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(54) Integrated window antenna

(57) The present invention concerns an antenna, e.g. for wireless communication systems like LTE, UMTS, WiFi, WiMAX, etc. The antenna structure is e.g. a patch or dipole antenna, wherein at least one conductive layer is applied on a substrate or other carrier medium. At least one part of the conductive antenna structure, e.g. the metallic dipole or patch, is metalized onto at least one glass pane of a window. Thus, the window itself serves as carrier medium.

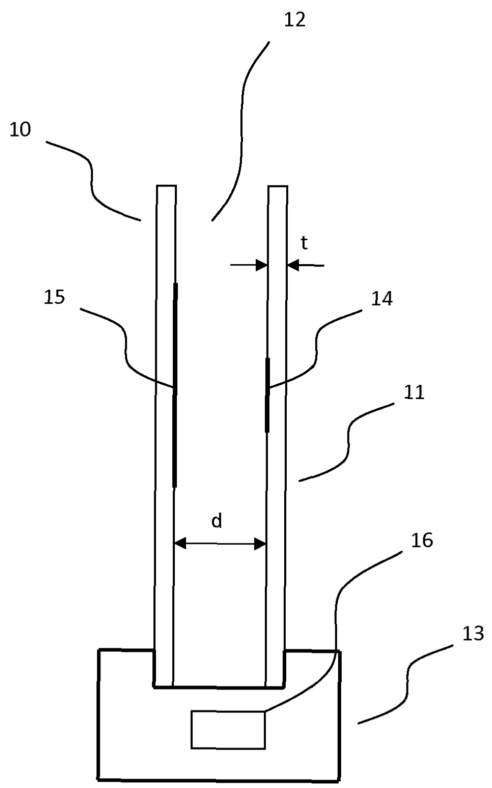

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to antenna systems.

BACKGROUND OF THE INVENTION

[0002] This section introduces aspects that may be helpful in facilitating a better understanding of the invention. Accordingly, the statements of this section are to be read in this light and are not to be understood as admission about what is in the prior art.

[0003] Today's windows as used in buildings are of a heat absorbing nature to save the overall energy costs for heating a building by reducing thermal losses. For this purpose, insulated glass consists of two or more glass panes, also referred to as double-glazed window or triple-glazed window. Between the glass panes, which are arranged in a defined distance to each other, a gas, e.g. argon is present. On at least one glass pane, a thin metallization is applied for further reducing thermal losses. The thickness of the metallization is that low that the metallization stays nearly invisible.

[0004] Today's cellular communication systems rapidly evolve due to higher bandwidth demands of the users. In enhanced 4G wireless system and in future 5G wireless systems, this trend will still increase. To provide high bandwidth to a user and an overall high system bandwidth, multiple aspects are developed. E.g. small cells promise to provide more radio resources to users in a certain area and beam forming enables to address the user's location within a cell directly. These system request advanced antenna systems. The mounting of antenna elements is becoming more and more important to enable MIMO, massive MIMO or 3D-beamforming types of applications. The trend of distributed antennas requests more areas for mounting antennas, which cannot be provided using the known approach of mounting antennas on masts, special towers or rooftops.

SUMMARY OF THE INVENTION

[0005] It is an object of the invention to provide a solution to the above described problem.

[0006] The present invention concerns an antenna, e. g. for wireless communication systems like LTE, UMTS, WiFi, WiMAX, etc. The antenna structure is e.g. a patch or dipole antenna, wherein at least one conductive layer is applied on a substrate or other carrier medium. Such antennas may or may not have a reflector for focusing an electromagnetic beam radiated by the antenna. At least one part of the conductive antenna structure, e.g. the metallic dipole or patch, is metalized onto at least one glass pane of a window. Thus, the window itself serves as carrier medium. Metalized within this context is to be understood as a metallic deposit, e.g. film, coat, sputtering or layer, which is applied to at least a part of the window pane. Such metal deposit is applied to the window pane e.g. by sputtering, laminating or plotting the metal onto the carrier medium or by other known methods of application of the metal onto the carrier medium. If a window is metalized this way, in general, the metallization is attached irremovably. The metallization is usually of a thickness that it does not affect the transparency of the window too much. In some cases, the metallization is of the nature and of the thickness that the window is mirrored from one side and only transparent in one direction. In some cases, the metallization is of the nature and of the thickness that the clarity of the window is reduced, thus providing a sun blocking window. All these kinds of metallization and other known methods of metallization are suitable to realize the antenna structure. This has the advantage that the antennas may be integrated in buildings in windows, without being visible to the audience. In general, the structure of the antennas would only be visible if the window is inspected in greater detail, but not by casually looking at the window. Thus, the audience will not be negatively affected by the integrated antenna in the window. In one embodiment, the antenna structure is realized closely to the window frame or at another part of the window, where the audience usually looks at with less attention. As window panes in modern heat absorbing windows are metalized anyway, costs for the antenna are kept low.

[0007] In one embodiment, the antenna structure is integrated into an at least double-glazed window. The antenna patch structure is metalized on one glass pane and a reflector is metalized on another glass pane.

[0008] In one embodiment, the antenna structure is integrated into a single glass pane. The antenna patch structure is metalized on the one side of the glass pane. The reflector is metalized on the other side of the glass pane. Thus, the glass pane is used as dielectric material between patch and reflector. The single glass pane may be part of a double-glazed window, or may be the inner glass of a triple-glazed window. In the latter case, the metallization layer is inside the window and cannot be destroyed or scratched from the outside. The antenna structure is protected against environmental conditions.

[0009] In one embodiment, the metallization is on the inner surfaces of the glass panes of the at least double-glazed window. Thus, the metallization providing the patch and the reflector is within the double-glazed window and cannot be destroyed or scratched from the outside. The antenna structure is protected against environmental conditions.

[0010] In one embodiment, multiple patches forming a patch antenna array are metalized on one glass pane.

[0011] In one embodiment, at least part of the antenna structure is realized in the metallization of heat absorbing glass panes. As heat absorbing windows consist of at least one metalized glass pane anyway, the metallization layer is reused in order to reduce costs.

[0012] In one embodiment, the antenna structure is realized in proximity to the window frame. This has the advantage that the feeding line between antenna patch and RF electronics is short and electric losses are minimized. Further, even if the antenna structure is realized in a metallization layer which is invisible, the antenna structure may disturb somebody inspecting the window in greater detail. If the antenna structure is located closely to the window frame, it will not attract attention.

[0013] In one embodiment, at least part of the RF electronics is mounted in the window frame. Mounting e.g. the power amplifier and the low noise amplifier in the window frame keeps the distance between these RF components and the antenna patch short. This has the advantage that losses in the feeding line are kept minimal.

[0014] According to the invention, a wireless base station transceiver is proposed. The wireless base station transceiver comprises at least one antenna realized in a window as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Some embodiments of apparatus and methods in accordance with embodiments of the present invention are now described, by way of examples only, and with reference to the accompanying drawings, in which:

Fig. 1 shows a double-glazed window including an antenna structure

Fig. 2 shows a triple-glazed window including an antenna structure

Fig. 3 shows an antenna structure realized on one metallization layer of a window

Fig. 4 shows an antenna structure realized on one metallization layer of a window and a reflector realized on a second metallization layer of the window

Fig. 5 shows an antenna patch realized on one metallization layer of a window and an inductive coupled feeding line on a second metallization layer of the window

Fig. 6 shows an antenna patch realized on one metallization layer of a window and an inductive coupled feeding line on a second metallization layer of the window and

a reflector on a third metallization layer of the window

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventors to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

[0017] Fig. 1 shows a window antenna integrated in a double-glazed window. The window consists of two window panes 10, 11 of the thickness t and a window frame 13. The two window panes 10, 11 are arranged to each other with a certain distance d, leading to a well defined space 12 between the two window panes 10, 11. The space 12 may be filled with air or with a gas which increases isolation properties of the window. Further, in one embodiment, the gas filling in the space 12 between the window panes 10, 11 increases directivity of the antenna. At least at one side of the window panes a metallization is attached. The metallization provides heat isolation and is of a thickness so that it is almost invisible. An antenna structure is integrated in the metallization. In one embodiment, the antenna structure is a microstrip antenna with a directly connected feeding line as described in greater detail in Fig. 3 and the corresponding description. The antenna structure 14 is realized in one metallization layer on one side of a window glass 10. In a further embodiment, as described in greater detail in Fig. 4, the antenna structure 14 including feeding line is realized in one metallization layer on one side of a window glass 10. On a second window glass 11, a reflector 15 is realized in a metallization layer to improve the directivity of the antenna. In a further embodiment, as described in greater detail in Fig. 5, the antenna is realized having a coupled feeding line, thus the antenna structure consists for example of an antenna patch 14 on the inner side of a first window pane 10 and a feeding line 15 on the inner side of the second window pane 11. The feeding line 15 and the antenna patch 14 are inductive coupled. In a further embodiment, the feeding line 15 is realized in a coplanar manner providing additionally a ground plane on the inner side of the second window glass 11 in order to improve directivity of the antenna. In one embodiment, at least a power amplifier 16 for the transmitting path and/or a low noise amplifier 16 for the receiving path is integrated in the window frame 13 in order to keep the feeding line between antenna structure and RF electronics short. In one embodiment, even more RF circuits 16 and baseband logic 16 are integrated in the window frame 13. In one embodiment, in windows having only one metallization layer on one window pane 10, 11 for heat absorbing purposes, one of antenna patch 14 and feeding line 15 is integrated in the heat absorbing metallization attached to the window pane 10, 11. The other element 14, 15 is attached on the other window pane 10, 11 in a metallization layer not explicitly designated to heat absorbing purposes. Thus, e.g. only the feeding line structure is realized in this metallization layer covering only a small part of the whole window surface.

[0018] Fig. 2 shows a window antenna integrated in a triple-glazed window. The window consists of three window panes 20, 21, 26 of the thickness t and a window frame 23. The window panes 20, 21, 26 are arranged to each other with a certain distance d, leading to well defined spaces 22 between the window panes 20, 21, 26. The spaces 22 may be filled with air or with a gas which increases isolation properties of the window. At least at one side of at least one window pane 20, 21, 26 a metallization is attached. The metallization provides heat isolation and is of a thickness so that it is almost invisible. An antenna structure is integrated in the metallization. In one embodiment, the antenna structure is a microstrip antenna with a directly connected feeding line as described in greater detail in Fig. 3 and the corresponding description. The antenna structure 24 is realized in one metallization layer on one side of a window glass 26, preferably the middle glass of the triple-glass window. In a further embodiment, as described in greater detail in Fig. 4, the antenna structure 24 including feeding line is realized in one metallization layer on one side of a window glass 26, preferably the middle glass of the triple-glass window. On the second side of the middle window glass 26, a reflector 25 is realized in a metallization layer to improve the directivity of the antenna. In a further embodiment, as described in greater detail in Fig. 5, the antenna is realized having a coupled feeding line, thus the antenna structure consists for example of an antenna patch 24 on one side of one window pane 20, 21, 26, preferably one side of the inner window pane 26 and a feeding line 25 on the other side of this window pane 20, 21, 26, preferably the other side of the inner window pane 26. The feeding line 25 and the antenna patch 24 are inductive coupled. In a further embodiment, the feeding line 15 is realized in a coplanar manner providing a ground plane on the other side of the inner window pane 26 in order to improve directivity of the antenna. In one embodiment, the antenna patch 24 is realized on one side of the inner window pane 26 and the feeding line 25 is realized on the other side of the inner window pane 26 and a reflector is realized on the inner side of an outer window pane 20, 21. In one embodiment, at least a power amplifier 27 for the transmitting path and/or a low noise amplifier 27 for the receiving path is integrated in the window frame 23 in order to keep the feeding line between antenna structure and RF electronics short. In one embodiment, even more RF circuits 27 and baseband logic 27 are integrated in the window frame 23. In one embodiment, in windows having only one metallization layer on one window pane 20, 21, 26 for heat absorbing purposes, one of an antenna patch 24 and a feeding line 25 is integrated in the heat absorbing metallization attached to one side of a window pane 20, 21, 26. The other element 24, 25 is attached either to the other side of the window pane 20, 21, 26 or to another window pane 20, 21, 26 in a metallization layer not explicitly designated to heat absorbing purposes. Thus, e.g. only the feeding line structure is realized in this metallization layer covering only a small part of the whole window surface.

[0019] Fig. 3 shows a front view of an antenna structure realized on one metallization layer of a window pane 10, 11, 20, 21, 26. On one side of the window pane 10, 11, 20, 21, 26, the metallization used for thermal isolation of a heat absorbing window is structured such that a feeding line 30, an antenna patch 14, 24 and a ground area 31 is built. The feeding line 30 and the antenna patch are electrically connected to each other. The ground area 31 is not directly connected to the antenna patch 12, 24 and the feeding line 31. Thus, the metallization layer of a heat absorbing window is built in a way that it is used as antenna. The metallization layer may be attached to a window pane 10, 11, 20, 21, 26 of a double-glazed window or a triple-glazed window as described above.

[0020] Fig. 4 shows an antenna structure realized on one metallization layer 10, 11, 20, 21, 26 of a window. On one side of the window pane 10, 11, 20, 21, 26 the metallization is structured such that a feeding line 30 and an antenna patch 14, 24 is built. The feeding line 30 and the antenna patch are electrically connected to each other. On the other side of the window pane 10, 11, 20, 21, 26 or a second window pane 10, 11, 20, 21, 26 a metallization is attached which builds a reflector 32. The reflector is thus not in the same plane as the antenna patch 14, 24 and is not directly connected to the antenna patch 14, 24. At least one of the metallization layers is used for thermal isolation of a heat absorbing window. The metallization layers are integrated in the window panes of a double-glazed window or a triple-glazed window as described above.

[0021] Fig. 5 shows an antenna patch 14, 24 realized on one side of the window pane 10, 11, 20, 21, 26. The metallization is structured such that an antenna patch 14, 24 is built. On the other side of the window pane 10, 11, 20, 21, 26 or a second window pane 10, 11, 20, 21, 26 a feeding line 30 is built. The feeding line is surrounded by a ground area 31, which is not directly connected to the feeding line. The ground area 31 serves as reflector and for improving characteristics of the feeding line 30 which is realized as a coplanar line. At least one of the metallization layers, e.g. the metallization layer containing the feeding line 30 and the ground area 31, is used for thermal isolation of a heat absorbing window. The metallization layers are integrated in the window panes of a double-glazed window or a triple-glazed window as described above.

[0022] Fig. 6 shows an antenna patch 24 realized on one side of the window pane 20, 21, 26. The metallization is structured such that an antenna patch 24 is built. On the other side of the window pane 20, 21, 26 or a second window pane 20, 21, 26 a feeding line 30 is built. On a further side of a window pane 20, 21, 26 a metallization is attached which builds a reflector 32. In one embodiment, the metallization building the reflector 32 also serves as ground plane for the feeding line 30. Thus, the reflector 32, the feeding line 30 and the antenna patch 24 are arranged in a way that the reflector 32 and the antenna patch 24 are at the outer metallization planes and the feeding line 30 is in-between them. Neither the reflector 32, the feeding line 30 nor the antenna patch 30 is directly connected. At least one of the metallization layers is used for thermal isolation of a heat absorbing window. The metallization layers are integrated in the window panes of a triple-glazed window as described above.

[0023] The functions of the various elements shown in the Figures, including any functional blocks, may be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, the functions may be provided, without limitation, by digital signal processor (DSP) hardware, network processor, application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), and non volatile storage. Other hardware, conventional and/or custom, may also be included.

Claims

1. Antenna, **wherein** at least a part of a conductive antenna structure is metalized onto at least one glass pane of a window.

2. Antenna according to claim 1, **wherein** the antenna structure is integrated into an at least double-glazed window and an antenna patch structure is metalized on one glass pane and a reflector is metalized on another glass pane.

3. Antenna, according to claim 1, **wherein** the antenna structure is integrated into a single glass pane and an antenna patch structure is metalized on the one side of the glass pane and a reflector is metalized on the other side of the glass pane.

3. Antenna according to claim 1 or 2, **wherein** the metallization is on the inner surfaces of the glass panes of the at least double-glazed window.

4. Antenna according to one of claims 1 or 4, **wherein** multiple patches forming a patch antenna array are metalized on one glass pane.

5. Antenna according to one of claims 1 or 4, **wherein** at least part of the antenna structure is realized in the metallization of heat absorbing glass panes.

6. Antenna according to one of claims 1 or 5, **wherein** the antenna structure is realized in proximity to the window frame.

7. Antenna according to one of claims 1 or 6, **wherein** at least part of the RF electronics is mounted in the window frame.

8. Wireless base station transceiver, **wherein** the antenna of the transceiver is an antenna according to one of claims 1-7.

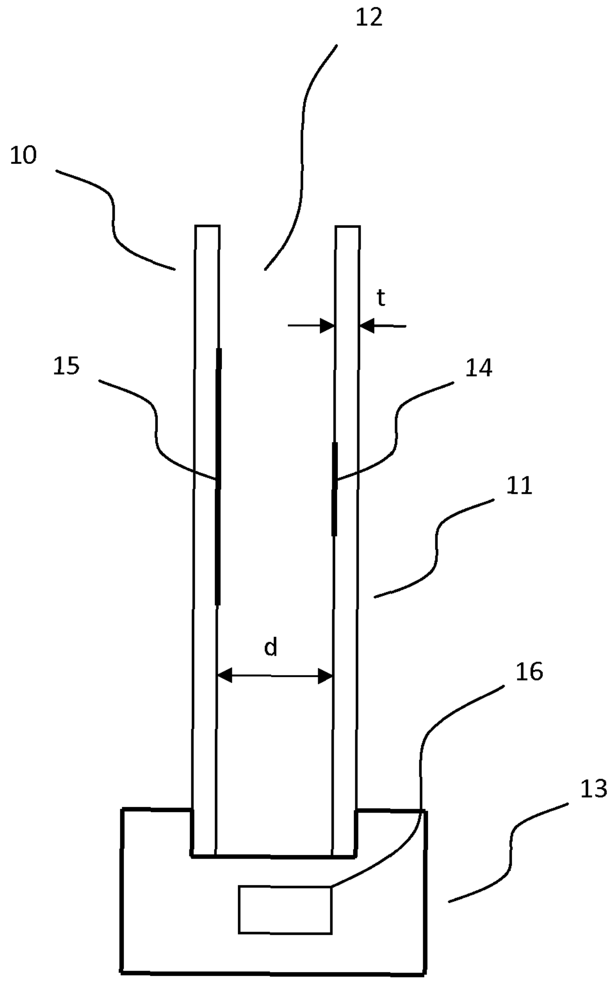

Fig. 1

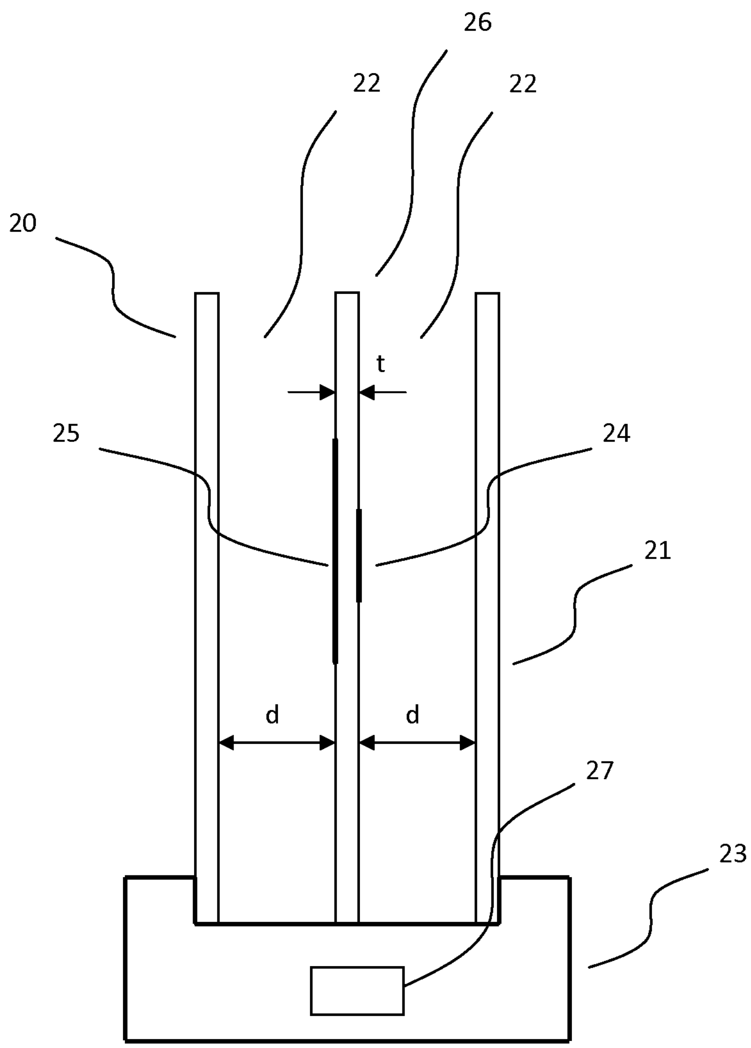

Fig. 2

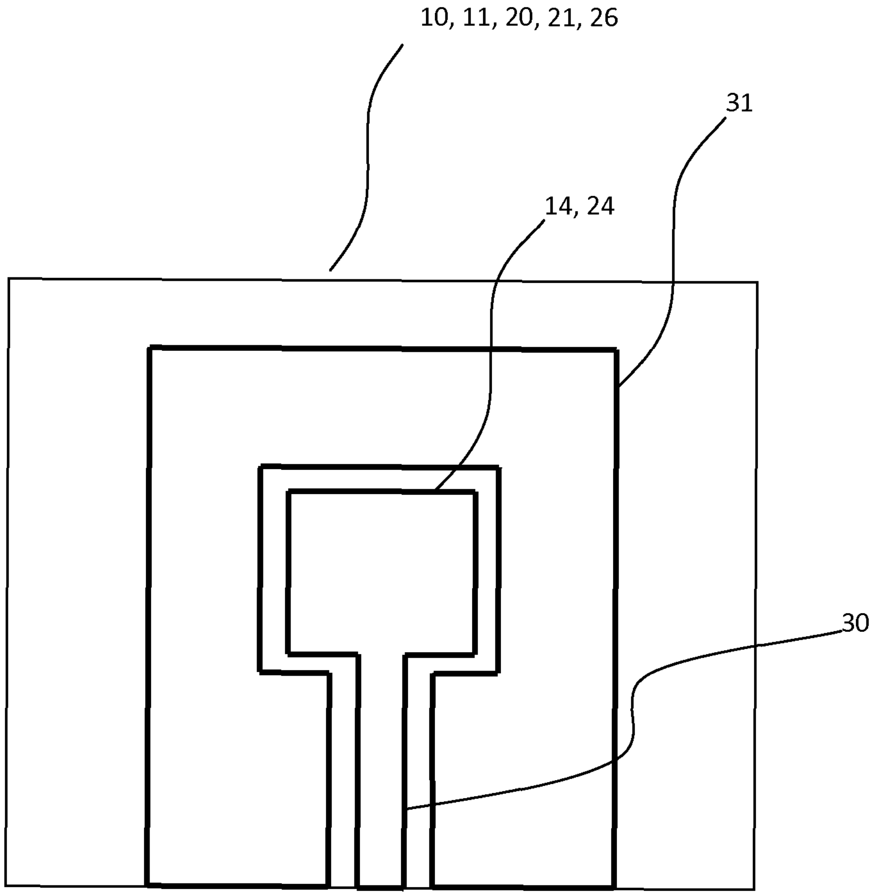

Fig. 3

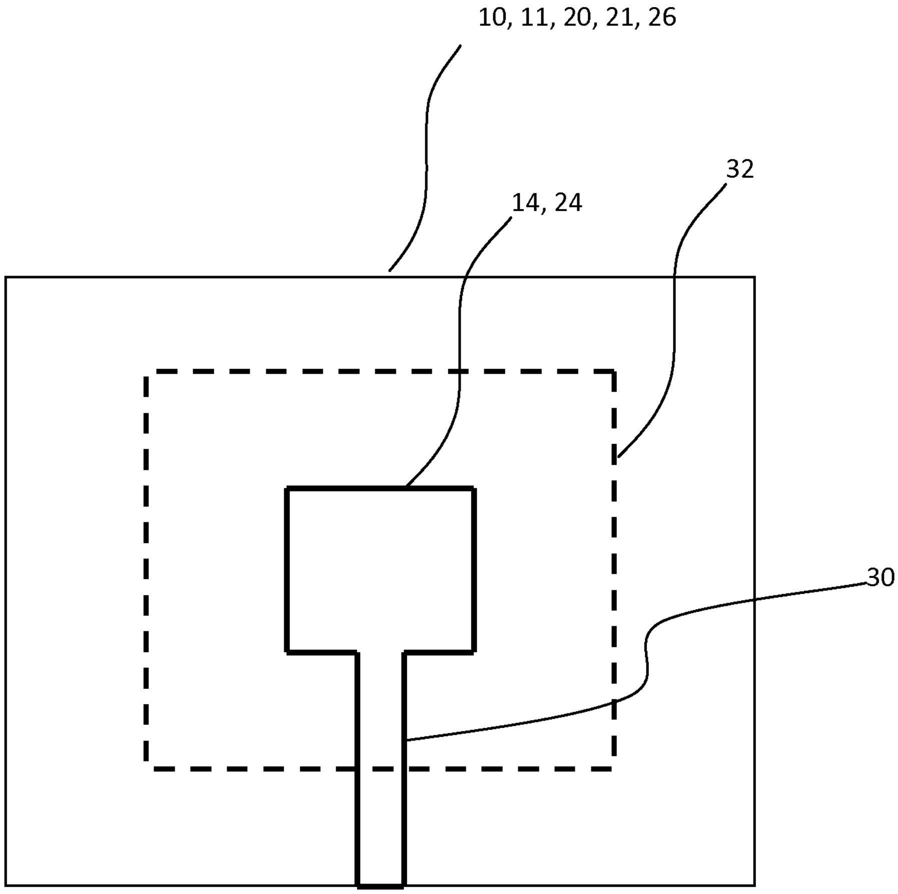

Fig. 4

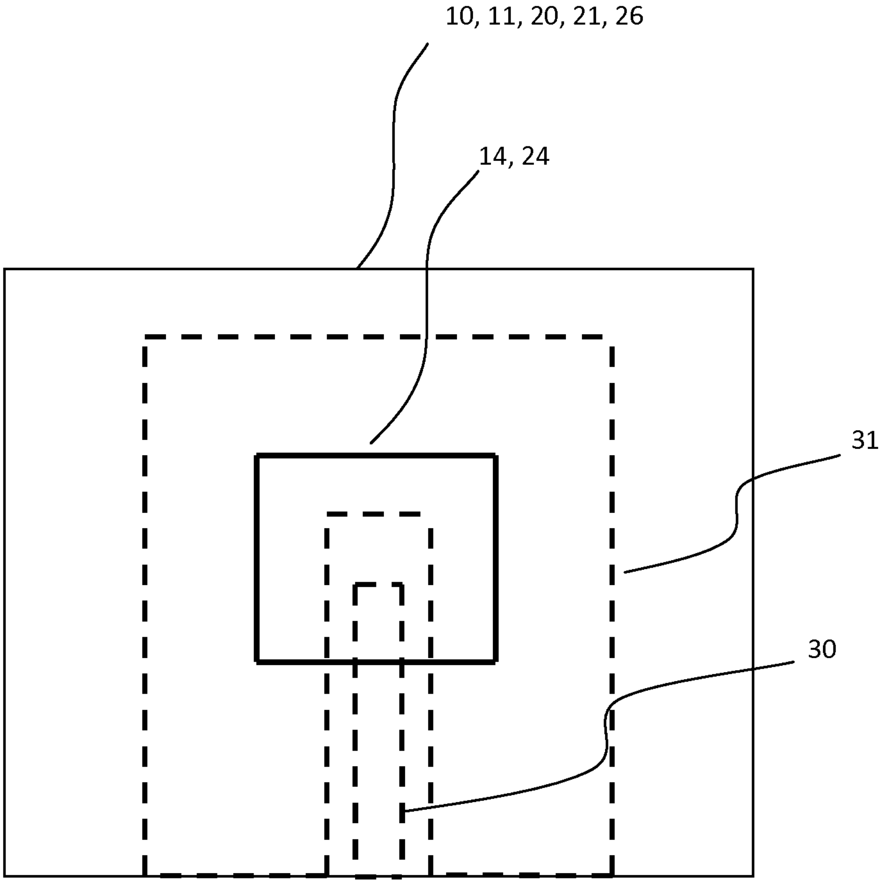

Fig. 5

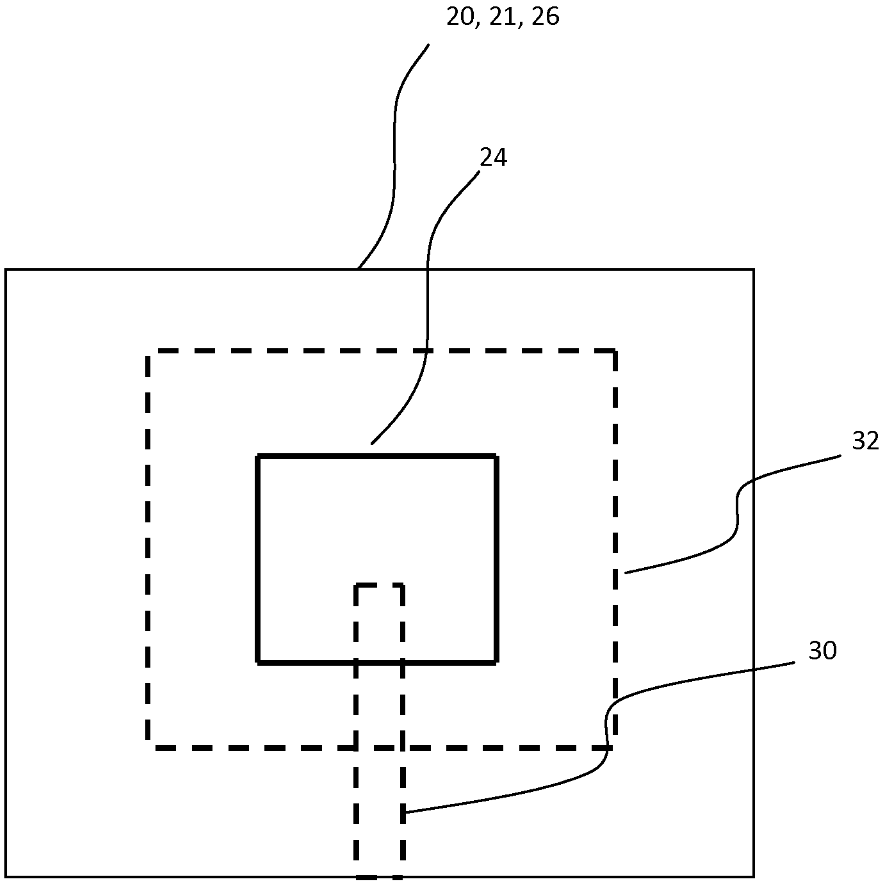

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 30 6302

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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