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(54) Packaging of active and passive microwave circuits using lid or bed of curved posts

(57) The present invention represents a new, way of packaging passive and active microwave circuits, and in particular circuits involving microstrip transmission lines and similar substrate bound transmission lines. The circuits are located between two conducting surfaces, one of these surface may be the ground plane of the microwave circuit, and at least one of these surfaces are provided with curved conducting posts. The two surfaces may form the bottom and lid of a cavity with conducting sidewalls. The posts may with advantage be arrange in a periodic grid, and create together with the ground plane of the microwave circuit board or the smooth metal plane below the microwave circuit board a stopband for waves propagating between the lid of posts and the ground plane. Thereby, cavity resonances are avoided or suppressed that otherwise create a big problem associated with the packaging in metal boxes with smooth metal walls.

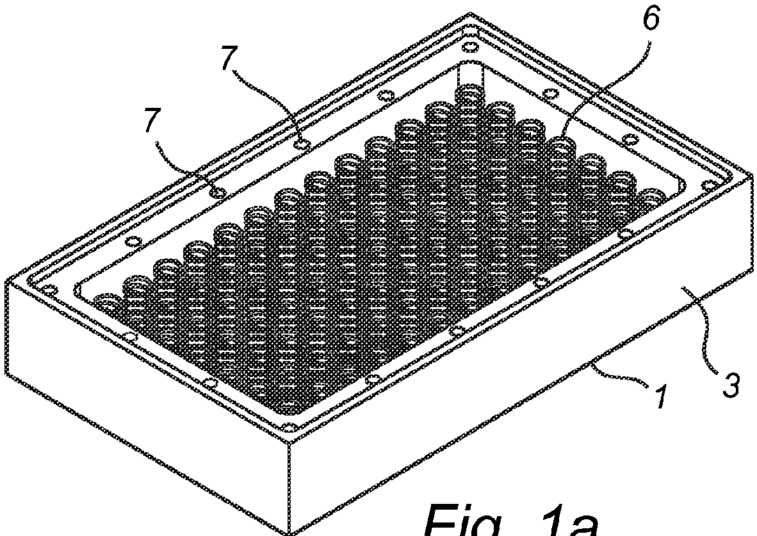

Fig. 1a

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Description

Field of the invention

[0001] The present invention represents a new way of packaging passive and active microwave circuits, and in particular circuits involving microstrip transmission lines and similar substrate bound transmission lines, in such a way that the problem associated with cavity mode resonances are avoided.

Background

[0002] Electronic circuits are today used in almost all products, and in particular in products related to transfer of information. Such transfer of information can be done along wires and cables at low frequencies (e.g. wire-bound telephony), or wireless through air at higher frequencies using radio waves both for reception of e.g. broadcasted audio and TV, and for two-way communication such as in mobile telephony. In the latter high frequency cases both high and low frequency transmission lines and circuits are used to realize the needed hardware. The high frequency components are used to transmit and receive the radio waves, whereas the low frequency circuits are used for modulating the sound or video information on the radio waves, and for the corresponding demodulation. Thus, both low and high frequency circuits are needed.

[0003] Electronic circuits below typically 300 MHz (i.e. wavelengths longer than 1 meter) are easily realized in printed circuit boards (PCB) and in integrated circuits using designs based on concentrated circuit elements such as resistors, inductors, capacitors and transistor amplifiers. Such technology may also work at higher frequency, but the performance degrades gradually when the size of the PCB and integrated circuit package become comparable to a wavelength. When this happens, it is better to realize the circuits by connecting together in various ways pieces of transmission lines or waveguides, such as e.g. microstrip lines of coplanar waveguides. This is normally referred to as microwave technology and is commonly in use between 300 MHz and 30 GHz, i.e. the microwave region. The corresponding electronic circuits can therefore be referred to as microwave circuits, and they are often located on a planar dielectric substrate with a metal ground plane. We will herein refer to such microwave circuit on a substrate with a ground plane as a microwave circuit board.

[0004] Both passive and active electronics circuits often need to be packaged in a shielded environment such as a closed metal cavity, e.g. a metal box, for mechanical protection, but also to satisfy requirements to electromagnetic compatibility such as radiated emissions and susceptibility. Such requirements are often regulatory (for commercial devices), but can also be user-defined (such as for radio telescopes). Packaging is difficult in the microwave region, because the volume inside the packaging cavity may be large enough to support resonant modes within the frequency range of the microwave circuits, and, if such modal resonances are present, they will completely destroy the operation of the electronic circuit. Such destruction may appear not only at the frequency of the resonance, but even below and above this band due to nonlinearity and saturation effects in the circuits. There is therefore a need for an improved technical solution to this packaging problem.

[0005] There are already existing solutions to the packaging problem, such as reducing the size of the cavity volume and loading the cavity with microwave absorbers. However, the size reduction may not always be possible due to the given size of the circuit board. E. g., the enclosing cavity needs to have at least two dimensions (height and width) smaller than typically 0.5 wavelengths in order to be sure to avoid cavity resonances. The requirement may become even stronger if the substrate of the circuit board has high permittivity or is thick. Also, absorbers inside the cavity may cause undesired losses and therefore reduced performance of the microwave circuit. There is therefore a need for an alternative packaging solution that is easy to apply also when the circuit boards and correspondingly the enclosing cavities are wider than 0.5 wavelengths, and which does not require use of any absorbing material.

[0006] P.-S. Kildal disclosed in the application WO 2010/003808 a new way of realizing microwave devices, such as electromagnetic transmission lines, waveguides and circuits of them, that is advantageous when the frequency is so high that existing transmission lines and waveguides have too large losses or cannot be manufactured cost-effectively with the tolerances required. The microwave devices are realized by a narrow gap between two parallel surfaces of conducting material, by using a texture or multilayer structure on one of the surfaces. The fields are mainly present inside the gap, and not in the texture or layer structure itself, so the losses are small. The microwave device further comprises one or more conducting elements, such as a metal ridge or a groove in one of the two surfaces, or a metal strip located in a multilayer structure between the two surfaces. The waves propagate along the conducting elements. No metal connections between the two metal surfaces are needed. At least one of the surfaces is provided with means, such as a bed of posts/nails, to prohibit the waves from propagating in other directions between them than along the ridge, groove or strip,

[0007] WO 2010/003808 describes how at least one of two parallel metal plates can be provided with means that stop wave propagation in the gap between the two surfaces, which may be used as a packaging solution. In particular, the bed of posts/posts disclosed in WO 2010/003808 has been demonstrated to be very useful, as described in "Parallel Plate Cavity Mode Suppression in Microstrip Circuit Packages Using a Lid of Posts", by E. Rajo-Iglesias, A. U. Zaman and P-S. Kildal, IEEE Microwave and Wireless Components Letters, Vol. 20, No.

1, January 2010. However, when this technique is applied at frequencies typically below 10 GHz, the packaged microwave device becomes large and bulky because the height of the posts needs to be close to a quarter of a wavelength. Therefore, there is a need for a thinner and more compact solution, still providing low loss and a large stopband for cavity resonances.

[0008] Kildal describes also in WO 2010/003808 how wave propagation between two parallel metal plates can be stopped by using a multilayer structure on one of the surfaces, where the posts/posts are replaced by an EBG surface in the form of metal patches. These form a periodic pattern in two directions along the lower surface..". However, such multilayer surfaces are relatively expensive to realize. There is therefore a need for a more cost-efficient solution.

Summary of the invention

[0009] The object of the present invention is to provide a compact and cost-efficient way of packaging passive and active microwave circuits that removes or at least strongly reduces problems related to resonances in the cavity inside which the circuit board is located.

[0010] This object is achieved by means of a microwave circuit package including at least one curved post/ nail as defined in the appended claims.

[0011] According to a first aspect of the present invention there is provided passive or active microwave circuit package, comprising: two conducting surfaces forming a gap therebetween; and a microwave circuit located on a microwave substrate with a ground plane and comprising one or more sections of one or more different transmission lines, e.g. microstrip lines or coplanar waveguides;

wherein said microwave circuit is enclosed in the gap between said two conducting surfaces, where one of the surfaces may be formed by the ground plane of the microwave circuit board or an extension of this,

wherein at least one of the surfaces is provided with at least one conducting element in the form of a curved post of conducting material rising from and being attached to the conducting surface in such a way that wave propagation inside the gap between the two surfaces is stopped, at least at the frequency of operation, and

wherein said curved post has on at least part of its extension a helical configuration.

[0012] Preferably, there is provided a plurality of curved posts having at least partly a helical configuration.

[0013] The invention is in particular useable for packaging of microstrip circuits, but it is not limited to this. According to the invention, there is provided a metal cavity with conducting walls, e.g. of metal, that encloses the microwave circuit board, where the ground plane of the microwave circuit board may form at least part of one of the larger walls of the cavity. At least one of the two larger opposing surfaces of the cavity is provided with conducting posts, e.g. of metal, curved in a helical configuration and preferably located in a periodic or nearly-periodic grid over at least part of the surface. The posts are preferably arranged in such a way that there is a narrow or no gap between the ends of the curved posts and the microwave circuits, and in such a way that the posts do not mechanically touch the conducting parts of the transmission lines on the microwave circuit board. Thus, the curved posts may be connected only to one of said surfaces each in such a way that the curved posts on either of the surfaces are facing a smooth part of the opposite conducting surface, and preferably the surface not carrying the transmission line. The other end of the posts may form a gap to the other surface. Alternatively, the other end may be touching a dielectric parts of the microwave circuit board, or be touching the ground plane of the microwave circuit board.

[0014] The microwave circuit packaging solution of the present invention provides a very efficient remedy to the above-discussed problem with resonant modes experienced in many prior art packaging solutions. Further, the present invention provides an alternative packaging solution that is easy to apply also when the circuit boards and correspondingly the enclosing cavities are wider than 0.5 wavelengths, and it does not require use of any absorbing material. Still further, the microwave circuit package of the present invention is relatively simple and cost-efficient to realize, and e.g. more cost-efficient than EBG surfaces. The present invention represents a new, way of packaging passive and active microwave circuits, and in particular circuits involving microstrip transmission lines and similar substrate bound transmission lines. The two surfaces may form the bottom and lid of a cavity with conducting sidewalls. The posts, preferably arranged in a periodic grid, creates together with the ground plane of the microwave circuit board, or together with the smooth metal plane below the microwave circuit board, a stopband for waves propagating between the lid of posts and the ground plane. Thereby, cavity resonances are avoided or suppressed that otherwise create a big problem associated with the packaging in metal boxes with smooth metal walls.

[0015] The smooth surface of the present invention may together with the conducting lines on the microwave circuit board work as a waveguide or waveguide circuit, similar to embodiments disclosed in WO 2010/003808, said document hereby incorporated by reference. Therefore, the present invention is to be considered as a specific realization of the more general invention described in WO 2010/003808, wherein the present invention provides a new realization which is particularly advantageous at low frequencies, such as in an operation frequency range of 100 MHz to 30 GHz, and preferably within the range 500 MHz to 10 GHz, and most preferably within the range 1-10 GHz.

[0016] The curved posts of the present inventions have, at least partly, a helical configuration. This is a way to reduce the effective length of the posts at the same time as their electrical function that stops wave propagation between the two plates is maintained. Therefore, they will also prevent cavity mode resonances. Compared to straight posts, the height of curved posts having at least partly a helical configuration can be 3-10 times shorter in effective length, thus resulting in a significantly more compact packaged microwave circuit. The period of the helical configuration can be sub-wavelength.

[0017] By curved posts in "helical configuration" is in the present application meant a helix or coil shape, continuously forming a number of turns. Preferably, the turns are arranged as concentric rings, but other configurations are feasible as well. For example, the turns need not be circular, but may have other forms, such as an oval shape, a square or hexagonal shape, an octagonal shape, or the like. Preferably, the helical configuration forms a curve that lies on or abuts a cylinder or cone, at a constant angle to the line segments making up the surface. However, the angle need not necessarily be constant, and further, other shapes than cylinders and cones are feasible, such as the shape of an hourglass or a barrel, and even flat spirals on a dielectric substrate. Such flat spirals are preferably connected to the surface by means of vertical posts, e.g. connected to the center of the spirals. The shape of the helical configuration, the total height, the diameter of the turns, the thickness of the wire, the number of turns, the angle of the turns, the distance between the posts and the opposite surface, etc. are all parameters that may be modified for optimization of the posts for particular use situations. For example, an increased number of turns, corresponding to an increased electrical length, will move the frequency band inside which cavity mode resonances are avoided to lower frequencies. Similarly, a larger diameter shifts also the stopband down in frequency, corresponding to an increased wire length, and the relative size of the stop band is not much affected.

[0018] In one embodiment, each curved post is ending in a turn with a smaller inclination angle than the rest of the turns, and preferably ends in an essentially flat ring. The end turns/rings are preferably essentially parallel to the opposing surface. In this embodiment the ends of the curved posts define a more unique spacing to the opposite smooth surface than a pointed open-ended curved post.

[0019] The helical configuration may also be wound around a dielectric rod or similar, or surrounded by dielectric material e.g. foam, both of which will provide good mechanical support.

[0020] Preferably, the number of turns of the helical configuration is within the range 2-20, and preferably 3-15 and most preferably 4-10.

[0021] Further, the curved posts preferably have conductive contact only to one of said surfaces, leaving a gap towards the other surface inside which the microwave circuit board is located.

[0022] The curved posts comprise a first part connected to one of said surfaces that may have a relatively straight configuration, and a second part having the helical configuration. The provision of such a part with a relatively straight configuration may make production and assembly easier. Further, the height of this relatively straight part is part of the length of the wire, and an increase/reduction will contribute to reduce/increase the frequencies at which the stop band occurs. However, it is also feasible to use posts entirely being of a helical configuration.

[0023] The diameter of the turns of the helical configuration is preferably within the range 10-50% of the axial height of the part having the helical configuration, and preferably within the range 20-40%.

[0024] The gap inside which the microwave circuit board is located is preferably filled with air, gas or vacuum. However, it is also feasible to have the gap filled with a dielectric material. The curved posts of the present invention can also be surrounded by dielectric material preferable in the form of a foam, or wound around dielectric rods, both providing mechanical support for the curved posts that therefore can be made thinner such as e.g. by the soft copper wires used to wind inductive coils for low frequency circuits.

[0025] The two surfaces may be connected together for rigidity by a mechanical structure defining the sidewalls of the cavity. The sidewalls may be arranged on all the sides, thereby entirely enclosing the cavity, or along only some sides, leaving at least one opening on the sides. Alternatively, it is possible to use an open solution without sidewalls.

[0026] The two surfaces may be essentially planar. However, it is also feasible that at least part of the two surfaces are curved in the same way so that the gap between them is kept is so small that wave propagation inside the gap is stopped.

[0027] The microwave circuit boards enclosed between the two surfaces of the present invention may comprise one or more components such as power amplifiers, low noise amplifiers, ICs, MMICs, filters, matching networks, power dividers and combiners, couplers, antennas and so on.

[0028] The basic geometry of a microwave circuit package in accordance with the present invention comprises two parallel conducting surfaces forming the two larger walls of a cavity. These surfaces can be the surfaces of two metal bulks, but they can also be made of other types of materials having a metalized surface. They can also be made of other materials with good electric conductivity. One of the surfaces is provided with the curved posts. The two surfaces can be plane or curved, but they are in both cases separated by a very small distance, a gap, between the end of the curved posts the other plate, inside which the microwave circuits are located. The curved posts prohibit wave propagation inside the gap, in such a way that cavity resonances are avoided.

[0029] According to another aspect of the invention there is provided a method of packaging a passive or active microwave circuit, comprising the steps:

enclosing a microwave circuit located on a microwave substrate with a ground plane and comprising one or more sections of one or more different transmission lines, e.g. microstrip lines or coplanar waveguides, in the gap between two conducting surfaces, where one of the surfaces may be formed by the ground plane of the microwave circuit board or an extension of this,

providing at least one of the surfaces with at least one conducting element in the form of a curved post of conducting material rising from and being attached to the conducting surface in such a way that wave propagation inside the gap between the two surfaces is stopped, at least at the frequency of operation, said curved post having on at least part of its extension a helical configuration.

Drawings

[0030]

Figure 1 shows a sketch of an example of a microwave circuit that is packaged by using a lid of curved posts of helical forms, according to the invention. The larger upper surface, i.e. the lid of helical posts/nails, is shown up-side-down as a bed of posts/nails in Figure 1a, the microstrip circuit board is shown in Figure 1c, and the microstrip circuit board is shown upside down as located on top of the bed of posts/nails in Figure 1b, thereby together forming a metal cavity where the cavity resonances are avoided by the curved helical posts according to the invention. Figure 1d shows a detail of the lid of helical posts.

Figures 2 and 3 show cross sections of the example in Figure 1 when the microstrip line is a so-called inverted or suspended microstrip line.

Figure 3 illustrates a packaged microwave circuit similar to the ones illustrated in Figs. 1-2, but with the metal walls of the cavity removed.

Figures 4a, b, c, d, e, f, g and h show different embodiments of the curved posts in helical configuration according to the invention. Figs 4a-d are side-views, whereas Fig. 4e-g are top-views, Fig 4h is a perspective view, and Fig 4i is a sideview.

Detailed description of the figures

[0031] Figure 1 shows a sketch of an example of a microwave circuit that is packaged by using a lid of curved posts of helical forms, according to the invention.

[0032] There are two metal pieces providing the upper 1 and lower 2 conducting surfaces. The lower surface 2 is preferably essentially smooth, and formed by a ground plane 2 on which a microstrip transmission line 5 is arranged. Connectors 9 are arranged on the side of the plane 2 opposite to said transmission line, and connected to the microstrip transmission line through the plane 2.

[0033] The upper surface 1 is provided with a surrounding rim 3 to which the upper surface can be mounted, and comprises a region which is lower than the rim and thereby provides a gap 4 between the upper and lower surfaces when assembled. The gap 4 is air-filled, but it can also be fully or partly filled with dielectric material.

[0034] The larger upper surface 1 comprises a bed of curved posts 6 comprising, at least partly, a helical configuration. The posts are preferably equidistantly and evenly distributed over the surface. In Fig. 1a the lid of helical posts is shown up-side-down as a bed of posts. The posts 6 provide cut-off conditions for all waves propagating between the lower and upper surfaces except the desired waves along the transmission line 5. The posts work similar to a PMC within the operating frequency band.

[0035] The rim 3 is preferably arranged to extend to a height exceeding the height of the posts.

[0036] The microstrip circuit board is shown in Figure 1c, and the microstrip circuit board is shown upside down as located on top of the bed of posts/nails in Figure 1b, thereby together forming a metal cavity where the cavity resonances are avoided by the curved helical posts according to the invention. The upper and lower surfaces may be connected to each other by bolting. To this end, screw holes 8 may be arranged at the boundary of the lower upper metal plane, to be used to fix it to the metal rim 3 of the upper metal piece, and there are matching screw holes 7 in this rim.

[0037] Figure 1d shows a detail of the lid of helical posts.

[0038] The microwave circuit of Fig 1 is a microstrip line with two 90 deg bends, and the ground plane of the circuit is used as the opposing larger wall of the enclosing cavity. This microwave circuit is too simple to have any special electronic function, and it is here shown only to demonstrate the packaging principle. It is actually the same type of microwave circuit that was used to demonstrate packaging by a lid of straight posts/nails in "Parallel Plate Cavity Mode Suppression in Microstrip Circuit Packages Using a Lid of Posts", by E. Rajo-Iglesias, A. U. Zaman and P-S. Kildal, IEEE Microwave and Wireless Components Letters, Vol. 20, No. 1, January 2010, and here similar properties are obtained in a significantly more compact realization.

[0039] This package can be used for packaging many conventional circuits to form microwave device of the type discussed above. The package component may typically have a length of about 10 cm, a width of about 5-6 cm. The posts may typically be arranged in even rows and columns. The distances between each row and between each column are preferably about the same. This distance is typically, from center to center of the adjacent posts, 7.5 mm.

[0040] Figures 2 and 3 show cross sections of the example similar to the one in Figure 1, where the microstrip line 5 forms a so-called inverted or suspended microstrip line. The transmission line is here supported by a thin substrate layer 10 located on the top of the posts 6. The space 11 between the posts may e.g. be air-filled, or filled with a dielectric, such as a foam. Such lines have the transmission line fields in an air gap, instead of in the dielectric substrate, and the substrate is only used to mechanically support the microstrip line 5 at distance from helical-shaped curved posts 6 according to the invention, and at distance from the other smooth metal surface acting as a ground plane 2 for the microstrip line. Figure 3 is used to illustrate that the metal walls 3 of the cavity actually can be removed. The curved posts 6 will still stop waves from propagating between the two plates according to the invention.

[0041] Figures 4 a-h show different embodiments of the curved posts in helical configuration according to embodiments of the invention.

[0042] The posts may have an entirely helical configuration. Such a post is illustrated in Fig 4a. This post, having an entirely helical configuration may typically have about 10 turns, and a height of about 15 mm. However, alternative configurations are possible as well.

[0043] Fig. 4b illustrates an example of a post having a first part having a straight configuration with a height L, and a second part with a helical configuration. The total height of the post is H, and a gap between the post and the opposite surface is g. The diameter of the turns of the helical part is D. In an exemplary configuration, g is 2 mm, H is 37 mm, D is 10.5 mm and L is 9 mm. The number of turns is in this example 6. With these dimensions, a wide stop band is created when used between the parallel plates, from 0.55 GHz to 1.41 GHz. However, all of these parameters may be adjusted for optimization of the posts for the intended frequency of operation and the intended application of the microwave device. For example, the posts can be made even more compact if required, by increasing the number of turns.

[0044] Fig 4c-d illustrates helical configurations similar to the one discussed with relation to Fig 4a, but where the general shape of the helical configuration is in the form of a cone (Fig 4c), with the diameters of the turns increasing from one end to the other, and in the form of a barrel (Fig 4d), with the diameters of the turns decreasing from the middle towards both ends, instead of the generally cylindrical shape illustrated in Fig 4a.

[0045] The turns of the helical configurations illustrated in Figs. 4a-d are generally circular, as seen from above. However, alternatively the turns may be arranged in other forms. For example, the turns may have a rectangular or square shape, as illustrated in Fig 4f, or have a hexagonal shape, as illustrated in Fig 4g, or an octagonal shape, as illustrated in Fig 4e.

[0046] The posts having a helical configuration may also be realized as flat spirals on a dielectric substrate, as illustrated in Fig 4h.

[0047] In yet another embodiment, illustrated in Fig 4i, the curved post is ending in a turn with a smaller inclination angle than the rest of the turns, and preferably ends in an essentially flat ring. The upper turn is hereby preferably essentially parallel to the opposing surface. In this embodiment the ends of the curved posts define a more unique spacing to the opposite smooth surface than a pointed open-ended curved post.

[0048] The shape of the helical configuration, the total height, the diameter of the turns, the thickness of the wire, the number of turns, the angle of the turns, the distance between the posts and the opposite surface, etc. are all parameters that may be modified for optimization of the posts for particular use situations.

[0049] The invention is not limited to the embodiments shown here. In particular, the invention can be located inside the package of an IC or in the multiple layers on an IC chip. Also, at least one of the conducting surfaces may be provided with penetrating probes, apertures, slots or similar elements through which waves are radiated or being coupled to exterior circuits. Further, the helical configuration of the curved posts may be arranged in many different shapes, as discussed above. Further, the posts may be arranged on either one of the two surfaces, or even on both surfaces. Further, the two surfaces may be connected in various ways, and the cavity need not be closed, but may be open at one or several sides.

Claims

1. A passive or active microwave circuit package, comprising:

   two conducting surfaces forming a gap therebetween; and
   a microwave circuit located on a microwave substrate with a ground plane and comprising one or more sections of one or more different transmission lines, e.g. microstrip lines or coplanar waveguides,
   wherein said microwave circuit is enclosed in the gap between said two conducting surfaces, where one of the surfaces may be formed by the ground plane of the microwave circuit board or an extension of this,
   wherein at least one of the surfaces is provided with at least one conducting element in the form of a curved post of conducting material rising from and being attached to the conducting surface in such a way that wave propagation inside the gap between the two surfaces is stopped, at least at the frequency of operation, and
   wherein said curved post has on at least part of its extension a helical configuration.

2. The microwave circuit package according to claim 1, wherein the two surfaces are connected to each other by vertical walls so that a shielded cavity is formed inside which the microwave circuits are located.

3. The microwave circuit package according to claim 1 or 2, wherein the curved posts are connected only to one of said surfaces, leaving a gap towards the other surface.

4. The microwave circuit package according to claim 3, wherein the curved posts comprise a first part connected to one of said surfaces and having a relatively straight configuration, and a second part having the helical configuration.

5. The microwave circuit package according to claim 4, wherein the curved posts are mounted in cavities in one of said surfaces in such a way that they are rising from the surface with their helical configuration.

6. The microwave circuit package according to any of the previous claims, wherein the gap is filled with air, gas or vacuum.

7. The microwave circuit package according to any of the previous claims, wherein the gap is filled fully or partly with dielectric material.

8. The microwave circuit package according to any of the previous claims, wherein the curved posts are wound on dielectric rods.

9. The microwave circuit package according to any of the previous claims, wherein each of the curved posts are ending in a turn with smaller inclination angle than the rest of the turns, and preferably ends in an essentially flat ring.

10. The microwave circuit package according to any of the previous claims, wherein the curved posts are connected only to one of said surfaces, and the other end is touching a dielectric parts of the microwave circuit board.

11. The microwave circuit package according to any of the previous claims, wherein the curved posts are connected only to one of said surfaces, and the other end is touching the ground plane of the microwave circuit board.

12. The microwave circuit package according to any of the previous claims, wherein the curved posts are realized as flat spirals with a vertical part connected to said surface.

13. The microwave circuit package according to any of the previous claims, wherein the curved posts are embedded in or on a dielectric material, e.g. a foam material.

14. The microwave circuit package according to any one of the preceding claims, wherein a plurality of curved posts are provided, and arranged in a periodic or nearly-period grid over at least part of said surface.

15. The microwave circuit package according to any one of the preceding claims, wherein the microwave circuit has a frequency of operation within the range 100 MHz - 30 GHz, and preferably within the range 500 MHz to 10 GHz, and most preferably within the range 1 - 10 GHz.

16. A method of packaging a passive or active microwave circuit, comprising the steps:

enclosing a microwave circuit located on a microwave substrate with a ground plane and comprising one or more sections of one or more different transmission lines, e.g. microstrip lines or coplanar waveguides, in the gap between two conducting surfaces, where one of the surfaces may be formed by the ground plane of the microwave circuit board or an extension of this,
providing at least one of the surfaces with at least one conducting element in the form of a curved post of conducting material rising from and being attached to the conducting surface in such a way that wave propagation inside the gap between the two surfaces is stopped, at least at the frequency of operation, said curved post having on at least part of its extension a helical configuration.

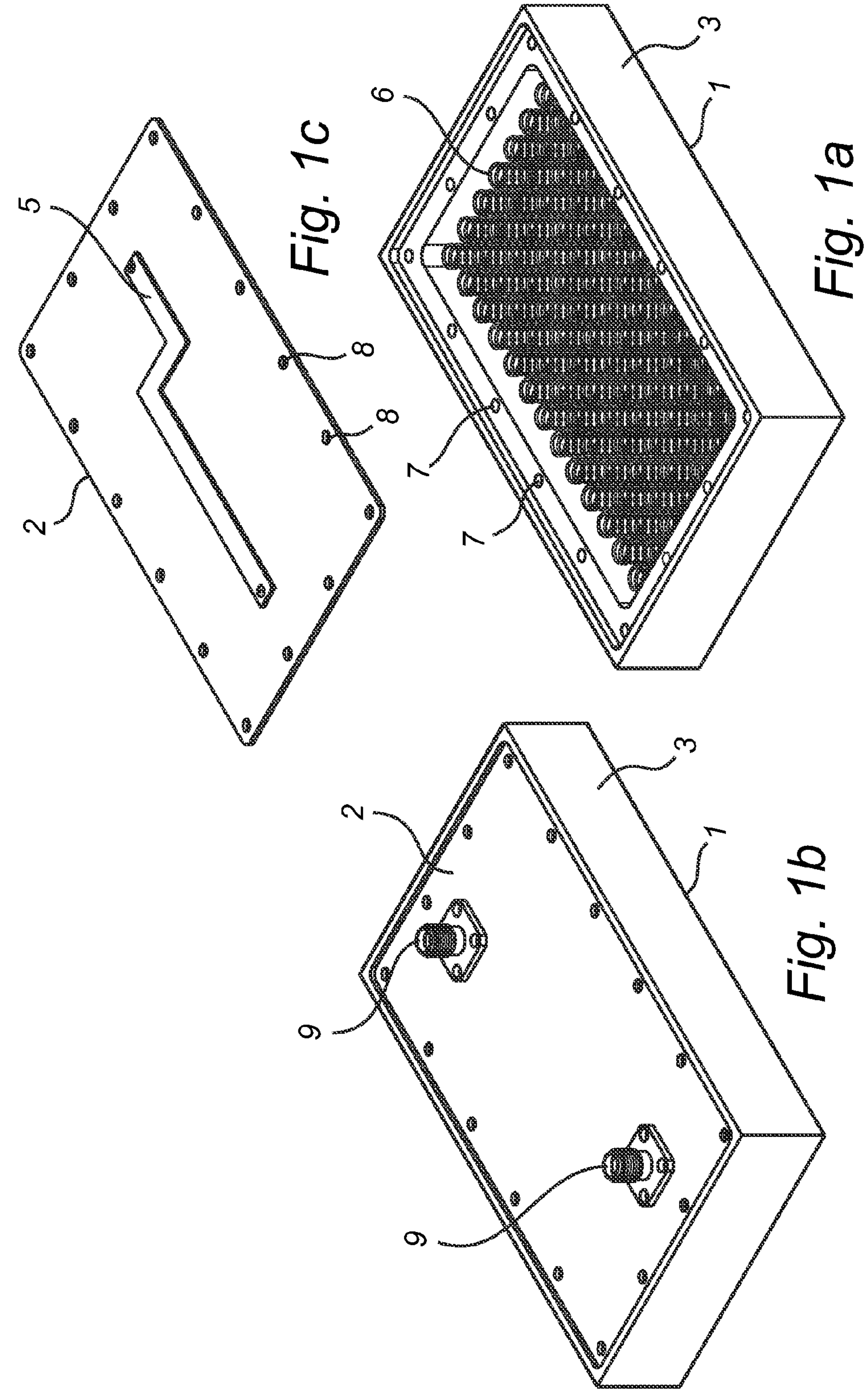

Fig. 1a

Fig. 1b

Fig. 1c

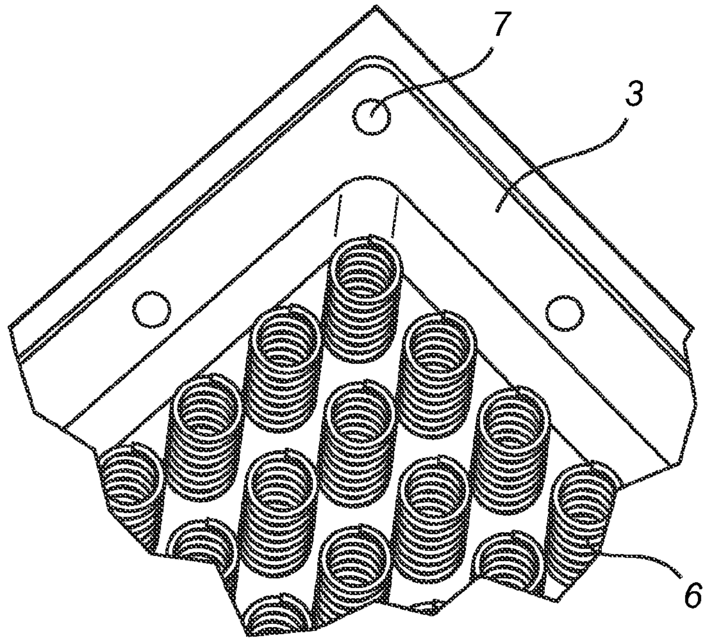

Fig. 1d

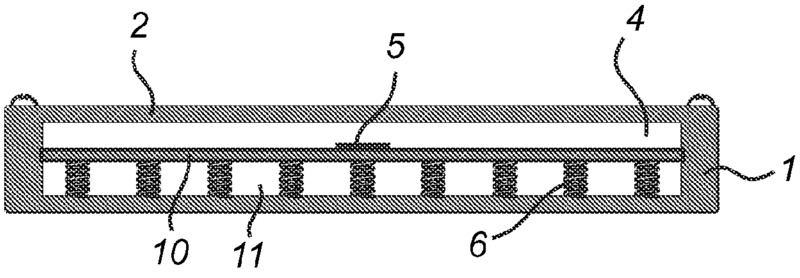

Fig. 2

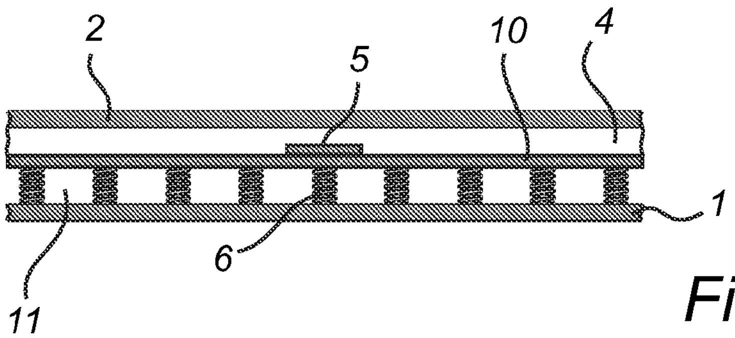

Fig. 3

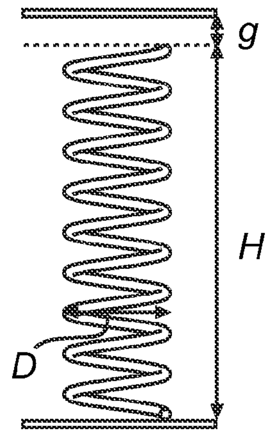

Fig. 4a

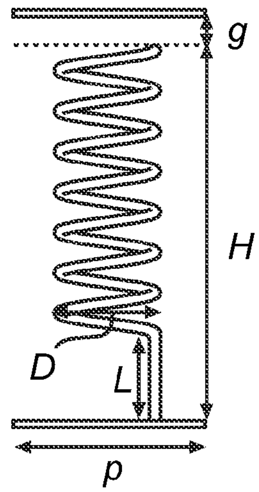

Fig. 4b

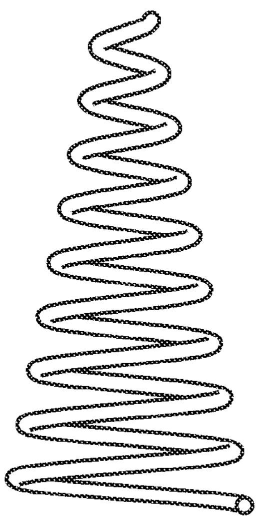

Fig. 4c

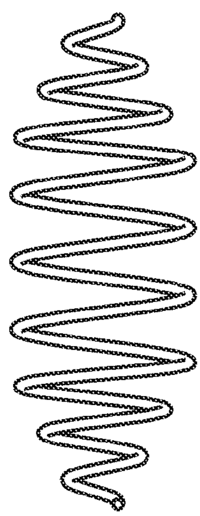

Fig. 4d

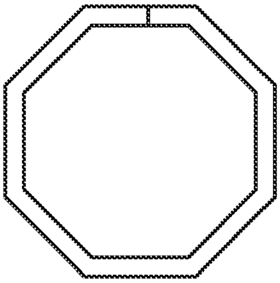

Fig. 4e

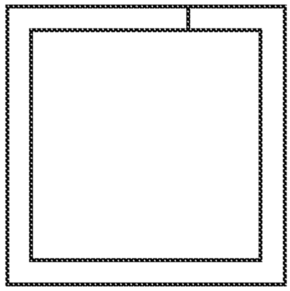

Fig. 4f

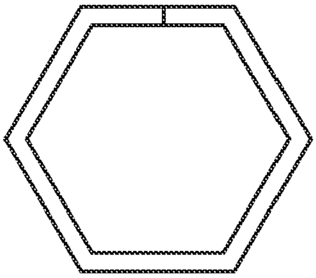

Fig. 4g

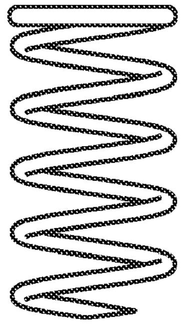

Fig. 4i

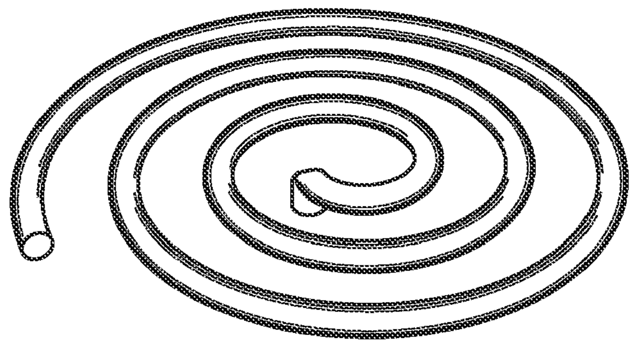

Fig. 4h

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 3740

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	KAMGAING T ET AL: "Design and Modeling of High-Impedance Electromagnetic Surfaces for Switching Noise Suppression in Power Planes" IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY, IEEE SERVICE CENTER, NEW YORK, NY, US LNKD- DOI:10.1109/TEMC.2005.850692, vol. 47, no. 3, 1 August 2005 (2005-08-01), pages 479-489, XP011140260 ISSN: 0018-9375 * page 480, left-hand column, lines 10-34 * * page 484, right-hand column, line 1 - page 485, left-hand column, line 14; figures 1,5,15,16 * -----	1,3,4,6, 7,12-16	INV. H01P1/16
A	EP 1 763 101 A1 (MURATA MANUFACTURING CO [JP]) 14 March 2007 (2007-03-14) * the whole document * -----	1,16	
A	GB 2 373 102 A (MARCONI CASWELL LTD [GB]; MARCONI OPTICAL COMPONENTS LTD [GB]) 11 September 2002 (2002-09-11) * page 1, lines 1-22 * * page 7, lines 5-21; figures 1,2,7 * -----	1	TECHNICAL FIELDS SEARCHED (IPC) H01P H01L H01Q H05K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 September 2010	Den Otter, Adrianus

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CATEGORY OF CITED DOCUMENTS

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16-09-2010

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