant ladite première feuille transparente de film mince (40), dans laquelle ledit premier plan de mas-

se plan transparent (38) est monté sur ladite deuxième feuille transparente de film mince (62), la première antenne plane transparente (34) étant de ce fait située sur deux feuilles transparentes de films minces superposés (40, 62).

5. Antenne transparente selon la revendication 1, **caractérisée en ce que** lesdites structures de films métalliques (44) sont sélectionnées parmi le groupe de matières composé du cuivre, de l'aluminium, de l'or, de l'argent, du nickel, du chrome, du titane, du molybdène, de l'étain, du magnésium, du cobalt, du platine, du tungstène, du manganèse, du silicium, du zirconium, du vanadium, du niobium, du hafnium, de l'indium et d'autres alliages des matières mentionnées ci-dessus.
6. Antenne transparente selon la revendication 1 ou 5, **caractérisée en ce que** lesdites lignes métalliques ont une largeur dans la gamme comprise entre 1 et 30 μm , et dans laquelle des lignes métalliques orientées parallèlement sont séparées par une distance dans la gamme comprise entre 30 μm et 1 mm.
7. Antenne transparente selon l'une quelconque des revendications 1 à 6, **caractérisée en ce que** lesdites structures de films métalliques (44) recouvrant ladite première feuille transparente de film mince (40) ont une épaisseur de film métallique dans la gamme comprise entre 0,03 μm et 10 μm .
8. Antenne transparente selon la revendication 1, **caractérisée en ce que** la matière desdites structures de films métalliques (44) est sélectionnée parmi le groupe de matières composé de indium-étain, indium-oxyde d'étain, oxyde d'étain, et dans laquelle ledit film métallique a une épaisseur de film métallique dans la gamme comprise entre 0,1 et 10 μm .
9. Antenne transparente selon l'une quelconque des revendications 1 à 8, **caractérisée en ce que** l'antenne transparente est transmissive à plus de 65 % dans la bande des longueurs d'onde de la lumière visible.
10. Antenne transparente selon la revendication 2, **caractérisée en ce qu'elle** comprend en outre un deuxième élément rayonnant plan transparent (52), dans laquelle ledit deuxième élément rayonnant plan transparent (52) est situé dans le même plan que ledit premier élément rayonnant plan transparent (38), lesdits premier et deuxième éléments rayonnants plans transparents (38, 52) étant de ce fait coplanaires audit premier plan de masse plan transparent (38).
11. Antenne transparente selon la revendication 2, **caractérisée en ce qu'elle** comprend en outre une

pluralité d'éléments rayonnants plans transparents (52, 58, 60), dans laquelle ladite pluralité d'éléments rayonnants plans transparents (52, 58, 60) est située dans le même plan que ledit premier élément rayonnant plan transparent (36) et que ledit premier plan de masse plan transparent (38).

12. Appareil de communication sans fil qui comprend un écran d'affichage électronique plat (32) et au moins une antenne plane transparente (34) selon l'une quelconque des revendications 1 à 9, dans lequel ladite antenne plane transparente (34) est située en recouvrement dudit écran d'affichage électronique plat (32).
13. Appareil de communication sans fil selon la revendication 12, **caractérisé en ce que** ladite première feuille transparente de film mince (40) est sélectionnée parmi le groupe de matières composé de polyéthylène téréphtalate (PET), polyéthylsulfone (PES), polyétherimide (PEI), polycarbonate, polyimide, polytétrafluoroéthylène, acrylique, verre, et des combinaisons des matières mentionnées ci-dessus.
14. Appareil de communication sans fil selon la revendication 12 ou 13, **caractérisé en ce qu'il** comprend en outre une section factice d'une structure de film métallique non conductrice (80) ayant la même transparence que celle de ladite structure de film métallique (44), dans lequel ladite section factice (80) comprend les mêmes lignes métalliques que la pluralité de lignes métalliques de ladite structure de film métallique (44), et ladite section factice (80) comprend une structure de film non conductrice en coupant une partie de chacune desdites lignes métalliques.
15. Appareil de communication sans fil selon l'une quelconque des revendications 12 à 14, **caractérisé en ce que** ledit écran d'affichage électronique plat (32) est un écran d'affichage à cristaux liquides (LCD).
16. Appareil de communication sans fil selon la revendication 12, **caractérisé en ce qu'il** comprend en outre une deuxième antenne plane transparente (50) présentant une deuxième fréquence de fonctionnement, différente de la première fréquence de fonctionnement, dans lequel ladite deuxième antenne plane transparente (50) comporte un deuxième élément rayonnant plan transparent situé dans le même plan que ledit premier élément rayonnant plan transparent (36), et dans lequel lesdits premier et deuxième éléments rayonnants plans transparents (36, 52) sont coplanaires au premier plan de masse plan transparent partagé (38).
17. Appareil de communication sans fil selon la reven-

dication 12, **caractérisé en ce qu'il** comprend en outre une deuxième antenne plane transparente (50) présentant une deuxième fréquence de fonctionnement, identique à la première fréquence de fonctionnement, dans lequel ladite deuxième antenne plane transparente (50) comporte un deuxième élément rayonnant plan transparent (52) situé dans le même plan que ledit premier élément rayonnant plan transparent (36), et dans lequel lesdits premier et deuxième éléments rayonnants plans transparents (36, 52) sont coplanaires au premier plan de masse plan transparent partagé (38).

18. Appareil de communication sans fil selon la revendication 12, comprenant en outre une deuxième feuille transparente de film mince (62) recouvrant ladite première feuille transparente de film mince (40), et une deuxième antenne plane transparente (50) présentant une deuxième fréquence de fonctionnement, différente de la première fréquence de fonctionnement, dans lequel ladite deuxième antenne plane transparente (50) comporte un deuxième élément rayonnant plan transparent (52) situé en recouvrement de ladite deuxième feuille transparente de film mince (62), et dans lequel lesdits premier et deuxième éléments rayonnants plans transparents (36, 52) partagent ledit premier plan de masse plan transparent (38).

19. Appareil de communication sans fil selon la revendication 12, **caractérisé en ce qu'il** comprend en outre une deuxième feuille transparente de film mince (62) recouvrant ladite première feuille transparente de film mince (40), et une deuxième antenne plane transparente (50) présentant une deuxième fréquence de fonctionnement, identique à la première fréquence de fonctionnement, dans lequel ladite deuxième antenne plane transparente (50) comporte un premier élément rayonnant plan transparent (52) recouvrant ladite deuxième feuille transparente de film mince (62) et ledit premier élément rayonnant plan transparent (36) et ledit deuxième élément rayonnant plan transparent (52) partagent ledit premier plan de masse plan transparent (38).

20. Appareil de communication sans fil selon la revendication 12, **caractérisé en ce qu'il** comprend en outre une pluralité d'antennes planes transparentes (50, 54, 56), dans lequel ladite pluralité d'antennes ont chacune un élément rayonnant plan transparent (52, 58, 60) situé dans le même plan que ledit premier élément rayonnant plan transparent (36), et dans lequel chacun de ladite pluralité d'éléments rayonnants plans transparents (52, 58, 60) est coplanaire audit premier plan de masse plan transparent (38).

21. Appareil de communication sans fil selon la reven-

dication 12, **caractérisé en ce qu'il** comprend en outre une pluralité de feuilles transparentes de film mince (62, 70) d'une structure stratifiée, une pluralité d'antennes planes transparentes (50, 54, 60), ladite pluralité d'antennes planes transparentes comportant des éléments rayonnants plans transparents (52, 58 et 60) respectivement, et partageant ledit premier plan de masse plan transparent (38), et ladite pluralité d'antennes planes transparentes (50, 54, 56), chacun de ladite pluralité d'éléments rayonnants plans transparents (52, 58, 60) recouvrant une feuille correspondante de ladite pluralité de feuilles de film mince (62, 70, 76).

22. Appareil de communication sans fil selon la revendication 12, **caractérisé en ce qu'il** comprend en outre un panneau tactile transparent (74), activé par l'utilisateur, recouvrant ledit écran d'affichage électronique plan (32), ledit panneau tactile transparent activé par l'utilisateur comportant des capteurs (75) activés par l'utilisateur, correspondant à des guides visuels affichés sur ledit écran d'affichage électronique plan visibles à travers ladite première antenne transparente (34) et ledit panneau tactile transparent (74).

23. Appareil de communication sans fil selon la revendication 22, **caractérisé en ce que** ledit panneau tactile transparent (74) et ladite première antenne plane transparente (34) sont tous les deux montés sur ladite première feuille transparente de film mince (40).

24. Appareil de communication sans fil selon la revendication 12, **caractérisé en ce qu'il** comprend en outre une deuxième antenne plane transparente (50) présentant une deuxième fréquence de fonctionnement, ledit deuxième élément rayonnant plan transparent (52) étant situé dans le même plan que ledit premier élément rayonnant plan transparent (36), dans lequel lesdits premier et deuxième éléments rayonnants plans transparents (36, 38) sont situés conjointement dans une structure de film métallique interdigitée (44), dans lequel ladite structure de film métallique interdigitée (44) est sélectionnée parmi le groupe composé d'une grille de lignes métalliques orientées parallèlement et d'une trame de lignes métalliques orientées parallèlement et orthogonalement, et dans lequel lesdites lignes métalliques ont une largeur dans la gamme comprise entre 1 et 30 μm avec un écartement entre des lignes métalliques orientées parallèlement dans la gamme comprise entre 30 μm et 1 mm.

25. Appareil de communication sans fil selon la revendication 12 ou 24, **caractérisé en ce que** chaque ligne métallique de ladite structure de film métallique (44) est formée dans une zone sans affichage entre

des pixels dudit écran d'affichage électronique plan (32).

26. Appareil de communication sans fil selon la revendication 14, **caractérisé en ce qu'il** comprend en outre une première section de communication (90) pour communiquer des informations à la première fréquence de fonctionnement, une deuxième section de communication (94, 98) pour communiquer des informations à la deuxième fréquence de fonctionnement, dans lequel ladite première antenne plane transparente (34) est connectée de façon opérationnelle à ladite première section de communication (90) sans aucune connexion opérationnelle à ladite deuxième section de communication (94, 98), et ladite deuxième antenne plane transparente (50) est connectée de façon opérationnelle à ladite deuxième section de communication (94, 98) sans aucune connexion opérationnelle à ladite première section de communication (90), l'utilisation des deux antennes planes transparentes (34, 50) éliminant de ce fait la nécessité d'un circuit de duplexeur.
27. Appareil de communication sans fil selon la revendication 26, **caractérisé en ce que** ladite première section de communication (90) est une première section de réception (90) pourvue d'une section d'entrée pour recevoir des informations à la première fréquence de fonctionnement, et ladite deuxième section de communication (94, 98) est une deuxième section de réception (94) pourvue d'une section d'entrée pour recevoir des informations à la deuxième fréquence de fonctionnement.
28. Appareil de communication sans fil selon la revendication 26, **caractérisé en ce que** ladite première section de communication (90) est une section de réception (90) pourvue d'une section d'entrée pour recevoir des informations à la première fréquence de fonctionnement, et ladite deuxième section de communication (94, 98) est une section de transmission (98) pourvue d'une section de sortie (98) pour transmettre des informations à la deuxième fréquence de fonctionnement.

Patentansprüche

1. Transparente Antenne, umfassend:

- eine erste transparente Folienbahn aus Dünnschicht (40); und
- ein erstes transparentes planares Abstrahlelement (36) mit einer ersten Betriebsfrequenz, das über der ersten transparenten Folienbahn aus Dünnschicht (40) liegt, wodurch unter der ersten transparenten Folienbahn aus Dünnschicht (40) liegende Strukturen sichtbar sind, und

- eine erste transparente planare Grundplatte (38),

dadurch gekennzeichnet, dass:

das transparente planare Abstrahlelement (36) und die erste transparente planare Grundplatte (38) hoch leitfähige Metallschichtstrukturen (44) beinhalten, die aus der aus einem Gitter von parallel orientierten Metallleitungen und einem Netz von orthogonal und parallel orientierten Metallleitungen bestehenden Gruppe ausgewählt sind.

2. Transparente Antenne nach Anspruch 1, **dadurch gekennzeichnet, dass:**

die erste transparente planare Grundplatte (38) über der ersten transparenten planaren Folienbahn aus Dünnschicht (40) liegt, wodurch das erste transparente planare Abstrahlelement (36) und die erste transparente planare Grundplatte (38) planparallel zu einander angeordnet sind.

3. Transparente Antenne nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass:**

die erste transparente Folienbahn aus Dünnschicht (40) eine Dicke in dem Bereich zwischen 100 und 400 µm aufweist.

4. Transparente Antenne nach Anspruch 1, **gekennzeichnet durch:**

eine zweite transparente Folienbahn aus Dünnschicht (62), die über der ersten transparenten Folienbahn aus Dünnschicht (40) liegt;

wobei die erste transparente Grundplatte (38) auf der zweiten transparenten Folienbahn aus Dünnschicht (62) angebracht ist, wodurch die erste transparente planare Antenne (34) auf zwei transparenten Folienbahnen aus über einander liegenden Dünnschichten (40, 62) angeordnet ist.

5. Transparente Antenne nach Anspruch 1, **dadurch gekennzeichnet, dass:**

die Metallschichtstrukturen (44) aus der aus Kupfer, Aluminium, Gold, Silber, Nickel, Chrom, Titan, Molybdän, Zinn, Tantal, Magnesium, Kobalt, Platin, Wolfram, Mangan, Silizium, Zirkonium, Vanadium, Niobium, Hafnium, Indium und anderen Legierungen der vorstehend erwähnten Werkstoffe bestehenden Gruppe von Werkstoffen ausgewählt sind.

6. Transparente Antenne nach Anspruch 1 oder 5, **dadurch gekennzeichnet, dass:**

die Metallleitungen eine Breite in dem Bereich zwischen 1 und 30 μm aufweisen, und

wobei parallel orientierte Metallleitungen durch einen Abstand in dem Bereich zwischen 30 μm und 1 mm getrennt sind.

7. Transparente Antenne nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass:**

die über der ersten transparenten Folienbahn aus Dünnschicht (40) liegenden Metallschichtstrukturen (44) eine Metallschichtdicke in dem Bereich zwischen 0,03 μm und 10 μm aufweisen.

8. Transparente Antenne nach Anspruch 1, **dadurch gekennzeichnet, dass:**

der Werkstoff der Metallschichtstrukturen (44) aus der aus Indium-Zinn, Indium-ZinnOxid und Zinnoxid bestehenden Gruppe von Werkstoffen ausgewählt ist, und wobei die Metallschicht eine Metallschichtdicke in dem Bereich zwischen 0,1 und 10 μm aufweist.

9. Transparente Antenne nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass:**

die transparente Antenne in dem Band von Wellenlängen sichtbaren Lichts mehr als 65 Prozent lichtdurchlässig ist.

10. Transparente Antenne nach Anspruch 2, **gekennzeichnet durch:**

ein zweites transparentes planares Abstrahlelement (52), wobei das zweite transparente planare Abstrahlelement (52) planparallel zu dem ersten transparenten planaren Abstrahlelement (38) angeordnet ist, wodurch das erste und das zweite transparente planare Abstrahlelement (38, 52) planparallel zu der ersten transparenten planaren Grundplatte (38) angeordnet sind.

11. Transparente Antenne nach Anspruch 2, **gekennzeichnet durch:**

eine Vielzahl von transparenten planaren Abstrahlelementen (52, 58, 60), wobei die Vielzahl von transparenten planaren Abstrahlelementen (52, 58, 60) planparallel zu dem ersten transparenten planaren Abstrahlelement (36) und der ersten transparenten planaren Grundplatte (38) angeordnet sind.

12. Drahtlose Kommunikationseinrichtung, welche eine flachplattenförmige elektronische Sichtanzeige (32) und zumindest eine erste transparente planare Antenne (34) nach einem der Ansprüche 1 bis 9 beinhaltet, wobei die erste transparente planare Antenne (34) über der flachplattenförmigen elektronischen Sichtanzeige (32) liegend angeordnet ist.

13. Drahtlose Kommunikationseinrichtung nach Anspruch 12, **dadurch gekennzeichnet, dass:**

die erste transparente Folienbahn aus Dünnschicht (40) aus der aus Polyethylen-Terephthalat (PET), Polyethylen-Sulfon (PES), Polyether-Imid (PEI), Polycarbonat, Polyimid, Polyetrafluorethylen, Acryl, Glas und Kombinationen der vorstehend erwähnten Werkstoffe bestehenden Gruppe von Werkstoffen ausgewählt ist.

14. Drahtlose Kommunikationseinrichtung nach Anspruch 12 oder 13, **gekennzeichnet durch:**

einen Blindabschnitt aus einer nicht leitenden Metallschichtstruktur (80) mit derselben Transparenz wie die der Metallschichtstruktur (44), wobei der Blindabschnitt (80) dieselben Metallleitungen wie die Vielzahl von Metallleitungen der Metallschichtstruktur (44) beinhaltet, und der Blindabschnitt (80) **durch** Abschneiden eines Teils jeder der Metallleitungen eine nicht leitende Schichtstruktur hat.

15. Drahtlose Kommunikationseinrichtung nach einem der Ansprüche 12 bis 14, **dadurch gekennzeichnet, dass:**

die flachplattenförmige elektronische Sichtanzeige (32) eine Flüssigkristallanzeige (LCD) ist.

16. Drahtlose Kommunikationseinrichtung nach Anspruch 12, **gekennzeichnet durch:**

eine zweite transparente planare Antenne (50) mit einer zweiten Betriebsfrequenz, die sich von der ersten Betriebsfrequenz unterscheidet, wobei die zweite transparente planare Antenne (50) ein zweites transparentes planares Abstrahlelement aufweist, das planparallel zu dem ersten transparenten planaren Abstrahlelement (36) angeordnet ist, und wobei das erste und das zweite transparente planare Abstrahlelement (36, 52) planparallel zu der gemeinsamen ersten transparenten Grundplatte (38) angeordnet sind.

17. Drahtlose Kommunikationseinrichtung nach Anspruch 12, **gekennzeichnet durch:**

eine zweite transparente planare Antenne (50) mit einer zweiten Betriebsfrequenz, die gleich der ersten Betriebsfrequenz ist, wobei die zweite transparente planare Antenne (50) ein zweites transparentes planares Abstrahlelement (52) aufweist, das planparallel zu dem ersten transparenten Antennenabstrahlelement (36) angeordnet ist, und wobei das erste und das zweite planare Abstrahlelement (36, 52) planparallel zu der gemeinsamen transparenten planaren Grundplatte (38) angeordnet sind.

18. Drahtlose Kommunikationseinrichtung nach Anspruch 12, ferner umfassend:

eine zweite transparente Folienbahn aus Dünnschicht (62), die über der ersten transparenten Folienbahn aus Dünnschicht (40) liegt; und eine zweite transparente planare Antenne (50) mit einer zweiten Betriebsfrequenz, die sich von der ersten Betriebsfrequenz unterscheidet, wobei die zweite transparente planare Antenne (50) ein zweites transparentes planares Abstrahlelement (52) aufweist, das über der zweiten transparenten Folienbahn aus Dünnschicht (62) liegend angeordnet ist, und wobei das erste und das zweite transparente planare Abstrahlelement (36, 52) sich die erste transparente planare Grundplatte (38) teilen.

19. Drahtlose Kommunikationseinrichtung nach Anspruch 12, gekennzeichnet durch:

eine zweite transparente Folienbahn aus Dünnschicht (62), die über der ersten transparenten Folienbahn aus Dünnschicht (40) liegt; und eine zweite transparente planare Antenne (50) mit einer zweiten Betriebsfrequenz, die gleich der ersten Betriebsfrequenz ist,

wobei die zweite transparente planare Antenne (50) ein erstes transparentes planares Abstrahlelement (52) beinhaltet, das über der zweiten transparenten Folienbahn aus Dünnschicht (62) liegend angeordnet ist, und sich das erste transparente planare Abstrahlelement (36) und das zweite transparente planare Abstrahlelement (52) die erste transparente planare Grundplatte (38) teilen.

20. Drahtlose Kommunikationseinrichtung nach Anspruch 12, gekennzeichnet durch:

eine Vielzahl von transparenten planaren Antennen (50, 54, 56), wobei jede der Vielzahl von Antennen ein transparentes planares Abstrahlelement (52, 58, 60) aufweist, das planparallel zu dem ersten transparenten planaren Abstrah-

lelement (36) angeordnet ist, und

wobei jedes der Vielzahl von transparenten planaren Abstrahlelementen (52, 58, 60) planparallel zu der ersten transparenten planaren Grundplatte (38) angeordnet ist.

21. Drahtlose Kommunikationseinrichtung nach Anspruch 12, gekennzeichnet durch:

eine Vielzahl von transparenten Folienbahnen aus Dünnschicht (62, 70) in einer laminierten Struktur, eine Vielzahl von transparenten planaren Antennen (50, 54, 60), wobei die Vielzahl von transparenten planaren Antennen jeweils transparente planare Abstrahlelemente (52, 58 und 60) beinhalten und sich die erste transparente planare Grundplatte (38) teilen, und die Vielzahl von transparenten planaren Antennen (50, 54, 60), wobei jedes eine der Vielzahl von transparenten planaren Abstrahlelementen (52, 58, 60) über einer entsprechenden einen der Vielzahl von Folienbahnen aus Dünnschicht (62, 70, 76) liegt.

22. Drahtlose Kommunikationseinrichtung nach Anspruch 12, gekennzeichnet durch:

ein transparentes benutzerbetätigtes Sensorfeld (74), das über der planaren elektronischen Anzeigeplatte (32) liegt, wobei das transparente benutzerbetätigte Sensorfeld benutzerbetätigte Sensoren (75) einschließt, entsprechend zu visuellen Eingabeaufforderungen, die auf der planaren elektrischen Anzeige **durch** die erste transparente planare Antenne (34) und das transparente Sensorfeld (74) sichtbar angezeigt werden.

23. Drahtlose Kommunikationseinrichtung nach Anspruch 22, dadurch gekennzeichnet, dass:

das transparente Sensorfeld (74) und die erste transparente planare Antenne (34) beide auf der ersten transparenten Folienbahn aus Dünnschicht (40) angebracht sind.

24. Drahtlose Kommunikationseinrichtung nach Anspruch 12, gekennzeichnet durch:

eine zweite transparente planare Antenne (50) mit einer zweiten Betriebsfrequenz, wobei das zweite transparente planare Abstrahlelement (52) planparallel zu dem ersten transparenten planaren Abstrahlelement (36) angeordnet ist;

wobei das erste und das zweite transparente planare

Abstrahlelement (36, 38) in einer interdigitalen Metallschichtstruktur (44) nebengeordnet sind;
wobei die interdigitale Metallschichtstruktur (44) aus der aus einem Gitter von parallel orientierten Metallleitungen und einem Netz von orthogonal und parallel orientierten Metallleitungen bestehenden Gruppe ausgewählt ist; und
wobei die Metallleitungen eine Breite in dem Bereich zwischen 1 und 30 μm aufweisen, mit einem Abstand zwischen parallel orientierten Metallleitungen in dem Bereich zwischen 30 μm und 1 mm.

25. Drahtlose Kommunikationseinrichtung nach Anspruch 12 oder 24, **dadurch gekennzeichnet, dass:**

jede Metallleitung der Metallschichtstruktur (44) in einem Nichtanzeigeteil zwischen Pixeln der planaren elektrischen Sichtanzeige (32) ausgebildet ist.

26. Drahtlose Kommunikationseinrichtung nach Anspruch 14, **gekennzeichnet durch:**

einen ersten Kommunikationsabschnitt (90) zum Kommunizieren von Informationen bei der ersten Betriebsfrequenz;
einen zweiten Kommunikationsabschnitt (94, 98) zum Kommunizieren von Informationen bei der zweiten Betriebsfrequenz, wobei

die erste transparente planare Antenne (34) ohne jegliche wirksame Verbindung zu dem zweiten Kommunikationsabschnitt (94, 98) wirkend mit dem ersten Kommunikationsabschnitt (90) verbunden ist; und
die zweite transparente planare Antenne (50) ohne jegliche wirksame Verbindung zu dem ersten Kommunikationsabschnitt (90) wirkend mit dem zweiten Kommunikationsabschnitt (94, 98) verbunden ist; und
wodurch die Verwendung der beiden transparenten planaren Antennen (34, 50) die Notwendigkeit einer Duplexer-Schaltung beseitigt.

27. Drahtlose Kommunikationseinrichtung nach Anspruch 26, **dadurch gekennzeichnet, dass:**

der erste Kommunikationsabschnitt (90) ein erster Empfangsabschnitt (90) ist, der mit einem Eingangsabschnitt zum Empfangen von Informationen bei der ersten Betriebsfrequenz versehen ist, und
der zweite Kommunikationsabschnitt (94, 98) ein zweiter Empfangsabschnitt (94) ist, der mit einem Eingangsabschnitt zum Empfangen von Informationen bei der zweiten Betriebsfrequenz versehen ist.

28. Drahtlose Kommunikationseinrichtung nach Anspruch 26, **dadurch gekennzeichnet, dass** der erste Kommunikationsabschnitt (90) ein erster Empfangsabschnitt (90) ist, der mit einem Eingangsabschnitt zum Empfangen von Informationen bei der ersten Betriebsfrequenz versehen ist, und der zweite Kommunikationsabschnitt (94, 98) ein Sendeabschnitt (98) ist, der mit einem Ausgangsabschnitt zum Senden von Informationen bei der zweiten Betriebsfrequenz versehen ist.

FIG. 1

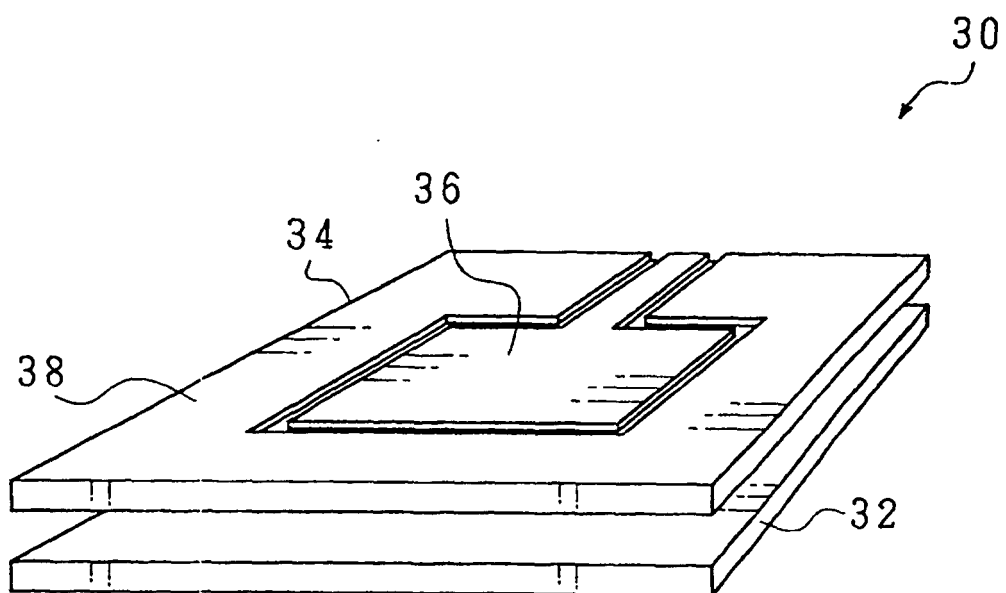


FIG. 2

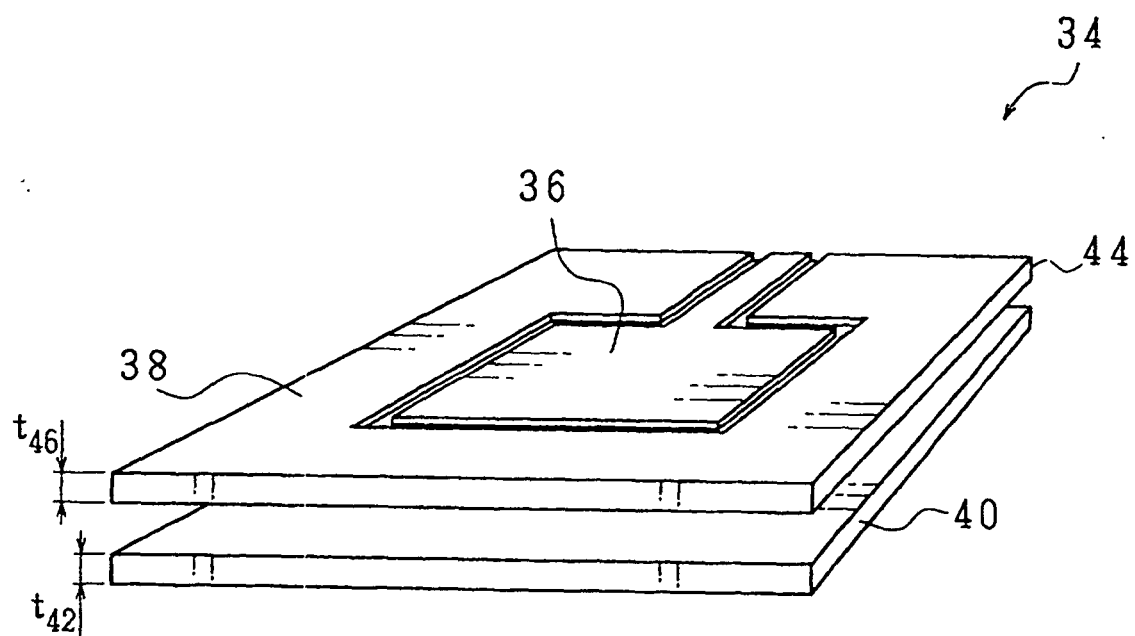


FIG. 3

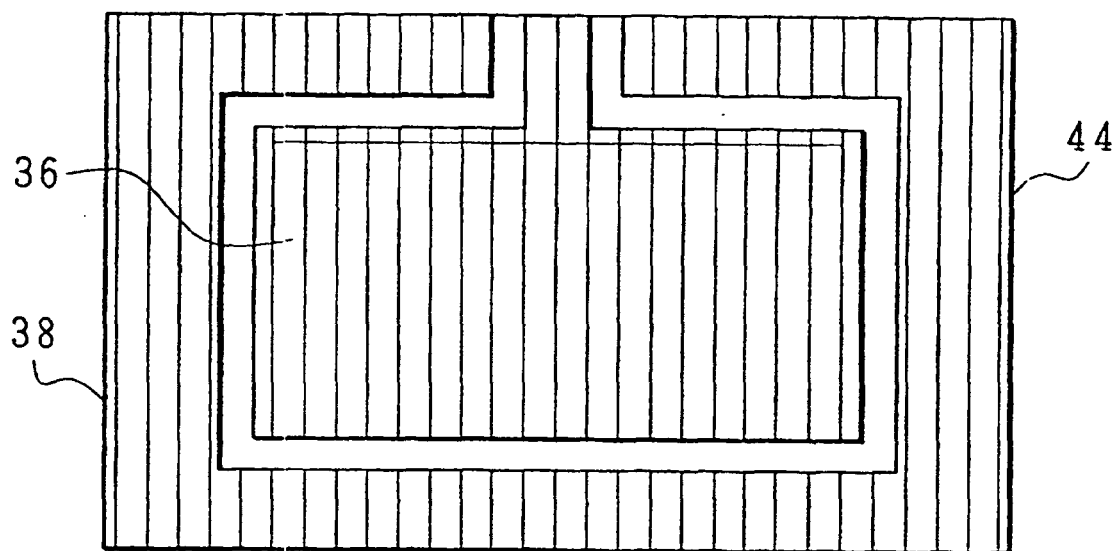


FIG. 4

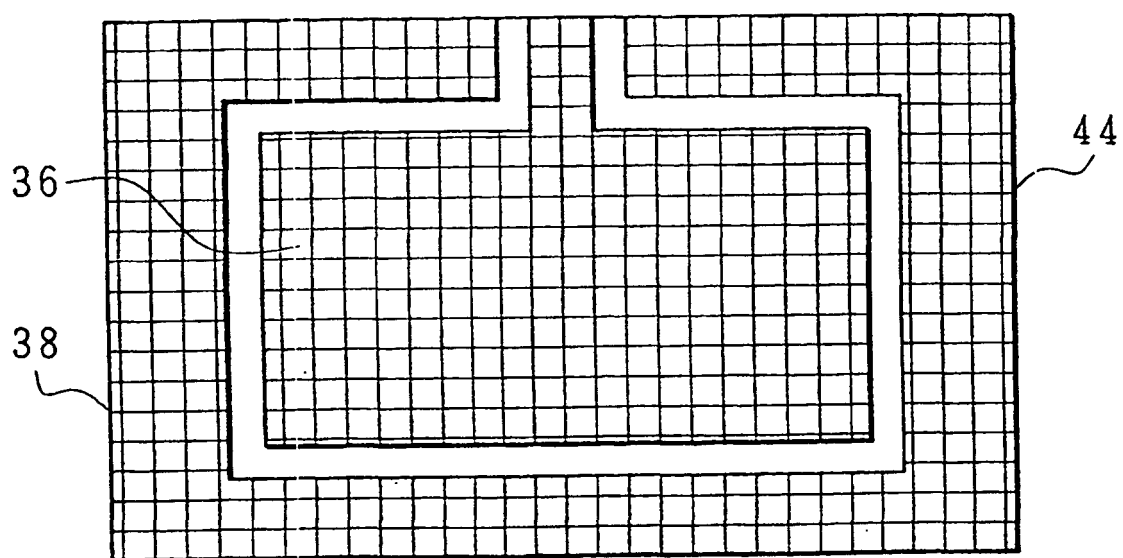


FIG. 5

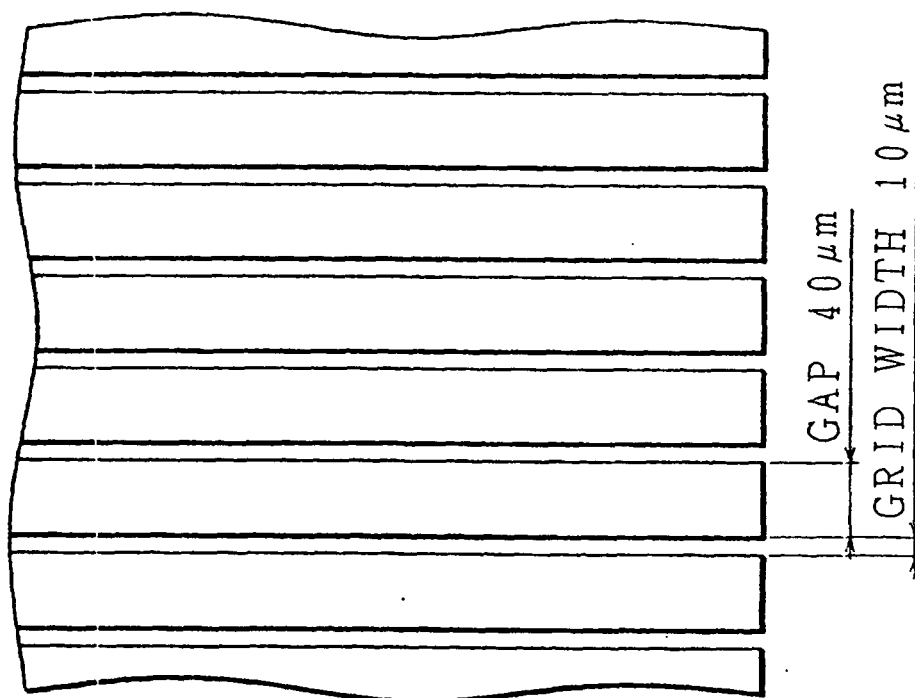


FIG. 6

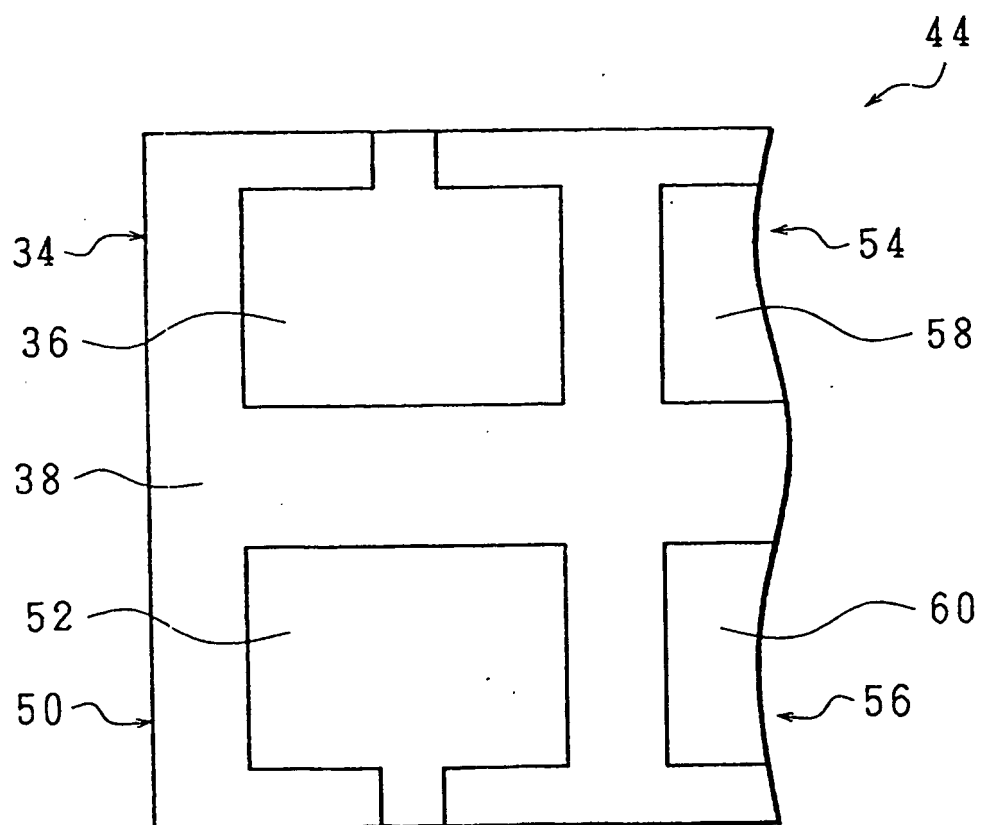


FIG. 7

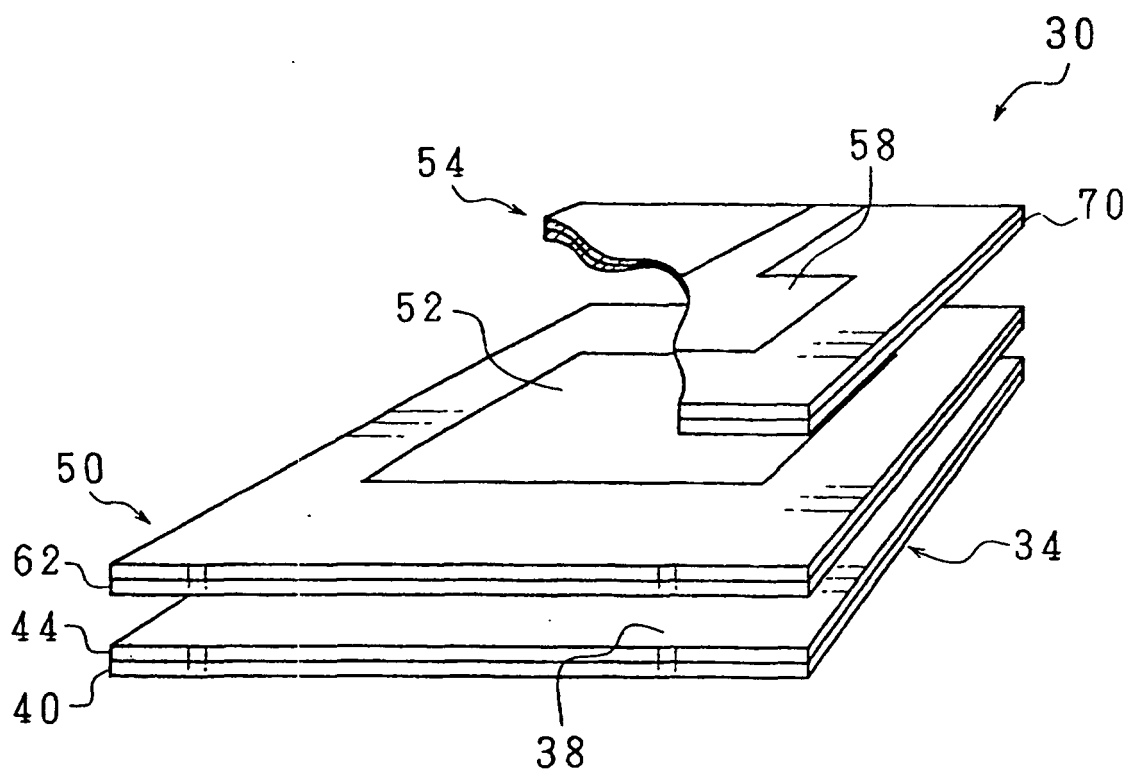


FIG. 8

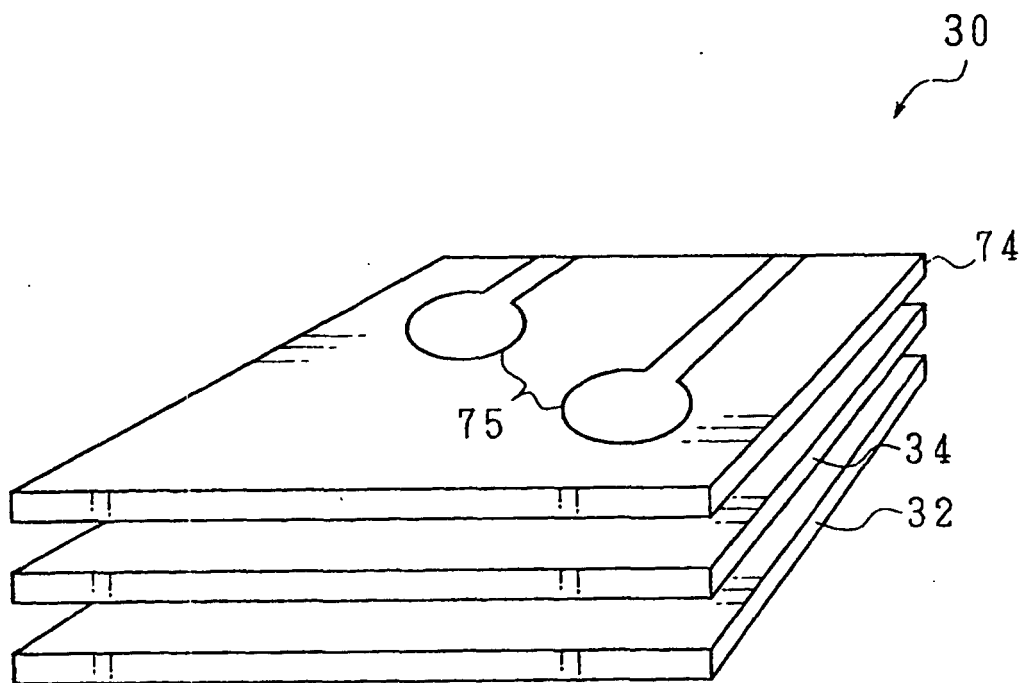


FIG. 9

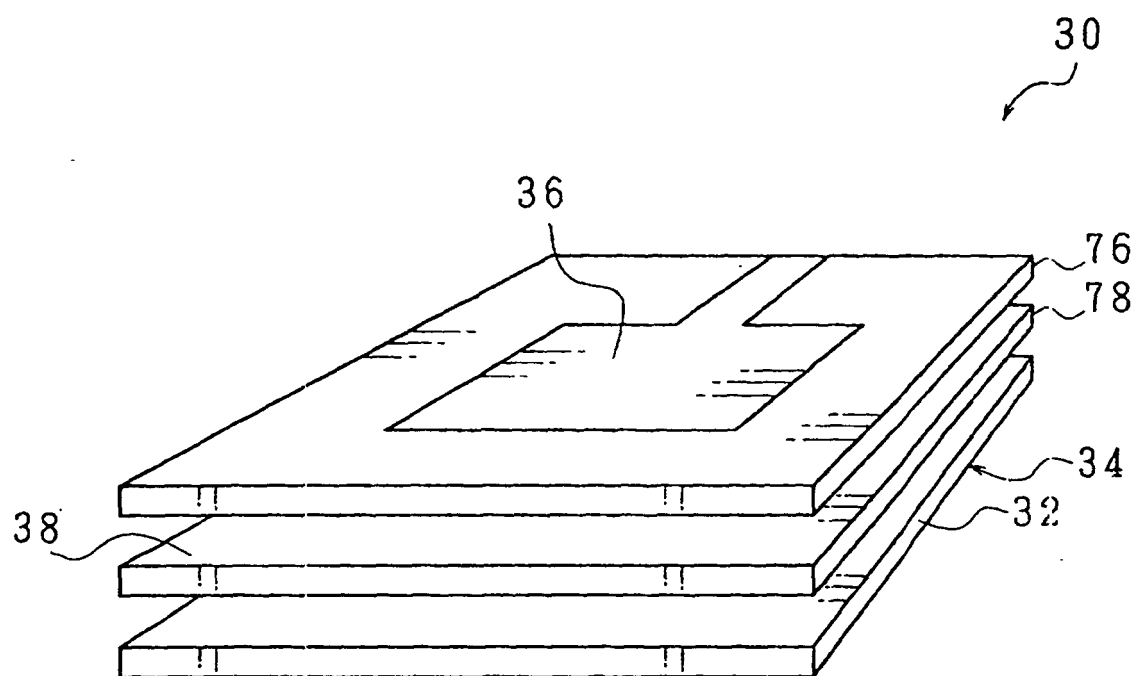


FIG. 10

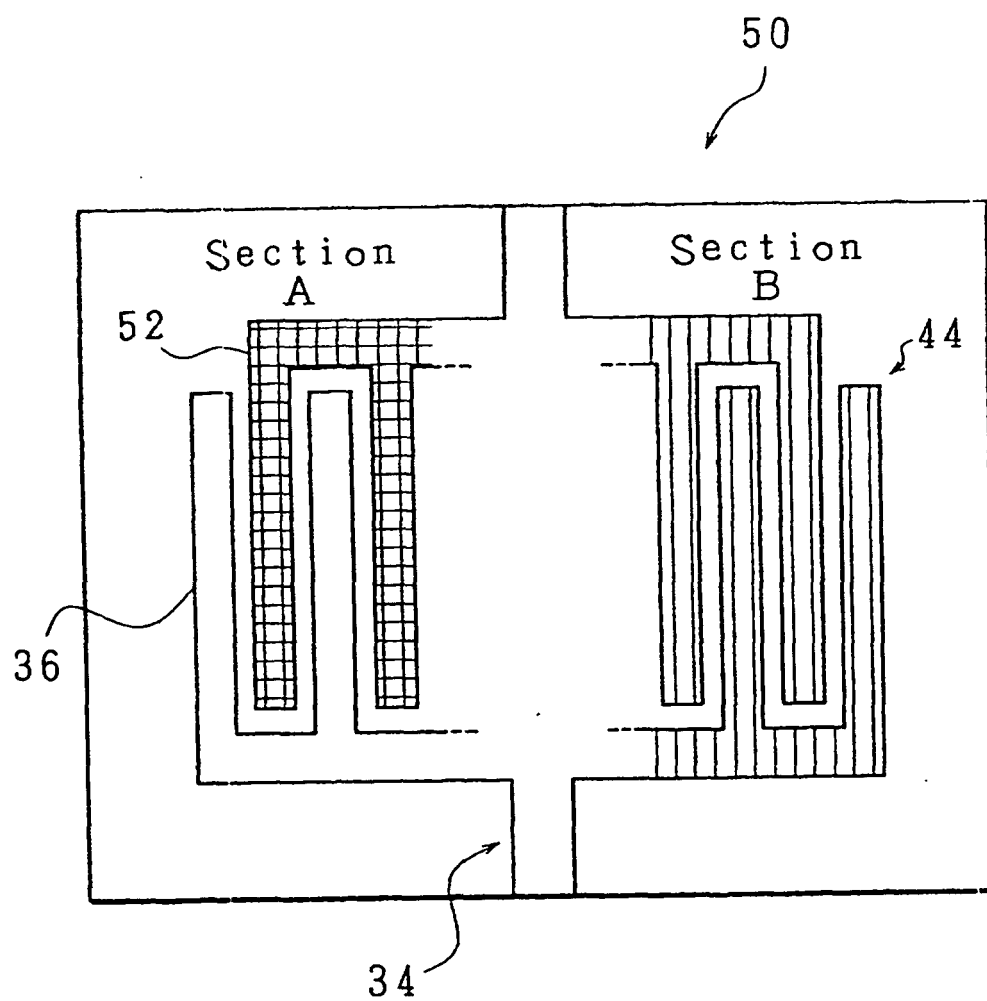


FIG. 11

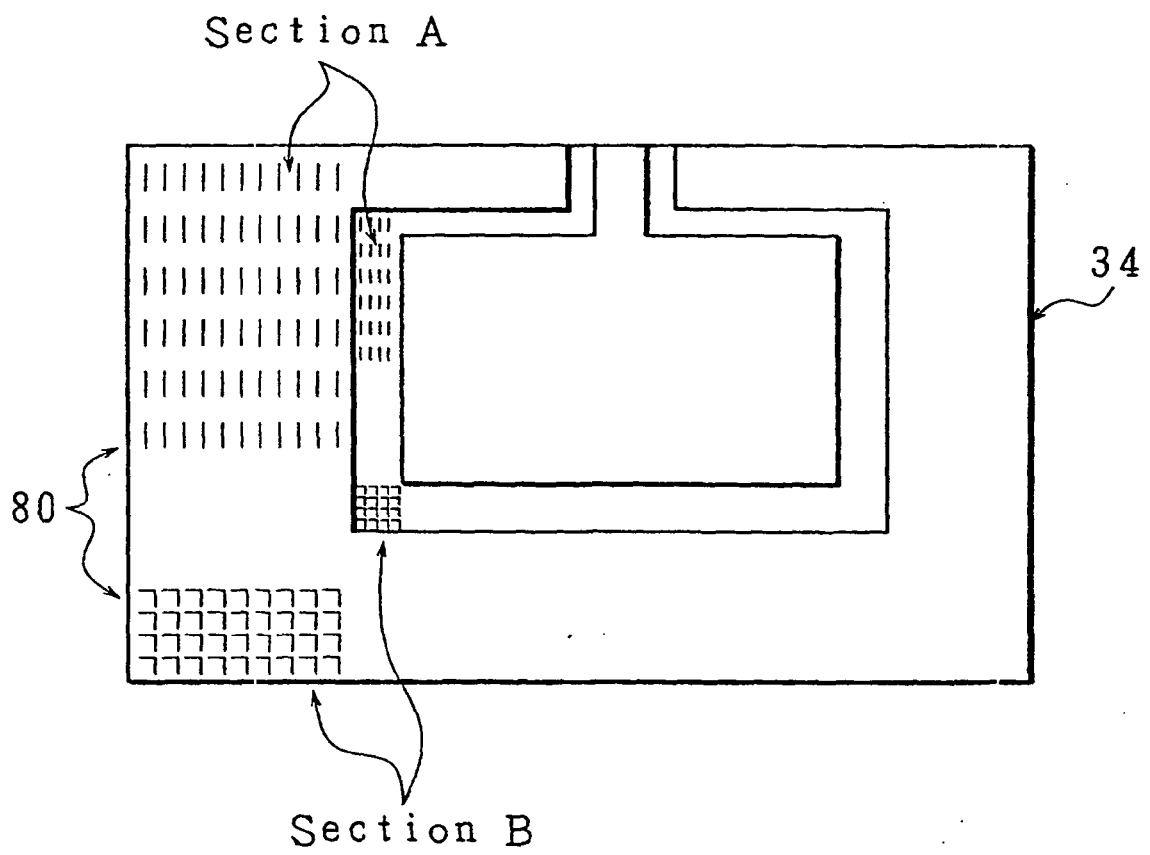


FIG. 12

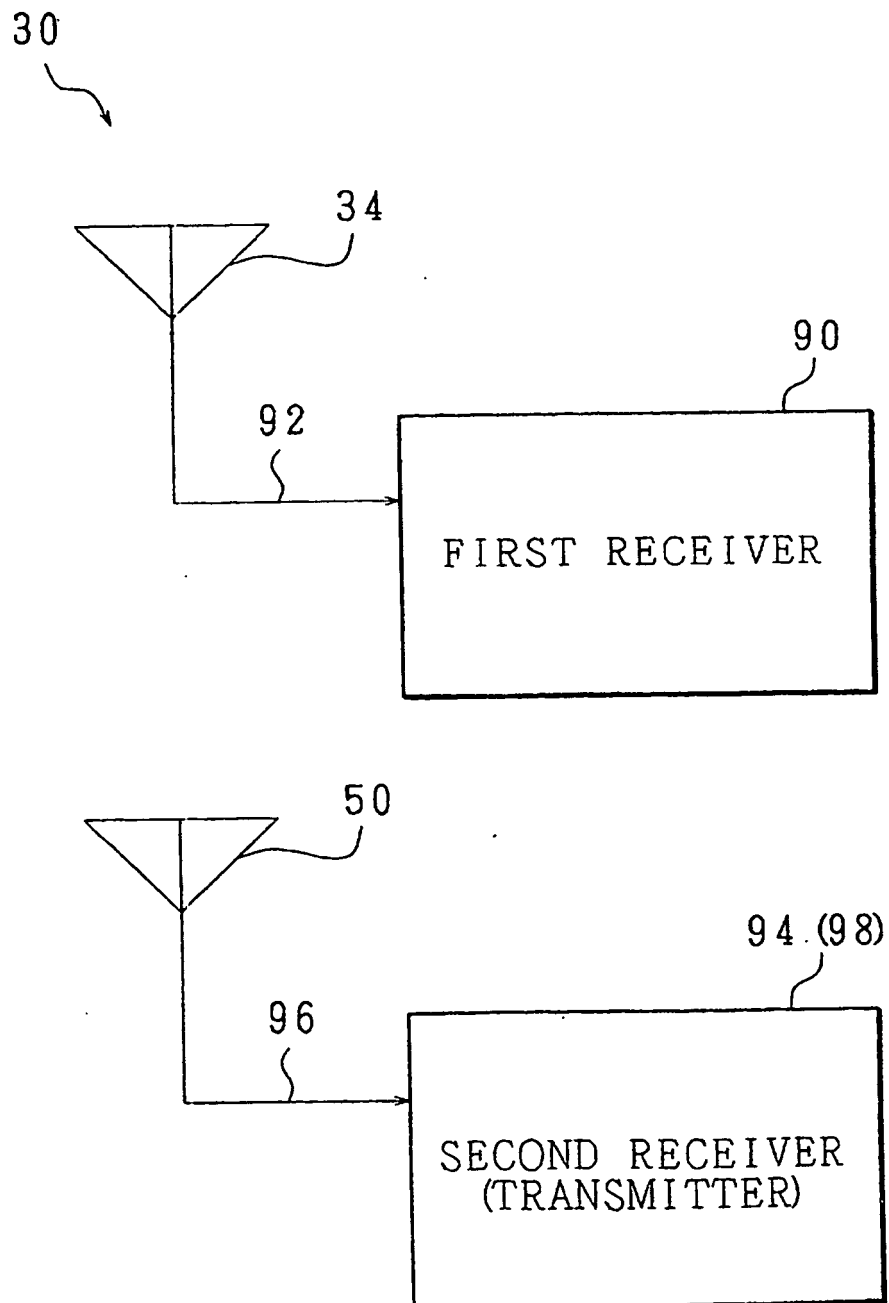


FIG. 13

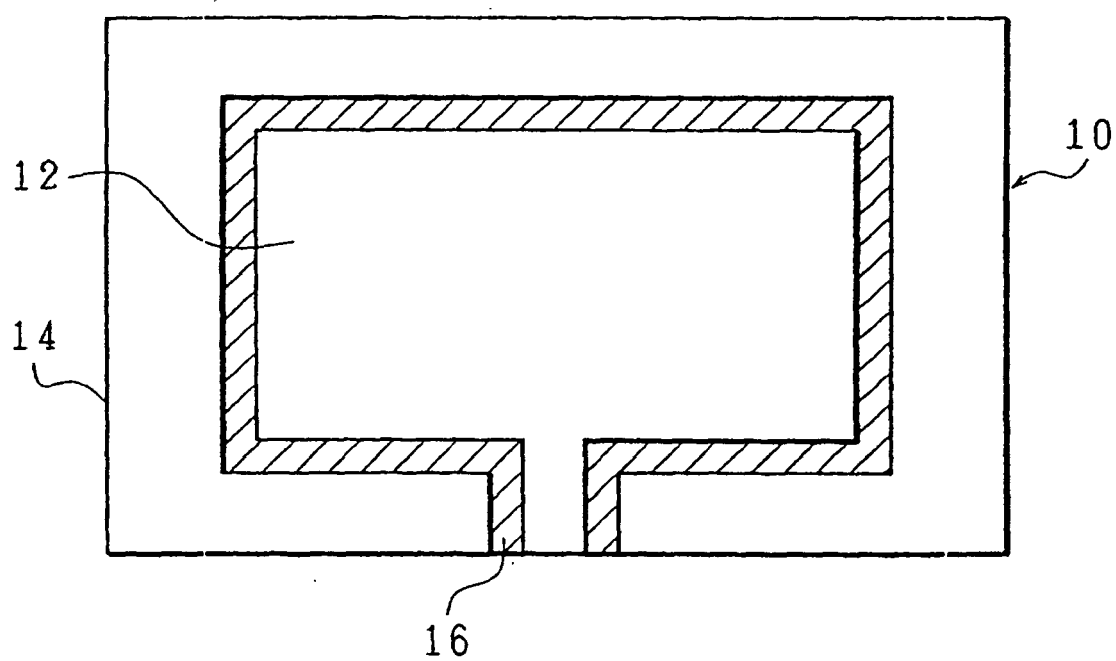


FIG. 14

