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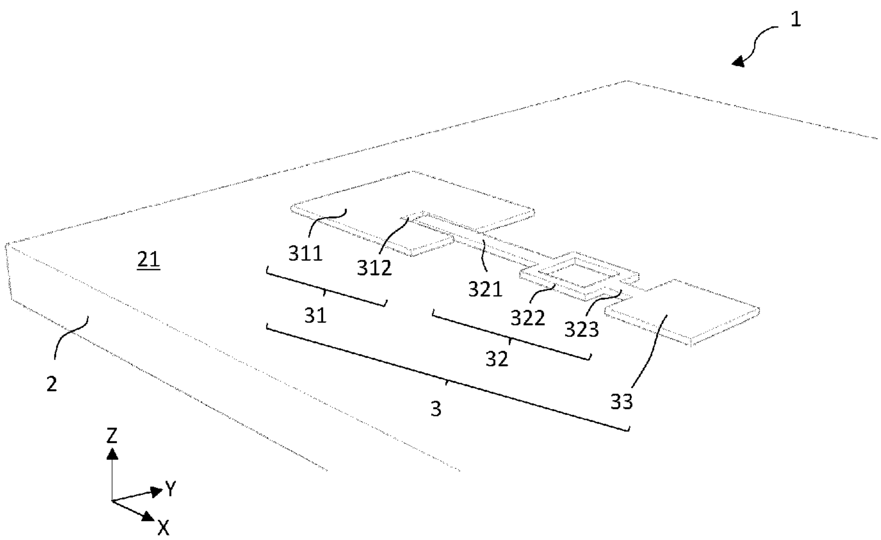

FIG. 1

(57) Abstract: The present invention discloses an antenna system, designed to emit and/or receipt at a desired frequency range, comprising a transparent dielectric panel having a first surface, a planar antenna element disposed on the first surface and comprising a patch network, a ground plane and a feeding system conductively connected to the patch network The ground plane comprises a recess. The feeding system comprises a transformer designed to enlarge the bandwidth of the antenna system The feeding system also comprises an elongated element extending from the transformer into the recess. The present invention discloses the associated method and use.

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[Continued on next page]

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Antenna arrangement

Description

Technical Field

[0001] The present invention relates to an antenna system in general and, more specifically, to an enhanced performance aperture-coupled or proximity coupling planar antenna arrangement comprising a transparent dielectric panel, to optimize the transmission and / or the reception of the radio-frequency signal.

[0002] Thus, the invention concerns multiple domains where an antenna system comprising a transparent dielectric panel is used.

Background Art

[0003] Mobile data traffic is increasing continuously and will boom significantly 4G, 5G, WiFi or other telecom technologies putting mobile network operators under CAPEX pressure. The deployment of antennas are described as a good solution for capacity improvement which requires to install a large number of antennas in order to stably perform electromagnetic wave transmission and reception. However, many drawbacks limit the deployment of antennas. First, it is very difficult to find location for new antennas. Second, bringing fiber and electricity everywhere is costly. Finally, urbanistic regulations, acceptable designs,… may limit possibilities for new antennas.

[0004] On the other hand, In recent years with miniaturization, antennas are increasingly installed in buildings. When installing the antenna in the building, it is necessary to select the proper placement of the antenna so that electromagnetic waves can be transmitted and received stably while preventing the appearance of the building from being impaired.

[0005] More and more antennas needs to be miniaturized to be as discrete as possible. Due to this miniaturization, the bandwidth of such antenna is limited to a narrow band.

[0006] The document US2011221652A1 discloses an antenna system including a circularly polarized antenna for receiving and/or transmitting a circularly polarized RF signal. The CP antenna includes a pair of radiating patches each having an elongated shape. An elongated axis is defined along a longest length of each of the radiating patches. The elongated axes are disposed generally perpendicular to one another to generate the circular polarization. A coplanar waveguide feeding element is disposed between the radiating patches for feeding RF signals from and/or to the radiating patches via electromagnetic coupling. A width of the slot of the coplanar waveguide is varied to provide impedance matching of the CP antenna with a transmission line.

[0007] The document CN113113757 A discloses a vehicle window comprising a light-transmitting assembly and an antenna assembly, and the antenna assembly is arranged on the surface of the light-transmitting assembly and comprises a radiation part, a feeding point, a tuning part and a grounding part.

[0008] The document US2015002360A1 discloses a semiconductor device including: a semiconductor circuit element configured to process an electrical signal having a predetermined frequency; and a transmission line configured to be connected to the semiconductor circuit element via a wire and transmit the electrical signal.

[0009] The document CN211956530U discloses an antenna and a radio frequency tag. The antenna comprises a first antenna arm, a second antenna arm and an antenna impedance matching part, one end of the antenna impedance matching part is connected with the first antenna arm, and the other end of the antenna impedance matching part is connected with the second antenna arm; the feed position of the antenna is arranged on the antenna impedance matching part; wherein the feed position is used for being connected with the radio frequency processing module.

[0010] To obtain a larger bandwidth, usually antennas are multi-antennas, having several antennas elements each working at a different frequency range and placed near each other to obtain a multiband antenna. Having such multi-antennas increases the necessary size of said multi-antennas and the cost.

[0011] Another way to reduce the size is to have antenna elements on different surfaces of a support; This enlarge the thickness of the antenna system and then the necessary size of the antenna system and the cost.

[0012] Therefore, there is a trade-off between frequency bandwidth, antenna system performances and the size, i.e. the surface area, of the antenna system.

[0013] Therefore, with such planar antennas is not possible to change the frequency band or the optimize the transmission and / or reception of the antenna to meet the requirement of current and future communication systems.

Summary of invention

[0014] It is an object of the present invention, in its different aspects, to alleviate the above described problems and in particular to have a widest frequency bandwidth with a small size.

[0015] Then, the present invention relates, in a first aspect, to an antenna system designed to emit and/or receipt at a desired frequency range, comprising a transparent dielectric panel, having a first surface, and a planar antenna element disposed on the first surface. The planar antenna element comprises a patch network, a ground plane and a feeding system electrically connected to the patch.

[0016] The solution as defined in the first aspect of the present invention is based on that the ground plane comprises a recess to improve the bandwidth.

[0017] The solution as defined in the first aspect of the present invention is also based on that the feeding system comprises a transformer designed to enlarge the bandwidth of the antenna system and on that the feeding system also comprises an elongated element extending from the transformer into the recess to increase the bandwidth.

[0018] Especially, the object of the first aspect of the present invention is to provide a ultra-wide band planar antenna element with a small size. Thus, the antenna system can work in a very large frequency bandwidth with a small size. Another advantage of the present invention is that antenna system enables seamless indoor and/or outdoor placement in line with urban aesthetics and EMF constraints.

[0019] The present invention relates, in a second aspect, to a glazing unit comprising an antenna system according to the first aspect.

[0020] The present invention relates, in a third aspect, to a method to manufacture an antenna arrangement according to the first aspect wherein the method comprises following steps :

A. Providing a dielectric panel,
B. Disposing a planar antenna element on a first surface of the dielectric panel
C. Connecting the ground plane and the feeding system to a power provider via a connection means.

[0021] The present invention in its different aspects permits to emit and/or receipt at an enlarged frequency range while keeping a small size for antenna element permitting to have the large possibilities of designs to place antenna systems in some places where it was not possible before.

[0022] It is noted that the invention relates to all possible combinations of features recited in the claims or in the described embodiments.

[0023] The following description relates to building applications but it’s understood that the invention may be applicable to others fields like cities, streets, urban furniture, automotive or transportation applications.

Brief description of the drawings

[0024] This and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing various exemplifying embodiments of the invention which are provided by way of illustration and not of limitation. The drawings are a schematic representation and not true to scale. The drawings do not restrict the invention in any way. More advantages will be explained with examples.

[0025] FIG. 1 is a schematic 3D view of an antenna system according to a first embodiment of the invention.

[0026] FIG.2 is a schematic top view of the antenna system of FIG.1.

[0027] FIG. 3 is a schematic sectional view along plane AA’ of the antenna system of FIG.1 and FIG. 2.

[0028] FIG. 4 represents an embodiment of an antenna systems according to the invention wherein the feeding system comprises a connection area designed to be connected to a connection means and wherein the ground plane comprises a first connection area and a second connection area; each of the connection areas are designed to be connected to the connection means.

[0029] FIG. 5 represents an embodiment of an antenna systems according to the invention wherein the feeding system comprises a connection area designed to be connected to a connection means and wherein the ground plane comprises a first connection area designed to be connected to the connection means.

[0030] FIG. 6a, FIG. 6b, FIG. 6c, FIG. 6d, FIG. 6e and FIG. 6f represent an antenna system according to different embodiments according to the invention.

[0031] FIG. 7 is a schematic top view of an antenna system according to a preferred embodiment of the invention.

[0032] FIG. 8 is a sectional view of a glazing unit comprising an antenna system according to an embodiment of the invention.

[0033] FIG. 9 is a sectional view of a glazing unit comprising an antenna system according to another embodiment of the invention.

[0034] FIG. 10 is a bottom view of the glazing unit illustrated in FIG.9.

Detailed description

[0035] According to a first aspect of the invention as illustrated in FIG.1, FIG. 2 and FIG.3, the invention relates to an antenna system 1 designed to emit and/or receipt at a desired frequency range. The antenna system comprises a transparent dielectric panel 2 having a first surface 21.

[0036] The term "transparent" denotes a property illustrating the average TL (light transmission) of visible light transmitted through a material in the visible spectrum of at least 1%. Preferably, transparent relates to a TL property of at least 10%. More preferably, transparent denotes a TL of at least 50%. Ideally, transparent denotes a TL of at least 70%.

[0037] A dielectric panel is a panel that is not electrically conductive as such.

[0038] The transparent dielectric panel 1 can have different chemical composition, such as plastic-based composition or glass. The plastic-based composition can be PET, polycarbonate, PVC or any other transparent dielectric plastic-based that can be used as a panel such as a transparent polymer interlayer. The glass can comprises at least 50 % in weight of SiO2 such as glass like soda lime glass, aluminosilicate glass or borosilicate glass.

[0039] A transparent polymer interlayer can be polyvinyl butyral (PVB), ethylene-vinyl acetate (EVA), polymethyl methacrylate (PMMA), a polycarbonate (PC), a polystyrene (PS), a polyvinyl chloride (PVC), a polyamide (PA), a polyetherimide (PEI), a polyethylene terephthalate (PET), a polyurethane, an acrylonitrile butadiene styrene copolymer (ABS), a styrene acrylonitrile copolymer (SAN), a styrene methyl methacrylate copolymer (SMMA) and any mixtures of these, a crosslinked resin, an ionoplast, an ionomer, a cyclo-olefin polymer (COP), cyclo-Olefin copolymer (COC) or an Optical Clear Adhesive (OCA).

[0040] Crosslinked or cured resins are known to the skilled person and are three dimensional polymer networks obtained by the crosslinking/curing of low molecular weight species either by reaction with a curing agent also known as crosslinker or upon exposure to heat, UV radiations (UV) or electron beam (EB). Non exhaustive examples of crosslinked resins are epoxy resins, polyurethane resins, UV or EB curable resins. In the present invention, the precursors of the crosslinked resin may be transparent or not provided that the crosslinked resin is transparent.

[0041] Remark that some polymer mixtures, copolymers and some semi-crystalline polymers can be opaque and non-transparent due to a dispersed phase or due to the presence of crystallites. Hence it is possible that not all compositions of the listed polymers mentioned above are transparent. The person skilled in the art is capable to identify what composition is transparent and hence identify if a given polymer falls within the claimed transparent polymers.

[0042] Preferably, the transparent dielectric panel can have a loss tangent equals to or smaller than 0.03 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.02 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.01 to reduce the energy loss in panels while increasing the antenna system efficiency.

[0043] In preferred embodiments, the transparent dielectric panel has a loss tangent equals to or smaller than 0.005 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.003 to reduce the energy loss in panels while increasing the antenna system efficiency.

[0044] The antenna system 1 further comprises a planar antenna element 3 disposed on the first surface 21.

<planar antenna element>

[0045] The planar antenna element comprises a patch network 33, a ground plane 31 and a feeding system 32 electrically connected to the patch.

[0046] The term “disposed on the first surface” for the planar antenna element means that the patch network 33, a ground plane 31 and a feeding system 32 are positioned on the same surface. However, it is possible in some embodiments according to the invention to have a part of the ground plane positioned on another surface of the transparent dielectric panel.

[0047] According to some embodiments, the material of the patch network, the ground plane and the feeding system comprises conductive material. Preferably, the conductive material is metal-based material such as Copper, Silver, conductive metal alloys with or without plated material, such as gold, or any other material able to be electrically conductive and able to be placed on a transparent dielectric panel.

[0048] In some preferred embodiments, to ensure the conductivity and transparency, the planar antenna element can be designed using a Cu-mesh on the top of a transparent layer, the transparent dielectric panel, such as a PET layer.

[0049] In some embodiments, the planar antenna element can be printed, glued, coated on an transparent interlayer or placed by any other methods able to non-removably place a planar antenna element on an transparent dielectric panel such as screen-printing, inkjet printing, deposition, glued wire, copper foil, copper mesh, etc.to facilitate the attachment to the transparent dielectric panel with the patch interlayer and the handling. Such transparent layers are preferably transparent polymer film. Preferably, transparent polymer film can be polyvinyl butyral (PVB), ethylene-vinyl acetate (EVA), polymethyl methacrylate (PMMA), a polycarbonate (PC), a polystyrene (PS), a polyvinyl chloride (PVC), a polyamide (PA), a polyetherimide (PEI), a polyethylene terephthalate (PET), a polyurethane, an acrylonitrile butadiene styrene copolymer (ABS), a styrene acrylonitrile copolymer (SAN), a styrene methyl methacrylate copolymer (SMMA) and any mixtures of these, a crosslinked resin, an ionoplast, an ionomer, a cyclo-Olefin copolymer (COC), cyclo-Olefin polymer (COP) or an Optical Clear Adhesive (OCA).

<patch network>

[0050] The patch network 33 can have any shape that fulfill with the requirements.

[0051] The conductive element of the patch network can have any shape such as a rectangular shape. In some embodiments in which the dual-polarized operation is desired, a circular or square shape is preferred. Preferably, the patch network is conductive patch network.

[0052] In some embodiments, the patch network 33 comprises at least one resonating conductive element. Preferably, the length of the conductive element is equivalent to the half of the effective wavelength at the operation frequency.

[0053] Preferably, the dimensions of the surface of the patch network is smaller than the surface of the transparent dielectric panel.

<Feeding system>

[0054] The planar antenna element 3 also comprises a feeding system 32.

[0055] In some embodiments, the feeding network comprises at least one conductive element to transfer the signal between the antenna system input and the patch network. Preferably, the width of the feeding network at the input side is in such a way to provide a characteristic impedance of about 50 Ohms.

[0056] According to the invention, the feeding system 32 comprises an elongated element 321, a transformer 322 and a connection element 323 connected to the patch network 33.

<Ground plane>

[0057] The planar antenna system 1 also comprises a ground plane 31 to ensure good and correct functioning of the antenna system.

[0058] The location of the ground plane compared to the patch network and the feeding network is important and can affect significantly the performance of the antenna system. In preferred embodiments as illustrated in FIG.1, the ground plane is substantially located at the opposite position to the location of the patch network. The ground plane is located at one end of the feeding system while the patch network is located at the other end of the feeding system to obtain a compromise between complexity and performance.

[0059] The ground plane can be printed, glued, coated on a dielectric panel, on a ground interlayer or on a transparent layer or placed by any other methods able to non-removably place a ground plane on a dielectric panel, on a ground interlayer or on a transparent layer such as screen-printing, inkjet printing, deposition, glued wire, copper foil, copper mesh, etc.

[0060] The ground plane comprises a recess 312 in which the elongated element 321 of the feeding system extends into from the transformer 322. The recess is designed to increase the bandwidth and to tune the planar antenna element while having a good matching.

[0061] The ground plane can have any shape as long as the shape 311 comprises the recess 3122 that fulfill with requirements and performances of the planar antenna element 3.

[0062] According to the invention, the ground is located on the same surface 21 than the patch network and the feeding system.

[0063] In some embodiments, a part of the ground can be positioned on another surface to optimize the planar antenna element while the other parts of the ground with the recess is on the surface 21. In such embodiments, the a part of the ground positioned on another surface is far enough from the feeding system and the patch network to avoid detuning.

[0064] Surprisingly, the antenna system according to the invention, especially the disposition on the same surface of the patch network , the ground plane and the feeding system, the recess of the ground plane and the elongated element (321) extending from the transformer into the recess, increases the frequency bandwidth while having a small needed surface for the planar antenna system.

[0065] Said antenna system is designed to emit and/or receipt at a desired frequency range, f. Depending on the desired applications, the frequency range can be between 0.5 to 12 GHz (0.5 GHz $\leq$ f $\leq$ 12 GHz). The frequency range can be tuned between 3.1 to 10.6 GHz (3.1 GHz $\leq$ f $\leq$ 10.6 GHz) for specific applications such as Wi-Fi, Ultra-wide band UWB applications such as wireless USB, medical, …

<transformer>

[0066] According to the invention, the transformer is designed to enlarge the bandwidth of the antenna system.

[0067] According to some embodiments, the transformer is a loop to increase the bandwidth in a specific frequency range. The loop comprises a conductive path having a defined width W332 and forming a loop. The width W332 can vary along the path.

[0068] In preferred embodiments the loop has a generic polygonal donut-like shape having a defined width W332, meaning that the transformer is a closed area with an opening inside. More preferably, the transformer is a polygonal loop having a width W332 substantially all equals along the loop and even more preferably a rectangular loop having a width W332 substantially all equals along the loop.

[0069] In preferred embodiments, the transformer has horizontal portions, along the X-axis, and vertical portions, along the Y-axis, as illustrated in FIG. 2.

[0070] Dimensions and size of the transformer can depends on the desired application and frequency range.

[0071] According to some embodiments of the inventions, a connection means can connect the planar antenna system to a power provider. The connection means is designed to connect a cable used for the transmission of high-frequency signals, such as coaxial cable, flat coax,…, to the planar antenna system. A coaxial cable is typically a cable consisting of a conducting outer metal tube enclosing, namely the shield, and insulated from a central conducting core, namely the pin. The flat coax has a three track, the central one is the pin while the two outers corresponds to the shield.

[0072] According to such embodiments as illustrated in FIG. 4 and FIG. 5, the feeding system 321 can comprise a connection area 34 designed to be connected to a connection means. In such embodiments, the ground plane 31 comprises a first connection area 35 designed to be connected to the said connection means. The connection means connects the shield to the ground plane and the pin to the feeding system.

[0073] The connections means can be a connector, can be a soldering material, a conductive glue or any means to conductively connect a pin to a feeding system and to conductively connect a shield to a ground plane.

[0074] In FIG. 4, according to some embodiments, the ground plane comprises a first connection area 35 and a second connection area 36 designed to be connected to the connection means. Preferably, the first and the second connection areas are symmetrically positioned on each side of the recess. The feeding system, preferably on the elongated element 321, comprises a connection area 34. In preferred embodiments the connection area 34 is near to the first connection 35 area to facilitate the connection.

[0075] According to some embodiments, the ground plane can comprise several connection areas 35, 36 designed to be connected to the connection means depending to the desired application.

[0076] In FIG. 5, according to some embodiments, the ground plane comprises a first connection area 35 and the elongated element 321 comprises a connection area 34. In such embodiments, the first connection area 35 is positioned near the bottom of the recess while the connection area 34 is substantially near the terminal part of the elongated element.

[0077] According to the invention, as illustrated in FIG. 6a – 6f, the ground plane and the elongated element 321 can have any shape as long as the elongated element 321 extending from the transformer into the recess.

[0078] The ground plane is isolated from the feeding system. The width of the recess is larger than the width of the elongated shape.

[0079] The recess 312 of the ground plane 31 corresponds to the shape of the elongated element 321 and the elongated element 321 corresponds to the shape of the recess 3122. It means that there is a non-zero distance, Dee, Del, between the border of the elongated shape and the border of the recess. Preferably, this distance is substantially the same all along the edge of the elongated element (Dee ≅ Del). The elongated element extends into the recess to the recess bottom with a non-zero distance Dee.

[0080] According to the invention, the distance, Del, between the lateral border of the elongated element and the ground plane can be smaller than or equal to 12 mm and larger than 0 preferably, the distance, Del, between the lateral border of the elongated element and the ground plane is smaller than or equal to 3 mm and more preferably the distance, Del, between the lateral border of the elongated element and the ground plane is smaller than or equal to 1.25 mm

[0081] FIG. 6d, FIG. 6e and FIG. 6f illustrate some embodiments in which the elongated element extends from the transformer with a specific shape. This shape has a y-component and a x-component in the plane defined by X-axis and Y -axis.

[0082] In the embodiment illustrated in FIG. 6d, the elongated element extends from the transformer with an angle A. This angle A is measured from the vertical axis (Y-axis). The angle A depends on the desired application. In this embodiments, the elongated element has a generic parallelogram shape. The length is longer than the width.

[0083] In the embodiment illustrated in FIG. 6e, the elongated element extends from the transformer with a rounded zigzag like shape. The length is longer than the width. The number and the shape of zigzags depend on the application.

[0084] In the embodiment illustrated in FIG. 6f, the elongated shape extends from the transformer with a sharped zigzag like shape. The angle A depends on the desired application. The length is longer than the width. The number and the shape of zigzags depend on the application.

[0085] In some embodiments, the angle A is about 45° to have electromagnetic component in X and Y.

[0086] In preferred embodiments, the angle A is about 0° as illustrated in FIG. 1, FIG. 2, FIG. 3, FIG. 6a, FIG. 6b, FIG. 6c and FIG. 7. That means that the elongated element extends from the transformer in a vertical direction, along the Y-axis.

[0087] In some more preferred embodiments, the elongated element extends from the transformer in a single vertical direction.

[0088] In some of the preferred embodiments, the ground plane 31 can comprise a right lateral finger 313 and a left lateral finger 314.

[0089] In some embodiments, as illustrated in FIG. 6a, the right lateral finger 313 and the left lateral finger 314 extend the recess length meaning that the distance between the recess opening 3121 and the recess bottom is longer than the distance between the recess opening 3121 and the recess bottom without lateral fingers. In such embodiments, a portion of the elongated element of the feeding line extending between the lateral fingers to a distance from the recess bottom 3122.

[0090] In some preferred embodiments to optimize the signal, the length of the lateral fingers are smaller than the length of the surface in which the transformer is inscribed in (L314 ≤ L332). Preferably, the length of the lateral fingers is smaller than 90% of the length of the surface in which the transformer is inscribed in (L314 ≤ 0.9*L332).

[0091] In some preferred embodiments to optimize the signal, the width of the transformer is substantially equals to the width of the connection element (W323 ≅ W321).

[0092] In some embodiments, the width of the transformer can be about 1.79 mm.

[0093] In some preferred embodiments to optimize the signal, the length of the extended element is longer than the length of the recess. Preferably, the length of the extended element is longer than 110% of the length of the recess and more preferably, the length of the extended element is substantially comprised between 110% and 120% of the length of the recess.

[0094] FIG. 6b illustrates some embodiments in which the ground plane 31 comprises a left extension 317 and a right extension 316 to optimize the signal. The ground plane comprises also a central extension 315. The central extension comprises the recess 312. A ground plane with a left, right and central extensions create a left space 319 and a right space 318. The extension(s) can have a specific shape and/or a specific location to optimize the signal.

[0095] In such embodiments, the central extension can also comprises a right and a left lateral finger.

[0096] According to some preferred embodiments, the shape of the ground plane is symmetrical with the axis being a longitudinal median axis of elongated element.

[0097] Coming back to FIG. 3, the dielectric element has a thickness T2. The thickness T2 can be comprises between 0.2 mm and 6 mm depending on the frequency range. In some preferred embodiments, the thickness T2 is about 0.8 mm.

[0098] The patch network has a thickness T33. The thickness T33 can be comprises between 2 µm and 20 µm. In some preferred embodiments, the thickness T33 is about 0.035 mm.

[0099] The transformer has a thickness T322. The thickness T322 is substantially the same than the thickness of the patch network T33.

[00100] In some preferred embodiments to optimize the signal, the length of the surface in which the patch network is inscribed in can be substantially the same than the length of the surface in which the transformer is inscribed in, measured along the Y-axis (L33 ≅ L332).

[00101] The elongated element has a thickness T321. The thickness T321 is substantially the same than the thickness of the patch network T33.

[00102] The ground plane has a thickness T31. The thickness T31 is substantially the same than the thickness of the patch network T33.

[00103] In some preferred embodiments, the thickness T31 of the ground plane substantially equals the thickness T32 of the feeding system.

[00104] Preferably, elements of the feeding system have substantially the same thickness (T321 ≅ T322).

[00105] In some more preferred embodiments, thicknesses of planar antenna element are substantially equals (T31 ≅ T32 ≅ T33).

[00106] FIG.7 illustrates some preferred embodiments of a planar antenna element for an antenna system working at a frequency range tuned between 3.1 to 10.6 GHz (3.1 GHz $\leq$ f $\leq$ 10.6 GHz).

[00107] In such embodiments, the planar antenna element 3 is symmetrical with the axis being a longitudinal median axis of the planar antenna element meaning that the left part of the planar antenna element equals to the right part of the planar antenna element.

[00108] In such embodiments, the patch network has a generic rectangular shape and thus inscribed in a rectangle having same dimensions and having a width W33, measured along the X-axis, and a length L33, measured along the Y-axis. The width W33 is about 15.2 mm and the length L33 is about 7.15 mm. The feeding system 32 comprises a connection element 323, a transformer 322 and an elongated element 321. The elongated element is conductively connected to the transformer. The patch network and the feeding system are produced as a single element

[00109] The said connection element conductively connects the transformer to the patch network. The connection element has a generic

rectangular shape having a width W323, measured along the X-axis, and a length L323, measured along the Y-axis. The width W323 is about 1.79 mm and the length L323 is about 0.75 mm.

[00110] The said transformer has a generic shape of a rectangular donut-like forming a rectangular ring. This rectangular ring is inscribed in a rectangle having same dimensions than external dimensions of the rectangular ring having an external length L332, measured along the Y-axis and an external width W332, measured along the X-axis. The external width W332 is about 6.25 mm and the external length L332 is about 7.15 mm. The hollow part has a width H322 of about 4.47 mm and a length H332 of about 5.36 mm.

[00111] This rectangular ring has four edges forming the ring. Each edges can have a specific thickness (Th332, Tb332, Tl332, Tr332) and preferably the thicknesses are about 0.89 mm.

[00112] In some preferred embodiment to optimize the signal, these specific thicknesses are substantially equals (Th332 ≅ Tb332 ≅ Tl332 ≅ Tr332).

[00113] The said extended element has a generic rectangular shape having a width W321, measured along the X-axis, and a length L321, measured along the Y-axis. The width W321 is about 1.79 mm and the length L321 is about 17.9 mm. The length of the extended element is substantially equals to 117% of the length of the recess.

[00114] The said patch network has a generic rectangular shape having a width W31, measured along the X-axis, and a length L31, measured along the Y-axis. The width W31 is about 17.88 mm and the length L31 is about 28.15 mm. The generic rectangular shape has a right and left lateral fingers having a width W313, measured along the X-axis, and a length L314, measured along the Y-axis. The width W313 is about 2.32 mm and the length L314 is about 5.9 mm. L314 is about 82.5% of L332. The length L321 of the recess is measured from the top of the lateral fingers to the bottom of the recess. The length L321 of the recess is about 15.3 mm. The width of the recess is about 4.29 mm. The end of this extended element is separated to the bottom of this recess of about 1.25 mm (Dee ≅ 1.25 mm), measured along the X-axis. Laterally, the extended element is separated from the patch

network by a distance Del of about 1.25 mm. The distance WPF, measured along the X-axis, between the end of the lateral fingers and the border of the patch network is about 4.47 mm (WPF ≅ 4.47 mm).

[00115] According to some embodiments of the invention, the antenna system can further comprises a parasitic element to optimize the radiation pattern.

<parasitic element>

[00116] A parasitic element is a conductive element disposed on a surface of the transparent dielectric panel and non-conductively connected neither to the patch network nor to the feeding system. Preferably, the parasitic element is far enough from the planar antenna system especially from the patch network and the feeding system. In the context of the invention, far enough means that one of the antenna elements is coupled to the radiation and current of the antenna elements, but not so close as to affect the basic resonance of the antenna.

[00117] In some embodiments, the antenna system can comprises at least two planar antenna elements. Each of the at least two planar antenna elements can radiate a specific frequency range. Preferably, in such embodiments, a parasitic element is positioned between each planar antenna system to avoid any coupling between planar antenna systems.

[00118] Some embodiments provide a glazing unit 100 comprising at least one antenna system 1 according to the first aspect of the invention to protect the at least one antenna system from scratches and to protect the at least one planar antenna element from the exterior attack, such as moisture, scratches,⋯, as illustrated in FIG. 8, FIG. 9 and FIG. 10.

[00119] In some of these embodiments, the glazing unit can comprises at least two antenna systems to create a MIMO.

<Glazing unit>

[00120] The glazing unit can comprises a first dielectric panel 101 and a second dielectric panel 102. The at least one antenna system is sandwiched between the first transparent dielectric panel and the second transparent dielectric panel.

[00121] The first dielectric panel and the second dielectric panel can have different composition.

[00122] In some preferred embodiments, the first and/or the second dielectric panel is a transparent dielectric panel.

[00123] The first and the second transparent dielectric panels can have different chemical composition, such as plastic-based composition. The plastic-based composition can be PET, polycarbonate, PVC or any other transparent dielectric plastic-based that can be used as a panel.

[00124] Preferably, the first and / or the second transparent dielectric panel comprises a glass panel to protect the antenna arrangement and the antenna system from scratches. The glass panel can comprises at least 50 % in weight of SiO2 such as glass like soda lime glass, aluminosilicate glass or borosilicate glass.

[00125] In some embodiments, the first and the second transparent dielectric panels have the same chemical composition to reduce the handling and the process of manufacturing.

[00126] The first and the second transparent dielectric panels can be manufactured by a known manufacturing method such as a float method, a fusion method, a redraw method, a press molding method, or a pulling method. As a manufacturing method of the glass panel, from the viewpoint of productivity and cost, it is preferable to use the float method.

[00127] Each of the first and the second transparent dielectric panels can be independently processed and / or colored,… and / or have different thickness in order to improve the aesthetic, safety,…

[00128] Each of the first and the second transparent dielectric panels can be processed, i.e. annealed, tempered,… to respect the specifications of security requirements. The transparent dielectric panel can independently be a clear or a colored transparent dielectric panel, tinted with a specific composition or by applying an additional coating or a plastic layer for example.

[00129] The first and the second transparent dielectric panels can have any shape. The shape of the transparent dielectric panels in a plan view is not limited to a rectangle and may be a trapeze, a triangle, a square, a circle or the like.

[00130] Preferably, the first and the second transparent dielectric panels can have a loss tangent equals to or smaller than 0.03 and more preferably

the loss tangent of the dielectric panels is equal to or smaller than 0.02 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.01 to reduce the energy loss in panels while increasing the antenna system efficiency.

[00131] In preferred embodiments, the first and the second transparent dielectric panels have a loss tangent equals to or smaller than 0.005 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.003 to reduce the energy loss in panels while increasing the antenna system efficiency.

[00132] Preferably, the first and the second transparent dielectric panels are borosilicate glass panels to reduce the loss tangent to a value equals to or is smaller than 0.01.

[00133] The dielectric panels can be manufactured by a known manufacturing method such as a float method, a fusion method, a redraw method, a press molding method, or a pulling method. As a manufacturing method of the glass panel, from the viewpoint of productivity and cost, it is preferable to use the float method.

[00134] Each transparent dielectric panel can be independently processed and / or colored,… and / or have different thickness in order to improve the aesthetic, safety,…

[00135] Each transparent dielectric panel can be processed, i.e. annealed, tempered,… to respect the specifications of security requirements. The transparent dielectric panel can independently be a clear or a colored transparent dielectric panel, tinted with a specific composition or by applying an additional coating or a plastic layer for example.

[00136] The first and the second dielectric panels can have any shape. The shape of the dielectric panels in a plan view is not limited to a rectangle and may be a trapeze, a triangle, a square, a circle or the like.

[00137] To sandwich the at least one antenna system 1 with the first 101 and second 102 transparent dielectric panels, a first interlayer 111 and a second dielectric panel 112 can be used. These interlayers are preferably transparent polymers.

[00138] In some embodiments, the interlayer are transparent interlayers and preferably the interlayers are transparent polymer interlayers.

[00139] A transparent polymer interlayer can be polyvinyl butyral (PVB), ethylene-vinyl acetate (EVA), polymethyl methacrylate (PMMA), a polycarbonate (PC), a polystyrene (PS), a polyvinyl chloride (PVC), a polyamide (PA), a polyetherimide (PEI), a polyethylene terephthalate (PET), a polyurethane, an acrylonitrile butadiene styrene copolymer (ABS), a styrene acrylonitrile copolymer (SAN), a styrene methyl methacrylate copolymer (SMMA) and any mixtures of these, a crosslinked resin, an ionoplast, an ionomer, a cyclo-olefin polymer (COP), cyclo-Olefin copolymer (COC), a sentry glass or an Optical Clear Adhesive (OCA).

[00140] Crosslinked or cured resins are known to the skilled person and are three dimensional polymer networks obtained by the crosslinking/curing of low molecular weight species either by reaction with a curing agent also known as crosslinker or upon exposure to heat, UV radiations (UV) or electron beam (EB). Non exhaustive examples of crosslinked resins are epoxy resins, polyurethane resins, UV or EB curable resins. In the present invention, the precursors of the crosslinked resin may be transparent or not provided that the crosslinked resin is transparent.

[00141] Remark that some polymer mixtures, copolymers and some semi-crystalline polymers can be opaque and non-transparent due to a dispersed phase or due to the presence of crystallites. Hence it is possible that not all compositions of the listed polymers mentioned above are transparent. The person skilled in the art is capable to identify what composition is transparent and hence identify if a given polymer falls within the claimed transparent polymers.

[00142] Preferably, the transparent dielectric panel can have a loss tangent equals to or smaller than 0.03 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.02 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.01 to reduce the energy loss in panels while increasing the antenna system efficiency.

[00143] In preferred embodiments, the transparent dielectric panel has a loss tangent equals to or smaller than 0.005 and more preferably the loss tangent of the dielectric panels is equal to or smaller than 0.003 to reduce the energy loss in panels while increasing the antenna system efficiency.

[00144] In some preferred embodiments, the first interlayer and the second

interlayer are sentryglas.

[00145] Preferably, the transparent interlayers are low-loss transparent layers to reduce the losses of the antenna arrangement while increasing performances.

[00146] The first and the second interlayers can be designed as a single interlayer in some embodiments in which the antenna system has a surface smaller than the interlayer surface.

[00147] In some embodiments, to provide an transmission and / or reception of at least an operating frequency through a window as discrete as possible, the glazing unit (or an antenna system) can be placed in front of the window. Preferably, the antenna system radiates towards a specific direction through the first transparent dielectric panel 101 to emit and /or receive through the window and to cover terminals outside a building for instance. In such embodiments, the first transparent dielectric panel 101 and / or the second transparent dielectric panel 102 can be mounted in front of the window.

[00148] In some embodiments, the antenna system radiates towards a specific direction through the side opposite to the first transparent dielectric to emit and /or receive at the opposite direction of the window and to cover terminals inside a building for instance.

[00149] The term “in front of” denotes that the first transparent dielectric panel is facing the antenna system front face, the second transparent dielectric panel is facing the first transparent dielectric panel.

[00150] In some embodiments, the antenna system radiates towards the two specific directions to emit and /or receive through the window and through the opposite side and to cover terminals outside and inside a building for instance.

[00151] In some others embodiments, a glazing unit can be hung to a ceiling or attached to a wall to irradiate around the location.

[00152] As illustrated in FIG. 8, the connection means 120 is connected to the antenna system inside the glazing panel. In such embodiments, the connection means has to be thin. The second interlayer can have a cutoff to leave enough space for the connection means.

[00153] As illustrated in FIG. 9 and FIG. 10, the second dielectric panel and

the second interlayer can have a recess 122 in front of the connection between the antenna system and the connection means to facilitate the handling and the connection.

[00154] This recess has a width, W122, measured along the X-axis and a length, L122 measured along the Y-axis. The width W122 can be about 1.5 mm and the L122 can be about 1 mm.

[00155] In some embodiments, a single recess can be used to connect more than one antenna system to a connection means.

[00156] Some embodiments provide a method to manufacture an antenna system according to claims 1 to 13, wherein the method comprises following steps :

A. Providing a dielectric panel,
B. Disposing a planar antenna element on a first surface of the dielectric panel
C. Conductively connecting the ground plane and the feeding system to a power provider via a connection means.

[00157] In some embodiments, the step B of disposition can be performed by applying a coating on the dielectric panel to create the planar antenna element or RF sputtering. Another disposition can be applying a coating and decoating some parts to create the planar antenna element. This step can also be performed by applying a mask and applying a conductive material and removing the mask to create the planar antenna element. The disposition can also be a printing the planar antenna element on said first surface of the dielectric panel.

[00158] According to some embodiments, the method can comprise a step of creating the planar antenna system before the disposing step (B) and the disposing step comprises a sub-step of fixing the planar antenna element on said first surface of the dielectric panel. The fixing sub-step can be a sub-step of gluing.

[00159] An embodiment provides the use to the patch network to enlarge the bandwidth of the antenna system of planar antenna system comprised in an antenna system; the planar antenna system comprises a planar antenna element (3) disposed on a first surface of a dielectric panel and comprising a patch network (33), a ground plane (31), comprising a recess,

and a feeding system (32) conductively connected; the feeding system comprises a transformer (322) designed to enlarge the bandwidth of the antenna system and the feeding system also comprises an elongated element (321) extending from the transformer into the recess.

[00160] The present invention permits to use the spectrum sensing technology and the dongle wireless USB application or any application using UWB technology with an ultra-wide band antenna system as claimed. Spectrum sensing is one of the most important components of cognitive radio networks. Spectrum sensing enables a cognitive radio to have information about its environment and spectrum availability. The most widely used spectrum sensing methods are energy detection and matched filter detection.

[00161] The invention also solves the need to have the smallest antenna system while having very large bandwidth.

Claims

Claim 1. An antenna system (1), designed to emit and/or receipt at a desired frequency range, f , comprising:

- a transparent dielectric panel (2) having a first surface,
- a planar antenna element (3) disposed on the first surface and comprising a patch network (33), a ground plane (31) and a feeding system (32) conductively connected to the patch network

characterized in that the ground plane comprises a recess (312),

in that the feeding system comprises a transformer (322) designed to enlarge the bandwidth of the antenna system,

in that the feeding system also comprises an elongated element (321) extending from the transformer into the recess

and in that the transformer is a loop.

.

Claim 2. An antenna system according to claim 1, wherein the transformer is a polygonal loop and preferably a rectangular loop.

Claim 3. An antenna system according to any preceding claims, wherein the distance, Dee, between the end part of the elongated element and the ground plane is smaller than or equal to 3 mm and larger than 0.

Claim 4. An antenna system according to any preceding claims, the distance, Del, between the lateral border of the elongated element and the ground plane is smaller than or equal to 12 mm and larger than 0 preferably, the distance, Del, between the lateral border of the elongated element and the ground plane is smaller than or equal to 3 mm and more preferably the distance, Del, between the lateral border of the elongated element and the ground plane is smaller than or equal to 1.25 mm

Claim 5. An antenna system according to any preceding claims, wherein the ground plane comprises a right lateral finger and a left lateral finger extending the recess length; a portion of the elongated element of the feeding line extending between the lateral fingers.

Claim 6. An antenna system according to any preceding claims, wherein the transparent dielectric panel is a transparent glass panel.

Claim 7. An antenna system according to claims 1 to 5, wherein the transparent dielectric panel is made of a plastic-based material.

Claim 8. An antenna system according to any preceding claims, wherein the thickness of the ground plane substantially equals the thickness of the feeding system.

Claim 9. An antenna system according to any preceding claims, wherein the material of the patch network, the ground plane and the feeding system comprises conductive material.

Claim 10. An antenna system according to claim 9, wherein the conductive material is a metal-based material such as copper, silver, conductive metal alloys with or without plated material.

Claim 11. An antenna system according to any preceding claims, wherein the feeding system comprises a connection area (34) designed to be connected to a connection means and wherein the ground plane comprises a first connection area designed to be connected to the connection means.

Claim 12. An antenna system according to claim 11, wherein the ground plane further comprises a second connection area designed to be connected to the connection means.

Claim 13. A glazing unit comprising an antenna system according to any preceding claims.

Claim 14. A method to manufacture an antenna system according to claims 1 to 12, wherein the method comprises following steps :

A. Providing a dielectric panel,
B. Disposing a planar antenna element on a first surface of the dielectric panel
C. Conductively connecting the ground plane and the feeding system to a power provider via a connection means.

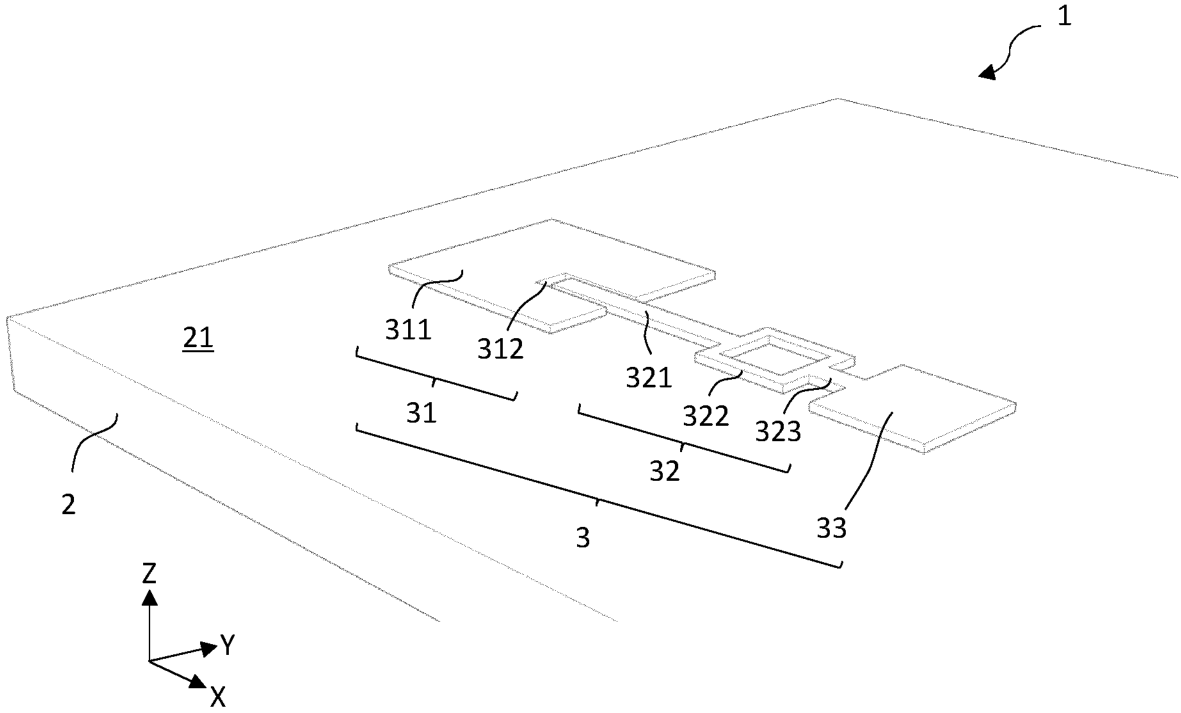


FIG. 1

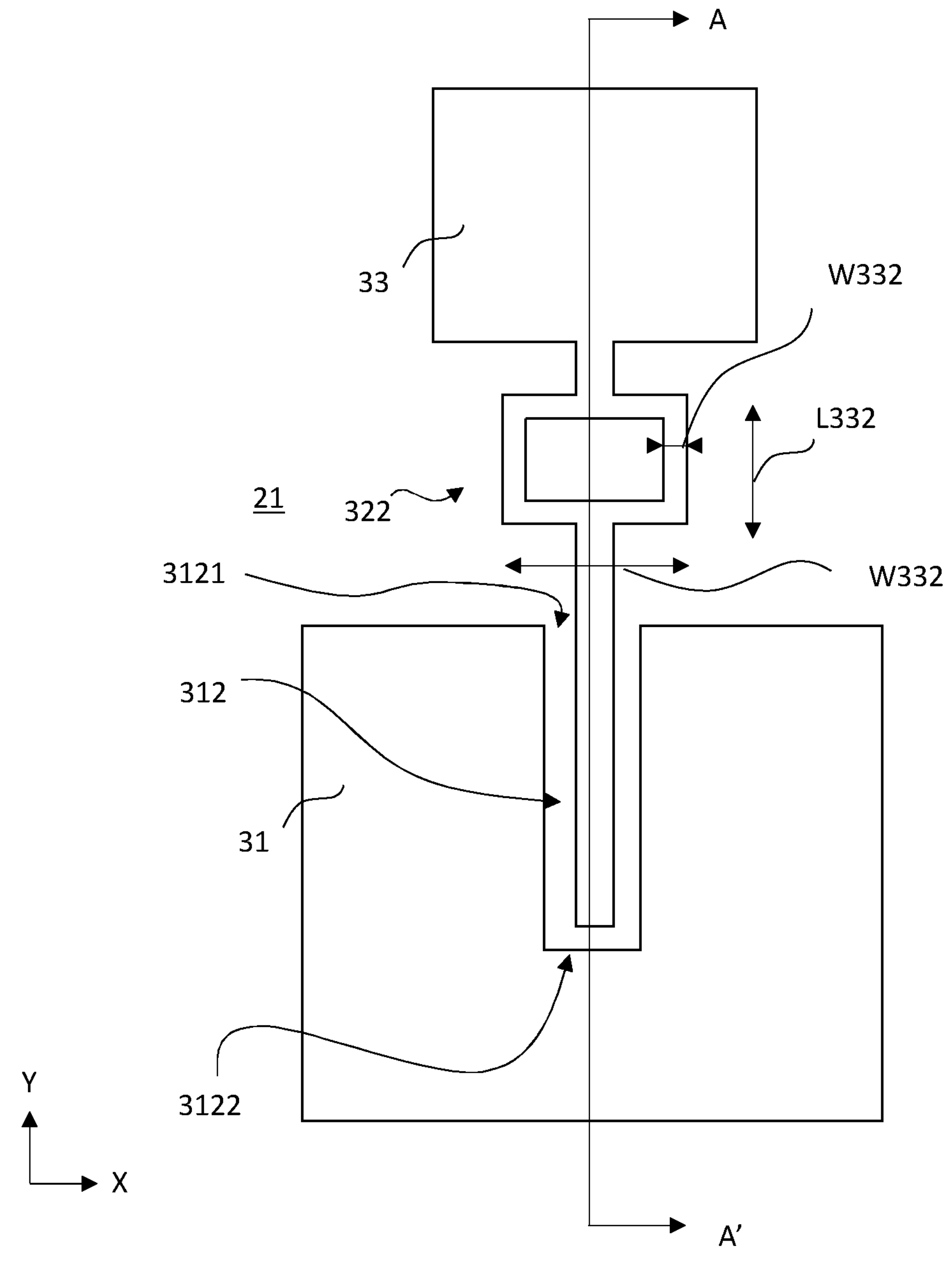

A
33
W332
L332
21
322
3121
W332
312
31
3122
Y
X
A’

FIG. 2

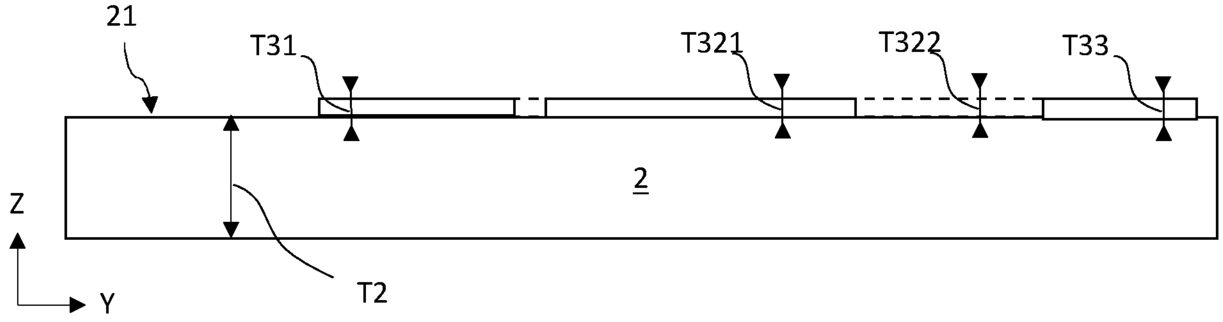

21
T31
T321
T322
T33
2
Z
Y
T2

FIG. 3

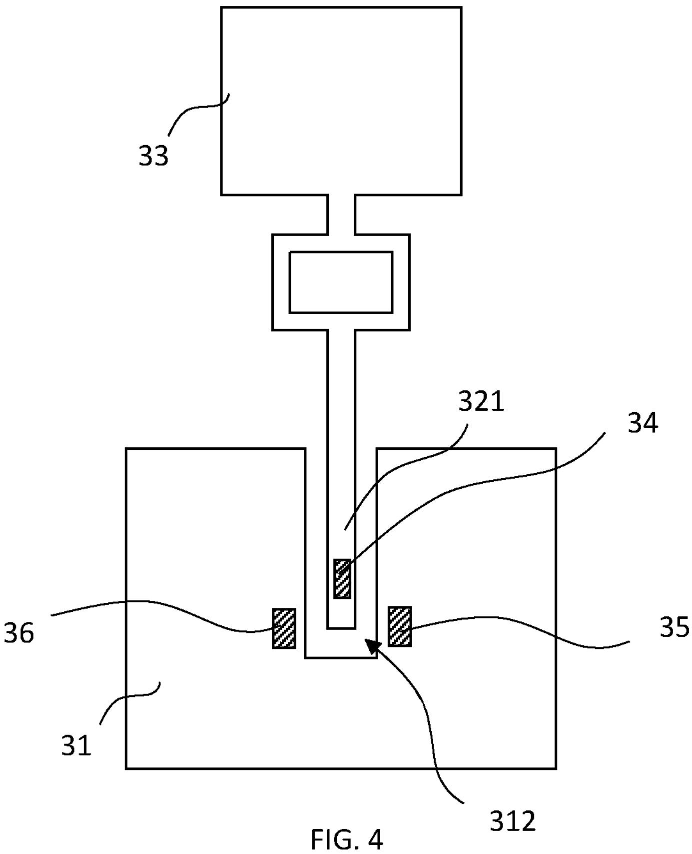


FIG. 4

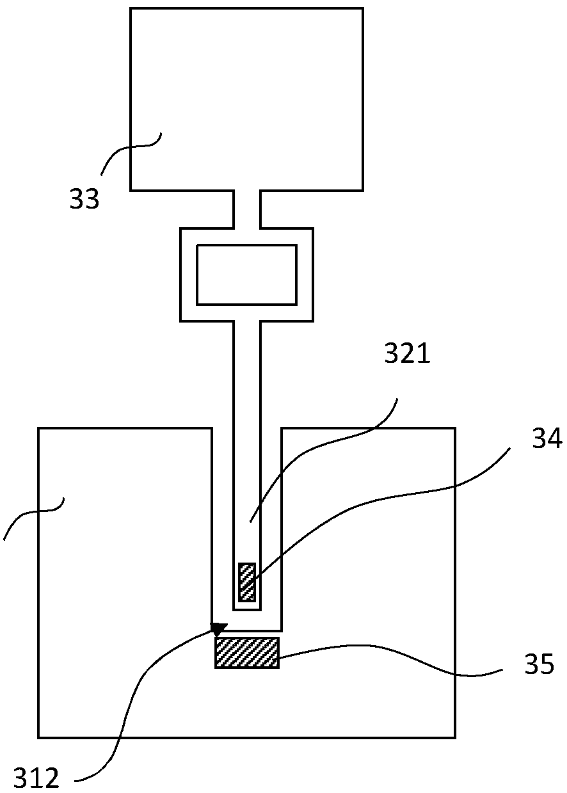


FIG. 5

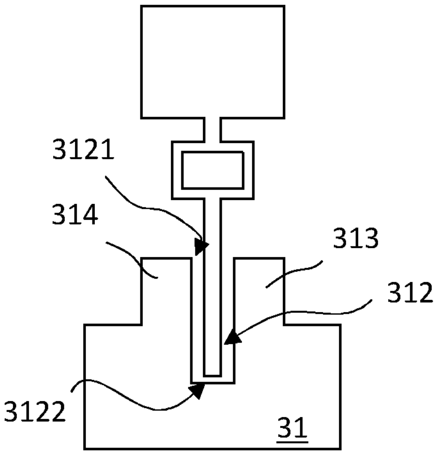


FIG. 6a

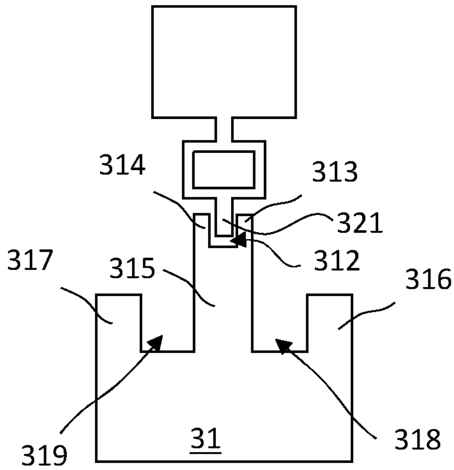
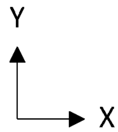


FIG. 6b



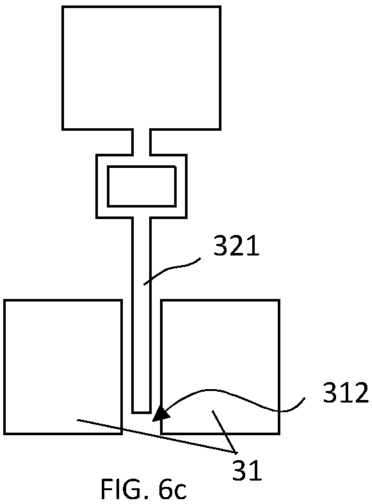


FIG. 6c

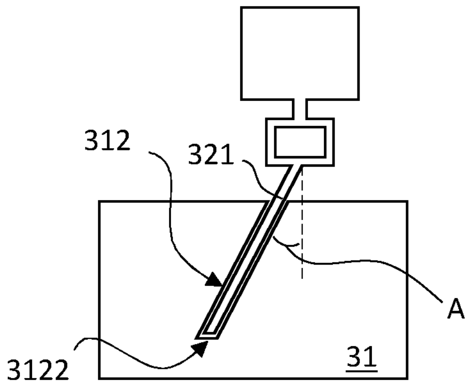


FIG. 6d

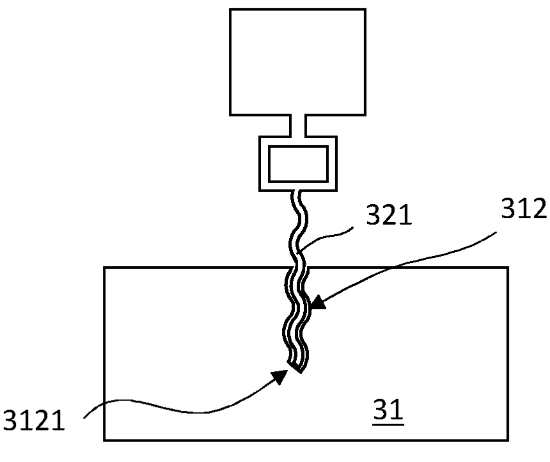


FIG. 6e

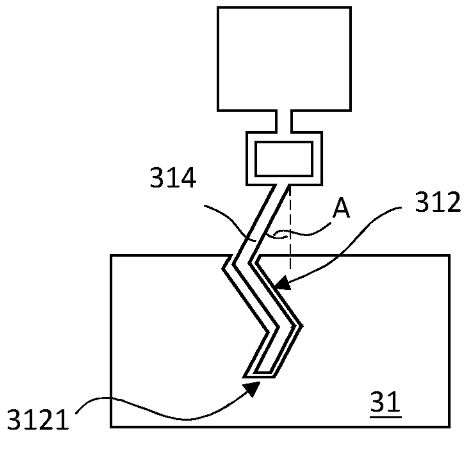


FIG. 6f

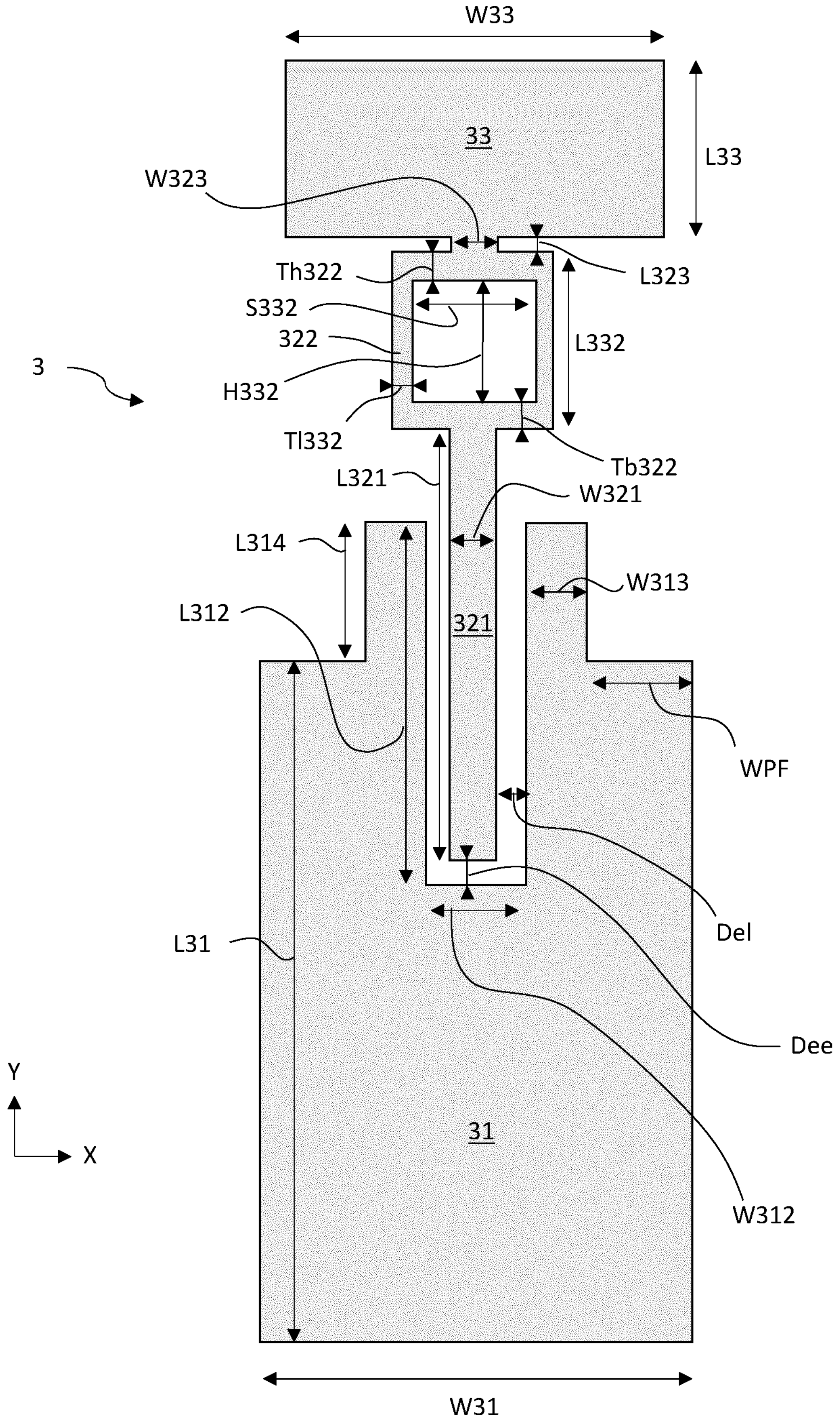

W33
33
L33
W323
L323
Th322
S332
322
L332
3
H332
Tl332
Tb322
L321
W321
L314
W313
L312
321
WPF
Del
L31
Dee
Y
X
31
W312
W31

FIG. 7

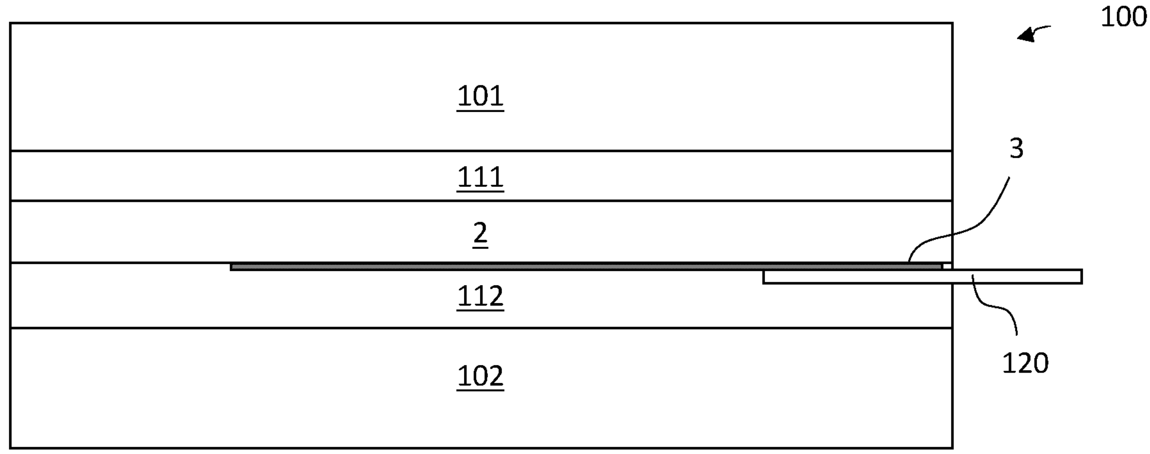


FIG. 8

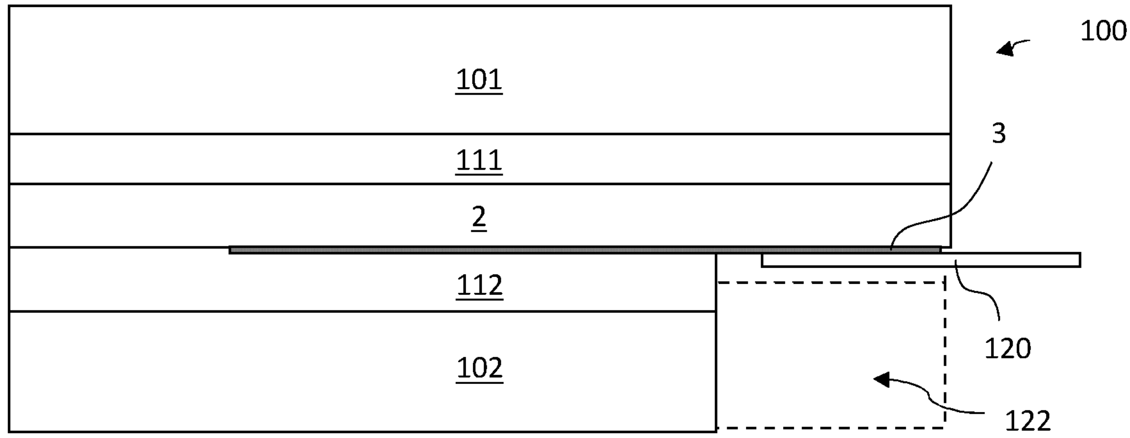


FIG. 9

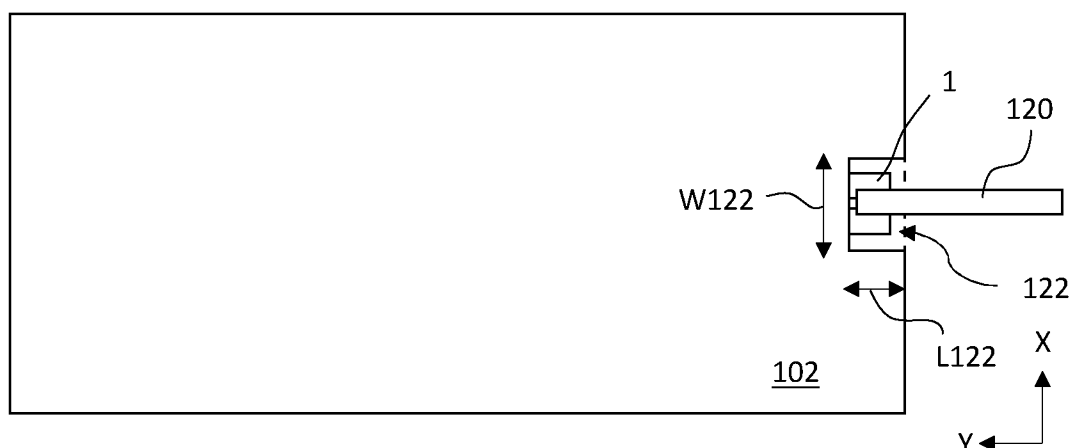


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/061472

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01Q1/12 H01Q1/38 H01Q1/48 H01Q5/50
ADD. H01Q9/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01Q H01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/221652 A1 (LI QIAN [US] ET AL) 15 September 2011 (2011-09-15) figures 3-5,9 paragraphs [0024] - [0042] -----	1-14
A	CN 113 113 757 A (FUYAO GLASS IND GROUP CO LTD) 13 July 2021 (2021-07-13) figures 1,2 paragraphs [0042] - [0058] -----	1-14
A	US 2015/002360 A1 (KAWAMURA HIROFUMI [JP]) 1 January 2015 (2015-01-01) figures 1-3 paragraphs [0052] - [0056] -----	1-14
A	CN 211 956 530 U (CAINIAO SMART LOGISTICS HOLDING LTD) 17 November 2020 (2020-11-17) figure 4 paragraph [0058] -----	1-14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 June 2024	07/08/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Niemeijer, Reint

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2024/061472

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			EP 2545610	A1	16-01-2013
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			US 2010231320	A1	16-09-2010
			US 2015002360	A1	01-01-2015
CN 211956530	U	17-11-2020	NONE		