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(54) **METHOD OF MANUFACTURING A MICROWAVE ANTENNA WITH INTEGRATED FUNCTION OF ORGANIC VAPOR SENSOR**

VERFAHREN ZUR HERSTELLUNG EINER MIKROWELLENANTENNE MIT INTEGRIERTER
FUNKTION DES ORGANISCHEN DAMPFSENSORS

PROCÉDÉ DE FABRICATION D'UNE ANTENNE À MICRO-ONDES À FONCTION INTÉGRÉE DE
CAPTEUR DE VAPEUR ORGANIQUE

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Description

Field of technology

[0001] The introduced invention is a method of manufacturing a microwave antenna with an integrated sensor for organic vapors, namely a microstrip antenna with a ground plane intended for information transmission over wireless networks and with an additional function for organic vapor detection.

Background of the invention

[0002] Nowadays, for microwave bands antennas of various structure designs are used. From the perspective of material there exist several kinds of microstrip antennas. For instance, they can consist of thin cupreous, silver or other metal small surfaces, or layers of these metals that are applied to an electrically nonconductive substrate (dielectric). These small surfaces are constructionally adjusted microstrips intended for specific frequencies. Most commonly, the ground plane is located on the back section of the microstrip antenna. The surface structure of such antennas is solid, which makes them incapable of responding to changes of vapors present in the surroundings and therefore, they cannot be used both for signal transmission and organic vapors detection.

[0003] Currently, the antennas based on carbon nanotube layers or parts are widely used in practice. The antenna as claimed by the Korean patent application KR20090105991 is made of a polymer composite that contains carbon nanotubes in a polymer matrix on the basis of polyamide (nylon).

[0004] "Multifunctional Meshed Carbon Nanotube Thread Patch Antenna" by S. D. Keller and A. I. Zaghloul discloses a patch antenna fabricated with carbon nanotubes for communications and gas sensing.

[0005] As conductive material for the antenna in the Japanese patent application JP2002109489 is a composite-based conductive paste containing carbon nanotubes, conductive metal powder and a polymer matrix.

[0006] The patent application USA 2005116861 relates to a smaller antenna with a radiator formed by carbon nanotubes which has excellent performance characteristics in the highfrequency band.

[0007] The subject of the patent application USA 2011220722 is an RFID tag antenna consisting of a substrate with a pattern layer formed by interconnected segments of carbon nanotubes.

[0008] In the international patent application PCT WO2012113322 the layer of carbon nanotubes is applied to the surface of the solar panel the function of which is, in this case, detection of photons. This indicates that multiple functions of the product, allowed by technological and utility characteristics of the carbon nanotube layers, are possible. However, the combination of several functions is based on combinations of individual functions of two structural parts of the product. Up to now, insufficient

attention has been paid to the possible multiple functions of the actual layer of carbon nanotubes.

Grounds of the technical solution

[0009] The previously mentioned problem can be addressed by means of a method according to claim 1. Optional features are set out in the dependent claims.

[0010] So far, antennas capable of operating in the microwave band and detecting organic vapors based on the change in resistance of the layer applied to a substrate used for high frequency technology have not been described. By means of the nanotubes it is possible to design such an antenna that does not affect its matching greatly when detecting organic vapors. Therefore, such a solution is regarded as innovative as it allows multiple functions of a small antenna incorporated in a mobile device, which includes signal transmission and detection of organic vapors. In terms of design, this is an unused production technology of the substrate for microstrip antennas. The antenna can then detect organic vapors in the air and on evaluating the data it notifies its user that some type of organic vapors is present in the air; in most cases these vapors are harmful even in small concentrations. The antenna does not perform the actual evaluation. In this case, the antenna is perceived as part of a chain in which it operates as the passive antenna and at the same time as the sensor of organic vapors.

Figures in the drawing

[0011] The accompanying drawing serves as an illustration of the principles of the invention:

- fig. 1 - Illustrative diagram of the antenna / sensor of organic vapors - front view;
- fig. 2 - Illustrative diagram of the antenna / sensor of organic vapors - cross-sectional view;
- fig. 3 - Circuit diagram of the antenna / sensor of organic vapors in the evaluation chain.

Examples of implementation

Example 1

[0012] The microstrip antenna, in the exemplary implementation (see fig. 1 and 2), is formed by a functional layer 2 consisting of randomly entangled carbon nanotubes (MWCNT) with the length of 1 - 10 μm and diameter in the range of 10 - 30 nm. The functional layer 2 is deposited on an electrically nonconductive substrate 1 made of PMMA. The substrate 1 consists of a strip with the length of 45 mm and width 9 mm, which is anchored in the ground plane 4 formed by the printed circuit board. The depth of the functional layer 2 is 200 μm and is connected by a coaxial line 3. The antenna can be integrated into the case of a portable device that uses wireless transmission of information.

[0013] The functional layer is produced by means of vacuum filtration through a polymer membrane of an aqueous dispersion composed of carbon nanotubes and a mixture of surfactants. The polymer filtration membrane composed of polyurethane nanofibers is produced by means of electrostatically spinning of a solution of polyurethane in dimethylformamide. Such amount of dispersion that corresponds to the depth of 200 μm is filtered through this membrane. Upon reaching this depth the resulting layer is washed by alcohol and water in order to remove residues of surfactants. The filtration membrane is then removed and the filtered layer is dried between filter papers. After drying the layer is formed into a suitable shape, which corresponds to the requirements of the frequency of the antenna; in this particular case it is a strip with dimensions of 9 x 45 mm. The strip is then applied to the PMMA substrate. This strip is best adapted to the frequency of 1.28 GHz.

[0014] The functional layer 2 is used as self-supporting (the filtration nanofibrous membrane is separated). The layer is electrically conductive and able to receive / transmit signal. Moreover, it is capable of adsorption of molecules of organic vapors when exposed to these vapors. This process is reversible; the removal of the layer leads to desorption of molecules of organic vapors. Adsorption and desorption of vapors can be easily detected by measuring the changes in DC resistance. It is also possible to employ scalar measuring of a reflection coefficient of the antenna or to measure changes in its resonant frequency, or possibly to detect changes in resonant frequency of the antenna.

[0015] The previously mentioned functions are implemented in the evaluation chain of the antenna / sensor of organic vapors (see the diagram in fig. 3), where antenna A is connected via a converter C and evaluation unit E with the display D of the mobile device.

Example 2

[0016] The structural design of the antenna is similar to Example 1. Likewise, the functional layer is produced by means of vacuum filtration of an aqueous dispersion composed of carbon nanotubes and mixture of surfactants.

[0017] The filtration polymer membrane composed of polystyrene or polyamide 6 is produced by means of electrostatically spinning of the solution. The dispersion is filtered through this membrane. Such amount of dispersion that corresponds to the depth of 30 μm of the functional layer 2 is filtered through this membrane. Upon reaching this depth the resulting layer is washed by alcohol and water in order to remove residues of surfactants. The filtration membrane is a part of the newly emerged structure and it is dried between filtration papers. After drying the layer is formed into an adequate shape, for instance triangle, square or others, in order to comply with the requirements of the frequency. The resulting formation is then connected to a non-conductive

substrate 1.

[0018] The size and shape is always dependent on a specific frequency for impedance matching of the antenna. The antenna can be easily implemented in unlicensed ISM bands, such as 2.45 GHz or 5.8 GHz; it is also possible to produce and operate the antenna in lower frequency bands. Also, the antenna can be miniaturized as in the case of the PIFA type.

Example 3

[0019] The design of the said antenna and its production correspond to Example 1 or 2. Nevertheless, in the exemplary implementation the functional layer 2 of carbon nanotubes is consequently functionalized by oxidation in order to increase sensitivity.

Claims

1. Method for manufacturing a microwave antenna with an integrated sensor for organic vapours, the method comprising providing an electrically non-conductive substrate (1) of planar shape wherein a surface of the electrically non-conductive substrate is covered with an electrically conductive functional layer (2) capable of receiving / transmitting a signal and also of reversible adsorption / desorption of molecules of organic vapours, **wherein** the electrically conductive functional layer (2) is based on randomly entangled nanotubes, wherein the randomly entangled nanotubes are produced by vacuum filtration of a dispersion of carbon nanotubes through a filtering membrane of polymeric nanofibers, wherein the electrically conductive functional layer (2) is either a self-supporting functional layer, or wherein the integrated filtering membrane forms a part of the resulting electrically conductive functional layer (2).
2. Method for manufacturing a microwave antenna with an integrated sensor for organic vapours according to the claim 1 **wherein** the carbon nanotubes have a diameter 10 - 30 nm and a length 1 - 10 μm .
3. Method for manufacturing a microwave antenna with an integrated sensor for organic vapours according to the claim 1 **wherein** a depth of the electrically conductive functional layer (2) is 30 - 500 μm .
4. Method for manufacturing a microwave antenna with an integrated sensor for organic vapours according to the claim 1 **wherein** the electrically conductive functional layer (2) is treated by oxidation treatment to increase sensitivity of the electrically conductive functional layer (2).
5. Method for manufacturing a microwave antenna with an integrated sensor for organic vapours according

to the claim 1 **wherein** the microwave antenna has a form of a planar dipole or planar biconical dipole.

6. Method for manufacturing a microwave antenna with an integrated sensor for organic vapours according to the claim 1 **wherein** the microwave antenna is a PIFA antenna.

Patentansprüche

1. Verfahren zur Herstellung einer Mikrowellenantenne mit integriertem Sensor für organische Dämpfe, wobei das Verfahren das Bereitstellen eines elektrisch nicht leitenden Substrats (1) mit planarer Form umfasst, wobei eine Oberfläche des elektrisch nicht leitenden Substrats mit einer elektrisch leitenden Funktionsschicht (2) bedeckt ist fähig ein Signal zu empfangen / zu senden und auch fähig die Molekülen organischer Dämpfe wiederholt zu absorbieren / zu verdampfen, **dadurch gekennzeichnet, dass** die elektrisch leitende Funktionsschicht (2) auf zufällig verschränkten Nanoröhren basiert wird wobei die zufällig verschränkten Nanoröhren durch Vakuumfiltration der Dispersion einer Kohlenstoffnanoröhren durch eine Filtermembran aus polymeren Nanofasern erzeugt werden, wobei die elektrisch leitende Funktionsschicht (2) entweder selbsttragend ist oder die integrierte Filtermembran bildet einen Teil der resultierenden elektrisch leitenden Funktionsschicht (2).
2. Verfahren zur Herstellung einer Mikrowellenantenne mit integriertem Sensor für organische Dämpfe nach dem Anspruch 1, **wobei** die Kohlenstoffnanoröhren einen Durchmesser von 10 bis 30 nm und eine Länge von 1 bis 10 μm haben.
3. Verfahren zur Herstellung einer Mikrowellenantenne mit integriertem Sensor für organische Dämpfe nach dem Anspruch 1, **wobei** die Tiefe der elektrisch leitenden Funktionsschicht (2) 30 - 500 μm beträgt.
4. Verfahren zur Herstellung einer Mikrowellenantenne mit integriertem Sensor für organische Dämpfe nach dem Anspruch 1, **wobei** die elektrisch leitende Funktionsschicht (2) durch Oxidationsbehandlung behandelt wird, um die Empfindlichkeit der elektrisch leitenden Funktionsschicht (2) zu erhöhen.
5. Verfahren zur Herstellung einer Mikrowellenantenne mit integriertem Sensor für organische Dämpfe nach dem Anspruch 1, **wobei** die Mikrowellenantenne eine Form eines planaren Dipols oder eines planaren bikonischen Dipols aufweist.
6. Verfahren zur Herstellung einer Mikrowellenantenne mit integriertem Sensor für organische Dämpfe nach

dem Anspruch 1, **wobei** die Mikrowellenantenne eine PIFA-Antenne ist.

5 Revendications

1. Procédé de fabrication d'une antenne micro-onde avec un détecteur intégré pour les vapeurs organiques, le procédé comprenant d'un substrat électrique non conducteur (1) de forme plane dans lequel une surface du substrat électrique non conducteur est couverte d'une couche fonctionnelle électrique conductrice (2) capable de recevoir / transmettre un signal et également d'adsorption / désorption réversible de molécules de vapeurs organiques, **caractérisée par le fait que** la couche fonctionnelle électrique conductrice (2) est basée sur des nanotubes entremêlés de manière aléatoire, dans lequel les nanotubes entremêlés de manière aléatoire sont produits par filtration sous vide d'une dispersion de nanotubes de carbone par une membrane filtrante de nanofibres polymères, dans laquelle la couche fonctionnelle électriquement conductrice (2) est soit une couche fonctionnelle autoportante, soit dans laquelle la membrane filtrante intégrée fait partie de la couche fonctionnelle électriquement conductrice (2) résultante.
2. Procédé de fabrication d'une antenne micro-onde avec un détecteur de vapeurs organiques intégré selon la revendication 1, **dans lequel le fait** que les nanotubes de carbone ont un diamètre 10 - 30 nm et une longueur 1 - 10 μm .
3. Procédé de fabrication d'une antenne micro-onde avec un détecteur de vapeurs organiques intégré selon la revendication 1, **dans lequel le fait** que une profondeur de la couche fonctionnelle électriquement conductrice (2) de 30 à 500 μm .
4. Procédé de fabrication d'une antenne micro-onde avec un détecteur intégré pour vapeurs organiques selon la revendication 1, **dans lequel le fait** que la couche fonctionnelle électriquement conductrice (2) suit un traitement d'oxydation pour augmenter la sensibilité de la couche fonctionnelle électriquement conductrice (2).
5. Procédé de fabrication d'une antenne micro-onde avec un détecteur pour les vapeurs organiques intégré selon la revendication 1, **dans lequel le fait** que l'antenne micro-onde a une forme de dipôle plan ou dipôle biconique plan.
6. Procédé de fabrication d'une antenne micro-onde avec un détecteur intégré de vapeurs organiques intégré selon la revendication 1, **dans lequel le fait** que l'antenne micro-onde est une antenne PIFA.

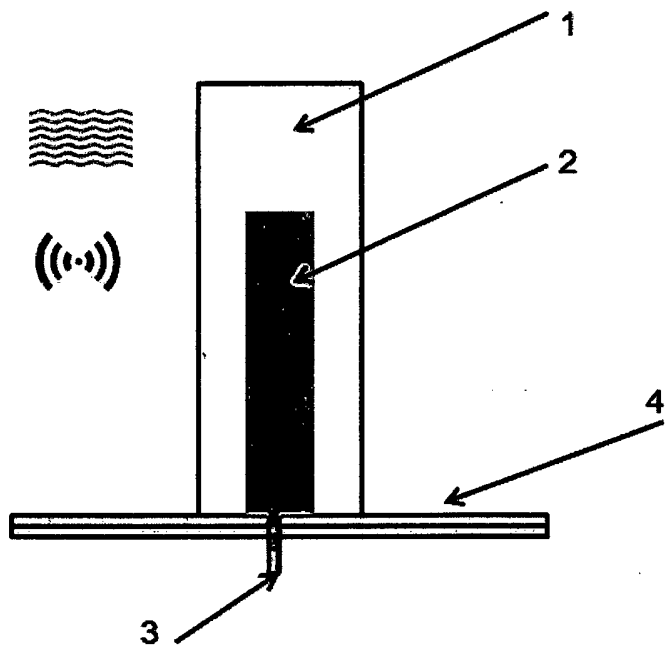


Fig.1

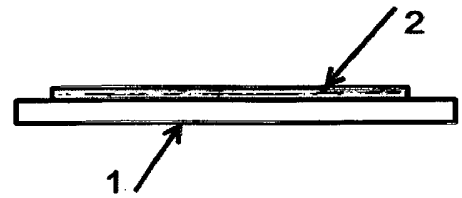


Fig.2

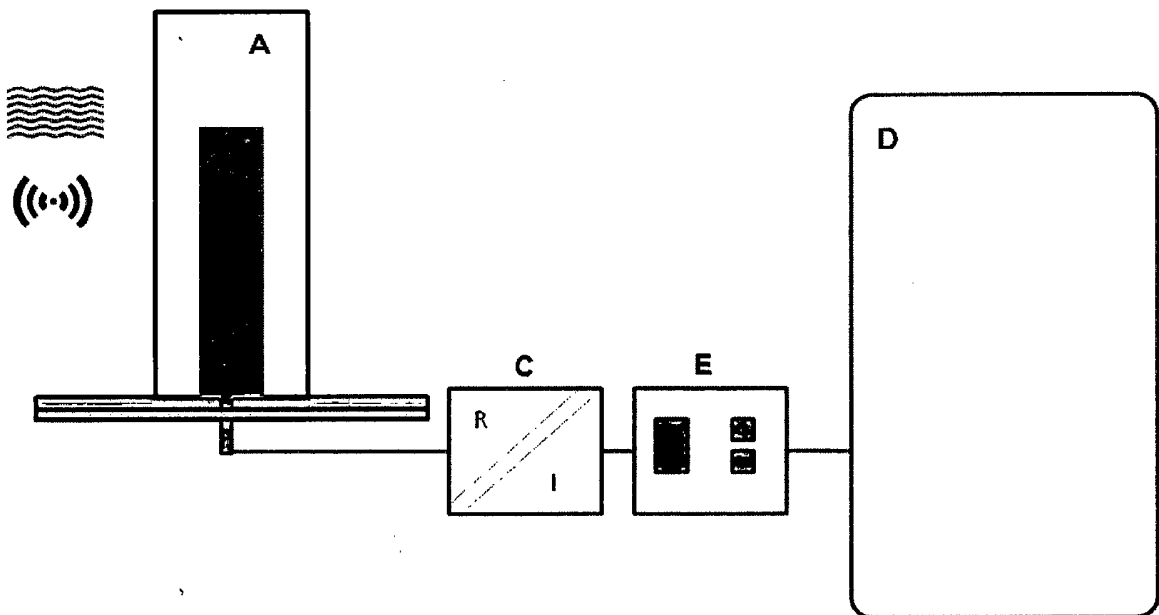


Fig.3

REFERENCES CITED IN THE DESCRIPTION

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