(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 863 114 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.12.2007 Bulletin 2007/49

(51) Int Cl.:
H01P 3/12 *(2006.01)* ***H05B 6/76*** *(2006.01)*

(21) Application number: **06011391.7**

(22) Date of filing: **01.06.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(71) Applicants:
- **BSH Bosch und Siemens Hausgeräte GmbH**
  81739 München (DE)
- **Eidgenössische Technische Hochschule Zürich**
  8092 Zürich (CH)

(72) Inventors:
- **Vahldieck, Rüdiger Prof.**
  6300 Zug (CH)
- **Gimersky, Martin Dr.**
  8004 Zürich (CH)
- **Mishrikey, Matthew**
  8002 Zürich (CH)

(54) **Electromagnetic bandgap seal for microwave energy**

(57) A sealing system for blocking or attenuating microwave energy (14) between two environments or regions of space (1, 2) includes an electromagnetic bandgap (EBG) seal (20) mounted within an opening (3) in the partition (4) that separates the two environments or regions of space (1, 2) from each other. The EBG seal (20) consists of an EBG structure (21) secured to one side of the opening (3), an electrically conducting surface (12) secured to the other side of the opening, and a dielectric volume (11) between the EBG structure (21) and the electrically conducting surface (12). Transmission spectral response of the EBG seal (20) features one or more distinct stop bands (bandgaps), as shown in Fig. 1 B, that the seal (20) operates in.

Said EBG structure especially refers to any metall-odielectric structure with substantially periodic metallization and featuring inherent frequency bands where propagation of electromagnetic energy is forbidden and allowed. Typical EBG structure may consist of substantially periodically-spaced electrically conducting patches (31) placed on, or embedded in, a dielectric layer (32) that is backed by an electrically conducting surface (33). The electrically conducting patches (31) may be connected to the electrically conducting surface by electrically conducting posts (34).

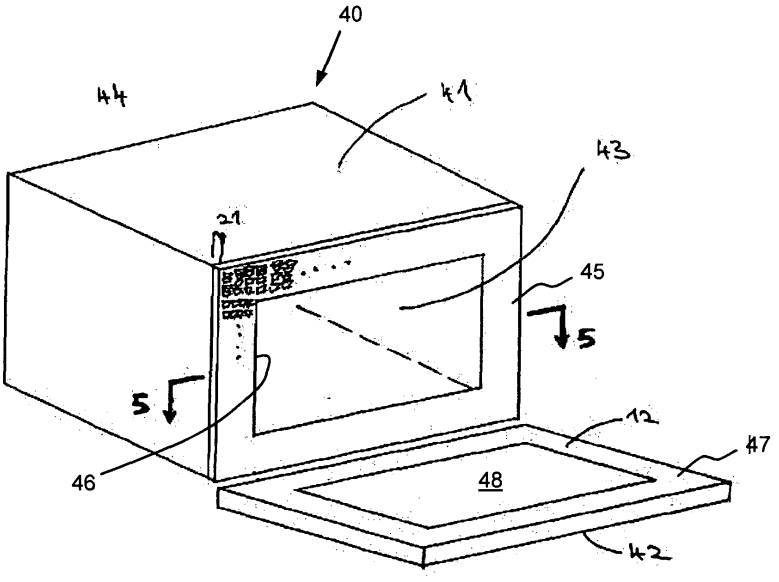


Fig. 4

EP 1 863 114 A1

Description

FIELD OF THE INVENTION,

[0001] The present invention relates to seals for microwave energy in general and in particular to such seals in the field of microwave heating and/or drying devices.

BACKGROUND OF THE INVENTION

[0002] Containment - and the necessary sealing or attenuating - of microwave energy is important for many reasons, including safety of people and electromagnetic interference with assorted electronic devices.

[0003] Conventional seals for microwave energy typically rely on a quarter-wavedeep electromagnetic choke. The choke functions so as to yield near-cancellation of electromagnetic energy in the immediate vicinity of the choke's aperture, in a narrow frequency band centered around the frequency where the choke's depth is one quarter wavelength. Also, in order to further improve the performance of the seal structure (by reducing the induced standing wave along the choke structure), a plurality of slits is usually provided along the choke. The choke and slit dimensions are determined by the required electrical performance and typically are such that the choke is bulky, heavy, aesthetically not pleasing and not amenable to cleaning.

[0004] Another group of conventional seals for microwave energy uses absorbers of microwave energy. Voltage absorbers, in order to be effective, have depths comparable to one half wave length; as a result they are physically large at microwave frequencies. Current absorbers, on the other hand, can be low in profile; however, they are based on ferrite matrices and as such are heavy and oftentimes also brittle. Moreover, as all absorber seals absorb the incident electromagnetic energy, their utility is invariably limited to low-power applications only.

[0005] U.S. Patent No. 6,825,741 B2, granted on November 30, 2004 to Chappell et al., discloses planar filters built on periodic electromagnetic bandgap substrates. The filters include resonant cavities in the electromagnetic bandgap substrates and external lines extending through the substrate lattice. This makes the filters suitable for feeding the signal in and out by transmission lines only.

OBJECTS OF THE INVENTION

[0006] It is therefore a general object of the present invention to provide a microwave seal that obviates at least some of the above-noted disadvantages.

[0007] Another object of the present invention is to provide a microwave seal that is easy to integrate.

[0008] A further object of the present invention is to provide a microwave seal that is fully scalable.

[0009] Yet another object of the present invention is to provide a microwave seal easily adaptable to microwave devices of various physical sizes, shapes and power ratings.

[0010] Still another object of the present invention is to provide a microwave seal having a low profile.

[0011] Another object of the present invention is to provide a microwave seal, having a simple, smooth and closed surface.

[0012] A further object of the present invention is to provide a microwave seal that is easy to clean.

[0013] Other objects and advantages of the present invention will become apparent from a careful reading of the detailed description provided herein, within appropriate reference to the accompanying drawings.

SUMMARY OF THE INVENTION

[0014] According to a first aspect of the present invention, there is provided a seal for blocking or attenuating microwave energy between two environments or regions of space, said seal comprises:

- an electromagnetic bandgap structure secured to one side of an opening in a partition that separates the two environments (e.g., humid / dry) or regions of space (e.g., inside / outside) from each other;
- an electrically conducting surface secured to the other side of the opening; and
- a dielectric volume between the electromagnetic bandgap structure and the electrically conducting surface. The dielectric volume may be any suitable dielectric like, e. g., a dielectric volume comprising one or more dielectric materials, e. g. comprised of a mosaic of dielectric subvolumes (wherein some of the dielectric subvolumes may be made of different dielectric materials), a dielectric layer of a thin-film type or of a thick film type, or a combination of multiple dielectric layers, wherein the used dielectrics may be respectively homogeneous or inhomogeneous.

[0015] According to a second aspect of the present invention, there is provided a microwave oven utilizing the seal according to the first aspect of the invention.

[0016] Especially preferred embodiments arise, inter alia, from the subclaims as such or in any possible combination thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In the annexed schematic drawings, like reference characters indicate like elements throughout.

Figure 1A is a cross-section view of an indicative embodiment of a microwave seal according to the present invention;

Figure 1B indicates a transmission spectral response between regions of space (1, 2) for the struc-

ture of Figure 1A, as understood by one of ordinary skill in the art;

Figure 2 is a perspective illustration showing a sample electromagnetic bandgap structure that can be employed in the present invention, also as understood by one of ordinary skill in the art;

Figure 3 is a cross-section view taken along line 3-3 of Fig. 2;

Figure 4 is a perspective illustration showing the embodiment of Fig. 1 installed in a microwave oven with the oven door open;

Figure 5 is a cross-section view taken along line 5-5 of Fig. 4 when the oven door is closed (i.e., in operating position);

Figure 6 is a perspective illustration showing the embodiment of Fig. 1 alternatively installed in a microwave oven with the oven door open; and

Figure 7 is a cross-section view taken along line 7-7 of Fig. 6 when the oven door is closed (i.e., in operating position).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] With reference to the annexed drawings, the preferred embodiments and examples of the present invention will be herein described on the example of a microwave oven for indicative purposes only and by no means as of limitation.

[0019] Fig. 1A schematically shows a general sealing system for blocking or attenuating microwave energy 14 between two environments or regions of space 1, 2 that includes an electromagnetic bandgap (EBG) seal 20 mounted within an opening 3 of a partition 4 that separates the two environments or regions of space 1, 2 from each other. The EBG seal 20 consists of an EBG structure 21 secured to one side of the opening 3, an electrically conducting surface 12 secured to the other, opposing side of the opening, and a dielectric layer 11 between the EBG structure 21 and the electrically conducting surface 12.

[0020] The dielectric layer 11 can be made of any suitable material and may be dependent of the types of environment or materials within the regions of space 1, 2. Thus, for two air-filled regions 1, 2, the dielectric layer 11, or volume in general, may be air; for two regions 1, 2 immersed in fluid, it may be this fluid. Of course, also a solid dielectric can be used, e. g. as a coating.

[0021] Fig. 1 B shows a diagram of a transmission spectral response of an EBG structure in terms of the magnitude of the energy passing the microwave seal in terms of dB as a function of the frequency of the energy for microwave ovens. There exists a frequency band where the energy entering the EBG seal is strongly attenuated or blocked. The width of the frequency band, here of around 200 MHz, can be suitably adapted. For microwave seals, the width of this band gap can be set such that part or all of the relevant microwave energy is blocked or attenuated. The EBG structure in general can have more than one distinct bandgaps (stop bands). In general, the specific frequency and attenuation values can be adapted to special conditions and other applications. One structure realising this transmission spectral response is described in greater detail below.

[0022] In general, the described EBG structure refers to any metallodielectric structure with substantially periodic metallization and featuring inherent frequency bands where propagation of electromagnetic energy is forbidden and allowed. Such an EBG structure is specially suitable for microwave seals and may be referred to as "patch-and-post" structure or "mushroom" structure. Similarly, other basic EBG structures may be used instead.

[0023] Now referring to Figs. 2 and 3, a typical EBG structure 21 may consist of substantially periodically-spaced electrically conducting patches 31 placed on, or embedded in, a dielectric layer 32 that is backed by an electrically conducting surface 33. The electrically conducting patches 31 may be connected to the electrically conducting surface by electrically conducting posts 34, thus forming a unit element 35.

[0024] The choice of material for the EBG structure's dielectric layer 32 depends on several factors, including:

- an operating temperature in the regions of space; for low-temperature environments (as found in some microwave ovens), common plastics, e.g., FR4, can be used, while high-temperature environments (such as found in microwave ovens with a pyrolytic self-cleaning function) require the use of materials with a higher temperature resistivity, preferably on the basis of glass or ceramics, e.g. silicon dioxide. Ultimately, air can be used as well;
- mechanical durability; the EBG seal should be resistant to chipping or cracking due to factors such as, on the example of microwave ovens, door impact or dropped cookware; brittle materials may be protected by coverings or silicon /rubber landing pads;
- sealing frequency; there is an inverse correlation between the EBG seal's stop-band frequency and the relative dielectric constant of the EBG structure's dielectric layer 32; a similarly designed seal employing a higher relative dielectric constant material for the EBG structure's dielectric layer 32 will seal at a lower frequency; and
- losses: if necessary, a lossy material may be used to accentuate the sealing behaviour of the EBG seal, e.g., glasses / ceramics doped with ferrite powder are one possibility for the material of the EBG structure's dielectric layer 32.

[0025] Indicative dimensions of the electrically conducting patches 31 with the EBG structure's dielectric layer 32 made of FR4 (relative dielectric constant 4.5) for a 200 MHz-wide stop band centered around 2.45 GHz are 14 x 14 mm when the EBG structure's dielectric layer 32 is 2-mm thick and 6.5 x 6.5 mm when the EBG structure's dielectric layer 32 is 10-mm thick. In both cases, the dielectric layer 11 is air 2 mm thick.

[0026] Standard printed-circuit-board printing techniques may be used for fabrication of the electrically conducting patches 31 when FR4 or some other plastics are used as the EBG structure's dielectric layer 32. Copper-plated holes or holes plated by conductive pastes can be used for the electrically conducting posts 34; rivets offer another manufacturing possibility for the electrically conducting posts 34. Alternatively, thumbtack-like structures combining the electrically conducting patches 31 with the electrically conducting posts 34 can be inserted into a molten dielectric that, upon hardening/curing, will serve as the EBG structure's dielectric layer 32; the electrically conducting surface 33 with prefabricated holes can be attached/soldered thereafter.

[0027] A technique that can be used to facilitate manufacture consists of relocating the electrically conducting posts 34 from the centers to the edges of the electrically conducting patches 31; this way, the electrically conducting posts 34 and the electrically conducting patches 31 can be manufactured as combined units, by stamping or cutting metal sheets, then folded (to provide the 90° angle between the electrically conducting posts' 34 parts and the electrically conducting patches' 31 parts of the combined units), inserted into prefabricated holes in the EBG structure's dielectric layer 32 and finally the end points of the electrically conducting posts 34 are folded over the electrically conducting surface 33. Connections between the electrically conducting posts 34 and the electrically conducting surface 33 can be ensured by conventional joining / welding techniques if care is taken to protect the EBG structure's dielectric layer 32. Yet another manufacturing possibility for the EBG seal 20 includes using a grid of metal rods to form a piece of glass with holes in it, allowing the glass to solidify, removing the grid from the glass and adding the metallic substructure of the EBG seal 20 (the electrically conducting surface 33, the electrically conducting patches 31 and the electrically conducting posts 34).

[0028] Referring now to Figs. 4 to 7, there are shown two embodiments of a microwave seal (system) 20 according to the present invention mounted in a generic household microwave oven 40, 60, i.e., a first embodiment in Figs. 4 and 5 and a second embodiment in Figs. 6 and 7. The microwave oven 40, 60 consists of an oven body 41 and an oven door 42. The oven body 41 and the oven door 42 enclose a heating chamber 43. Here, the oven body 41 comprises a substantially flat front side frame 45 (flange) that surrounds a loading port 46 to load and unload items into and from, resp., the heating chamber 43. The oven door 42 comprises a corresponding substantially flat frame 47 that surrounds a window 48 that is impenetrable to microwave radiation. For heating items within the heating chamber 43 by microwave energy, a microwave generator (not shown) is comprised by the oven 40. Typically, the oven 40 employs a safety means (not shown) to ensure that the microwave generator only operates if the oven door 42 is closed. If in a closed position, the frame 45 of the oven body 41 and the frame 47 of the oven door 42 are arranged opposite to each other and define a partitioning and a respective opening between each other that in this case is substantially planar. To prevent microwave energy from leaking to the outside through this opening, the opening must be sealed against microwave radiation.

[0029] To achieve this, in Figs. 4 and 5, the EBG seal 20 is mounted in the opening between the oven body 41 and the oven door 42 in such a way that the EBG structure 21 similar to Figs. 1A, 1B, 2, and 3 is secured to the oven body 41 and the electrically conducting surface 12 is secured to the oven door 42. In particular, the EBG structure 21 is secured to the substantially planar frame 45 of the oven body 41, and the electrically conducting surface 12 is secured to the substantially planar frame 47 of the oven door 42 such that, in a closed position, both frames - thus also the EBG structure 21 and the electrically conducting surface 12 - are, over large parts, arranged parallel to each other.

[0030] In Figs. 6 and 7, the EBG seal 20 is mounted in the opening between the oven body 41 and the oven door 42 of a microwave oven 60 in such a way that the EBG structure 21 is secured to the oven door 42 and the electrically conducting surface 12 is secured to the oven body 41.

[0031] In both types of arrangements, the EBG seal 20 prevents the microwave energy in the heating chamber 43 from leaking into outside space 44.

[0032] Referring to Figs. 4 to 7, the EBG seal 20 can be manufactured integrally with the microwave oven 40, 60, or it can be manufactured separately and only integrated with the assembled oven 40, 60 later. In the former case, the entire metallic substructure of the EBG seal 20 - consisting of the electrically conducting surface 33, the electrically conducting patches 31 and the electrically conducting posts 34 - can be manufactured integrally with the front side frame (flange) 45 of the heating chamber 43 (Figs 4 and 5) or the door 42 (Figs. 6 and 7). Subsequently, molten glass or any other suitable dielectric material can be poured in (or introduced in any other way) to fill in the EBG structure's dielectric layer 32. In the latter case, the EBG seal 20 is manufactured separately and secured to the front side frame (flange) 45 of the heating chamber 43 (Figs. 4 and 5) or the door (Figs. 6 and 7) by means of one or more fasteners or a suitable adhesive, for example. For example, the EBG seal 20 can also be manufactured and / or adhered to the oven 40, 60 by the methods and processes described in conjunction with Figs. 2 and 3.

[0033] The EBG structure 21 in the EBG seal 20 can

be made up of as many unit elements 35 as needed to provide required attenuation/blocking of microwave energy. Although the particular seal depicted in Figs. 4 to 7 consists of four rings (if seen from a radial direction) of unit elements 35, this is by no means to suggest the present invention would be limited to any particular number of unit elements 35. For more attenuation, additional rings of unit elements 35 can readily be added to the EBG structure 21. Conversely, the number of unit elements 35 can just as readily be reduced if less attenuation suffices. The EBG seal 20 is fully scalable this way.

[0034] With 5 rings of unit elements 35, radiated power flux levels, measured at 5 cm from the outer edges of the EBG seal 20, lower than 0.15 $\mu W/cm^2$ per 1 Watt of input microwave power have been achieved over a 200 MHz-wide stop band centered around 2.45 GHz for a microwave oven employing an EBG seal 20.

[0035] Advantageously, in the shown EBG seal 20, the EBG structure 21 and the electrically conducting surface 12 have a smooth and closed surface. This facilitates easy cleaning of the EBG seal 20 from the food spills, grease buildup and other deposits that are inevitable in regular normal use of any microwave oven.

The frequency position of at least one stop band (bandgap) in the transmission spectral response of the seal 20 in both embodiments can be controlled by at least one out of the geometry and material properties of the unit element 35 of the EBG structure 21, the thickness of the dielectric layer 11, and the relative dielectric constant of the dielectric layer 11. The dielectric layer 11 can be composed of one or more dielectric materials in any suitable form, e.g. as single or multi layer and / or layer(s) of a thin film type or thick film type, etc.

[0036] The width and depth of at least one stop band (bandgap) in the transmission spectral response can be controlled by at least one out of the geometry and material properties of the unit element 35 of the EBG structure 21, the number of unit elements 35 of the EBG structure 21, the thickness of one or more materials comprising the dielectric layer 11, and the relative dielectric constant of the dielectric layer 11.

[0037] By controlling / adjusting, e. g., at least one of the frequency position, width, and depth of the stop band (bandgap), along with the size and density of the EBG unit elements 35, the EBG seal 20 can be adapted to block or attenuate the permeating microwave radiation according to need. This may be done by taking into account, e. g., factors such as the maximum microwave power of the microwave oven 40, the in-plane width of the frames 45, 47 of the oven body 41 and the oven door 42, resp., and the height of the opening between the frames 45, 47.

[0038] The EBG structure 21 and the electrically conducting surface 12 are preferably flat. Such an arrangement allows the oven door 42 to open and close with maximum ease.

[0039] In a preferred embodiment of the EBG seal 20 of the present invention, the EBG structure's dielectric layer 32 is a solid and the dielectric layer 11 between the EBG structure 21 an the electrically conducting surface 12 is air. In such an embodiment, there is no physical contact between the solid seal part secured to the oven door 42 and the solid seal part secured to the oven body 41; as a result, there is no tear or wear due to opening and closing the door 42.

[0040] In an alternative embodiment of the EBG seal 20 of the present invention (not shown), the EBG structure (if seen from a radial direction) is divided into several segments, with some of the segments secured to the oven body 41 and the electrically conducting surface 12 secured to the oven door 42 and the remaining segments secured to the oven door 42 and their electrically conducting surface 12 secured to the oven body 41.

[0041] Although the EBG seal 20 has been described with a certain degree of particularity, it is to be understood that the disclosure has been made by way of example only and that the present invention is not limited to the features of the embodiments described and illustrated herein, but includes all variations and modifications within the scope and spirit of the invention as hereinafter claimed.

[0042] Generally, there are several advantages to using microwaves which the one skilled in the art will recognize for his field of expertise. In terms of heating, for example, with microwave heating, the energy is absorbed volumetrically, which means that the heat is generated inside the material in a more distributed manner, thus making it possible to obtain faster temperature rises than in conventional heating, where the heat flows into the body of the material from the surface. Greater time and energy savings, fast on and off switching, reduced floor space, ability to heat selectively, possible improved quality of products and creation of new types of material are the other notable benefits. A subsidiary advantage is the ability to add microwaves at various stages of an existing conventional process in order to optimize the yield and compatibility with other means of heating such as steam, hot air and infrared.

[0043] For example, other industrial applications of microwaves apart from household appliances include the processing of food (heating, pasteurizing, etc.), rubber (vulcanization), textiles (drying and sterilizing), wood products (drying), ceramics (curing), adhesives (bonding and curing), waste (drying and sterilizing) and so forth.

[0044] Regarding these and other applications, the corresponding devices should be sealed against leakage of microwave radiation which can be achieved by the seal according to the invention. The corresponding devices typically operate between around 460 MHz and around 2.45 GHz, with the two most heavily used frequency bands centered around 915 MHz and 2.45 GHz.

List of reference numbers

[0045]

1 region of space
2 region of space
3 opening
4 partition
11 dielectric layer
12 electrically conducting surface
14 energy
20 EBG seal
21 EBG structure
31 electrically conducting patches
32 dielectric layer
33 electrically conducting surface
34 electrically conducting posts
35 unit element
40 microwave oven
41 oven body
42 oven door
43 heating chamber
44 outside space
45 front side frame
46 loading port
47 frame
48 window
60 microwave oven

Claims

1. A seal (20) for blocking or attenuating microwave energy (14) between two environments or regions of space (1, 2), said seal comprising:

- an electromagnetic bandgap structure (21) secured to one side of an opening (3) in a partition (4) that separates the two environments or regions of space (1, 2) from each other;
- an electrically conducting surface (12) secured to the other side of the opening (3); and
- a dielectric volume (11) between the EBG structure (21) and the electrically conducting surface (12).

2. A seal (20) as defined in claim 1, wherein the EBG structure (21) is a metallodielectric structure with substantially periodic metallization and featuring inherent frequency bands where propagation of electromagnetic energy is forbidden and allowed.

3. A seal (20) as defined in claim 1, wherein the seal (20) has a transmission spectral response featuring one or more stop bands (bandgaps).

4. A seal (20) as defined in claim 3, wherein the frequency position of the stop band (bandgap) in the transmission spectral response can be controlled by at least one out of the geometry of the unit element (35) of the EBG structure (21),the material properties of the unit element (35) of the EBG structure (21), the thickness of the dielectric volume (11), and the effective relative dielectric constant of the dielectric volume (11).

5. A seal (20) as defined in claim 3, wherein the width of the stop band (bandgap) in the transmission spectral response can be controlled by at least one out of the geometry of the unit element (35) of the EBG structure (21), the material properties of the unit element (35) of the EBG structure (21), the number of unit elements (35) of the EBG structure (21), the thickness of the dielectric volume (11), and the relative dielectric constant of the dielectric volume (11).

6. A seal (20) as defined in claim 3, wherein the depth of the stop band (bandgap) can be controlled by at least one out of the geometry of the unit element (35) of the electromagnetic bandgap structure (21), the material properties of the unit element (35) of the EBG structure (21), the number of unit elements (35) of the electromagnetic bandgap structure (21), the thickness of the dielectric layer volume (11), and the effective relative dielectric constant of the dielectric volume (11).

7. A seal (20) as defined in claim 1, wherein at least one out of the electromagnetic bandgap structure (21) and the electrically conducting surface (12) has a smooth and closed surface.

8. A seal (20) as defined in claim 1, wherein at least one out of the electromagnetic bandgap structure (21) and the electrically conducting surface (12) is substantially flat.

8. A seal (20) as defined in claim 1, wherein the dielectric volume (11) is comprised of a single dielectric layer.

9. A seal (20) as defined in claim 1, wherein the dielectric volume (11) is comprised of multiple dielectric layers.

10. A seal (20) as defined in claim 9, wherein some of the dielectric layers are made of different dielectric materials.

11. A seal (20) as defined in claim 1, wherein the dielectric volume (11) is comprised of a mosaic of dielectric subvolumes.

12. A seal (20) as defined in claim 11, wherein some of the dielectric subvolumes are made of different dielectric materials.

13. A seal (20) as defined in claim 1, wherein the dielectric volume (11) is homogeneous or inhomogeneous.

14. Microwave oven (40) comprising:

an oven body (41) enclosing a heating chamber (43) and having a loading port (46) into the heating chamber (43);
an oven door (42) adapted to selectively open and close the loading port (46);

wherein, in a closed position of the oven (40), the oven body (41) and the oven door (42) define two respective sides of an opening (3) between the heating chamber (43) and an outside space (44);
wherein
at least part of the opening (3) is provided with a electromagnetic bandgap seal (20) to block or attenuate microwave radiation radiating through the at least part of the opening (3) while being in a closed position.

15. Microwave oven (40) as defined in claim 14, wherein the seal (20) is mounted in the opening (3) between the oven body (41) and the oven door (42) in such a way that an electromagnetic bandgap structure (21) is secured to the oven body (41) and an electrically conducting surface (12) is secured to the oven door (42).

16. Microwave oven (40) as defined in claim 14, wherein the seal (20) is mounted in the opening (3) between the oven body (41) and the oven door (42) in such a way that an electromagnetic bandgap structure (21) is secured to the oven door (42) and an electrically conducting surface (12) is secured to the oven body (41).

17. Microwave oven (40) as defined in claim 14, wherein the seal (20) is mounted in the opening (3) between the oven body (41) and the oven door (42) in such a way that an electromagnetic bandgap structure (21) - if seen from a radial direction - is divided into several segments, with some of the segments secured to the oven body (41), and an electrically conducting surface (12) secured to the oven door (42) and the remaining segments secured to the oven door (42) and their electrically conducting surface (12) secured to the oven body (41).

18. Microwave oven (40) as defined in claim 14, wherein the electromagnetic bandgap structure (21) is made by steps comprising:

manufacturing an electromagnetic bandgap structure's (21) electrically conducting posts (34) and electrically conducting patches (31) as combined units by stamping or cutting metal sheets; folding and inserting them into prefabricated holes in an EBG structure's dielectric layer (32); and folding end points of the electrically conducting posts (34) over an electrically conducting surface (33).

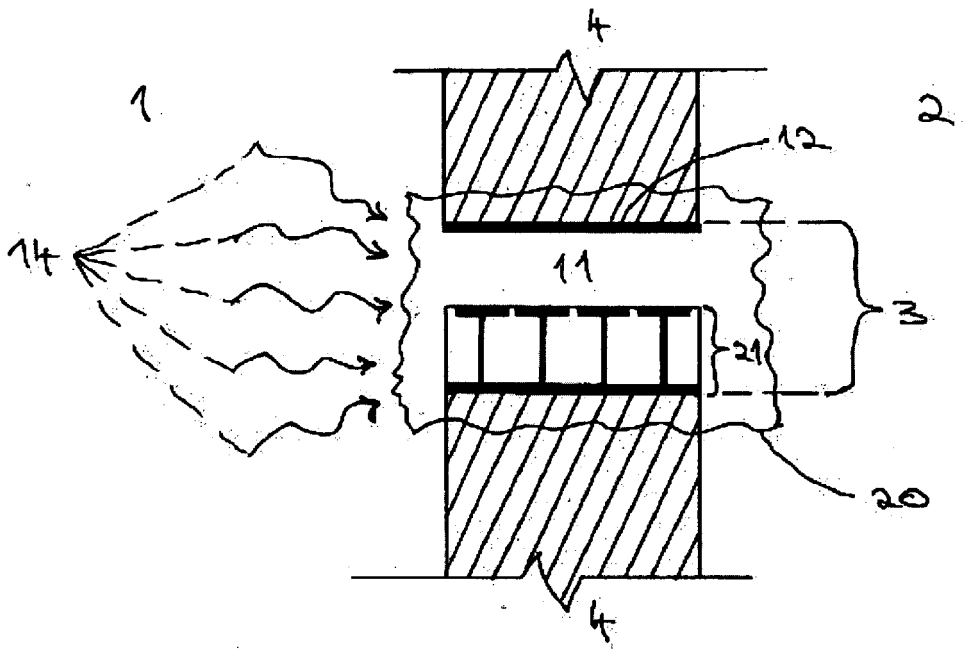

4
1
2
12
14
11
3
21
20
4

FIG. 1A

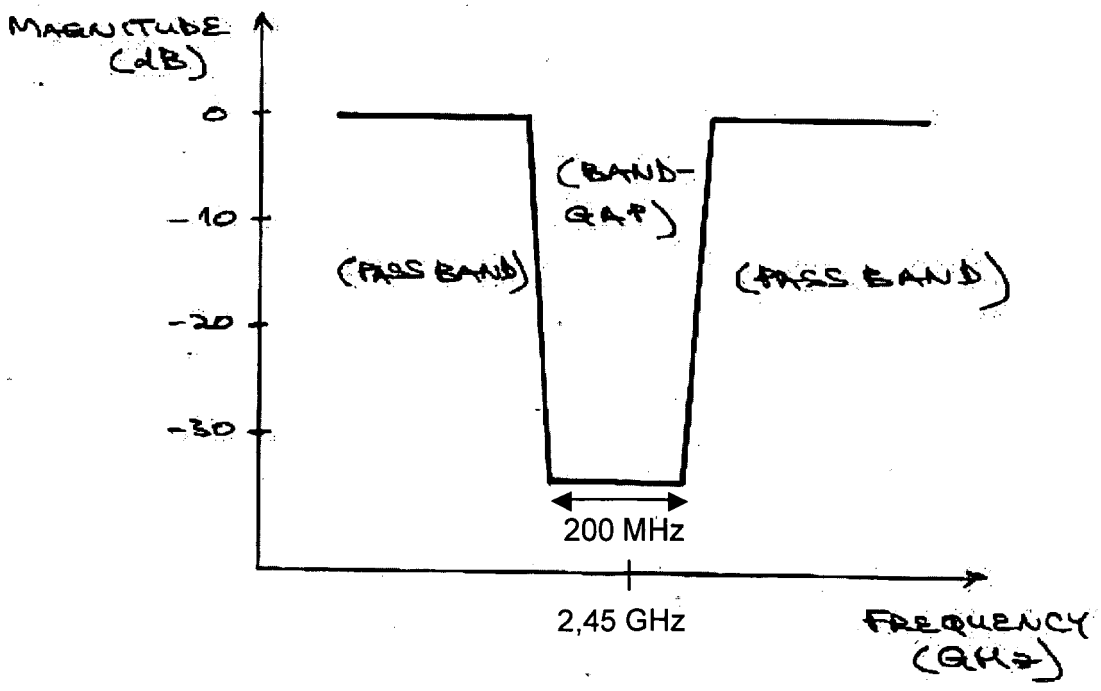

MAGNITUDE (dB)
0
-10
-20
-30
(PASS BAND)
(BAND-GAP)
(PASS BAND)
200 MHz
2,45 GHz
FREQUENCY (GHz)

FIG. 1B

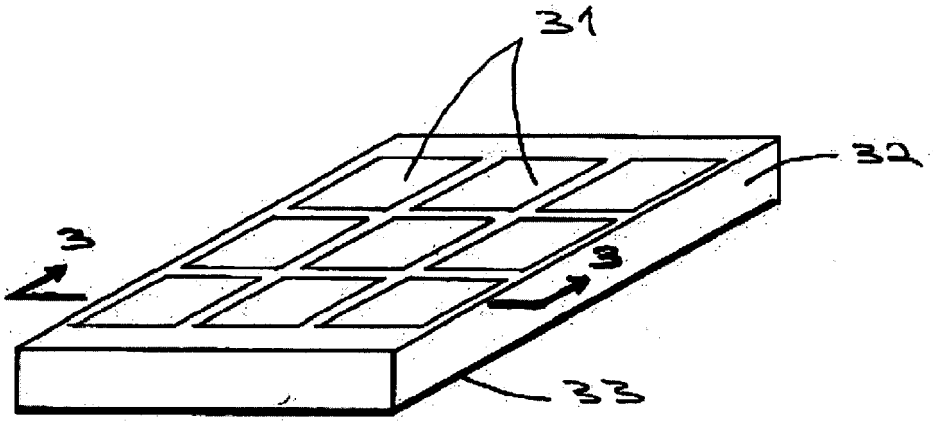


FIG. 2

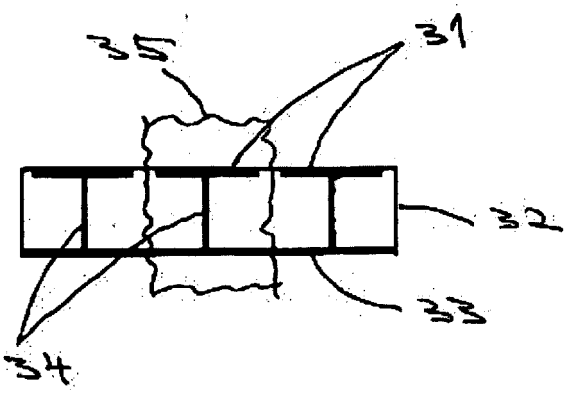


FIG. 3

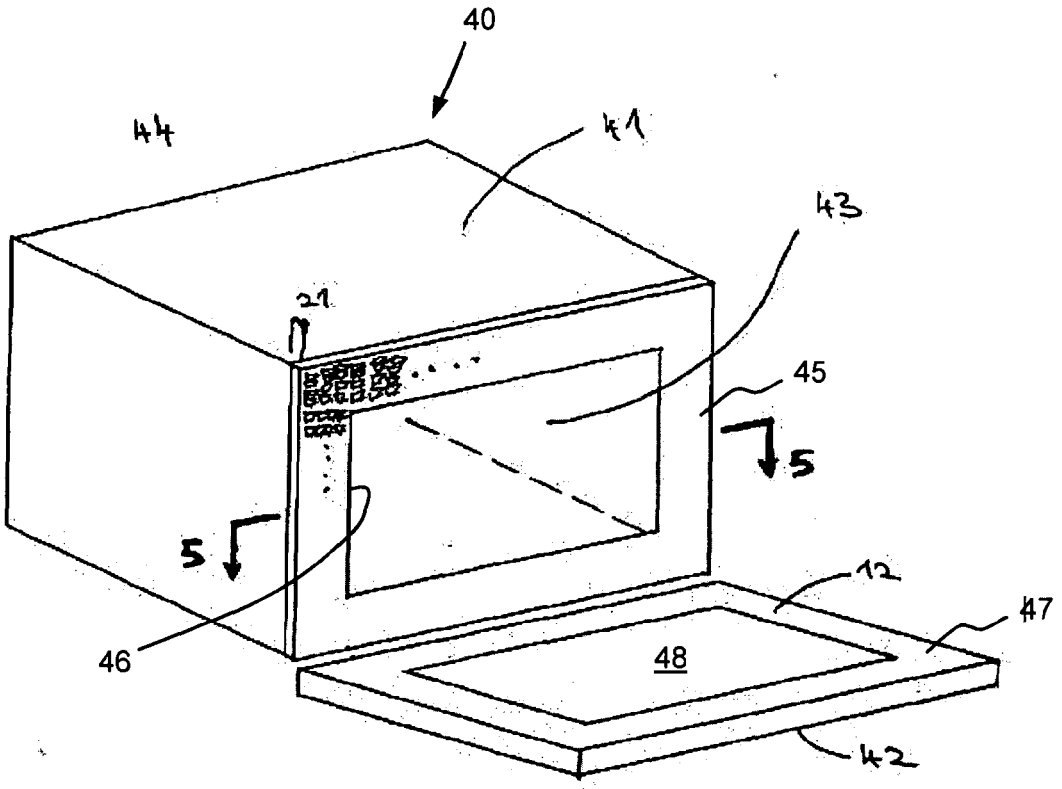


FIG. 4

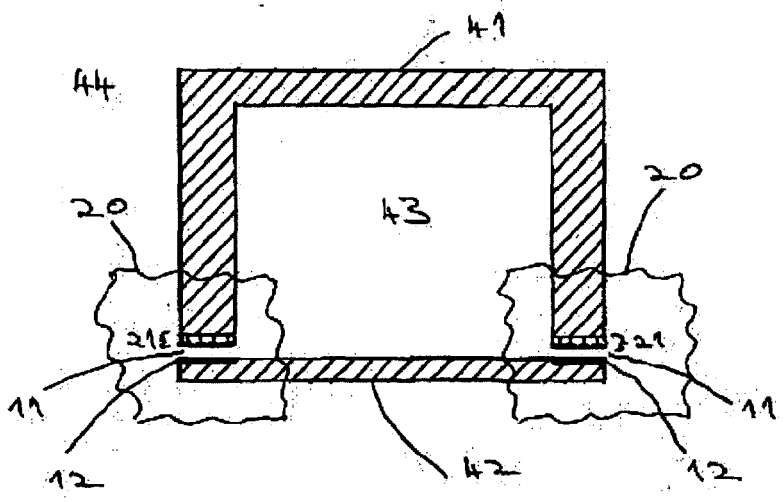


FIG. 5

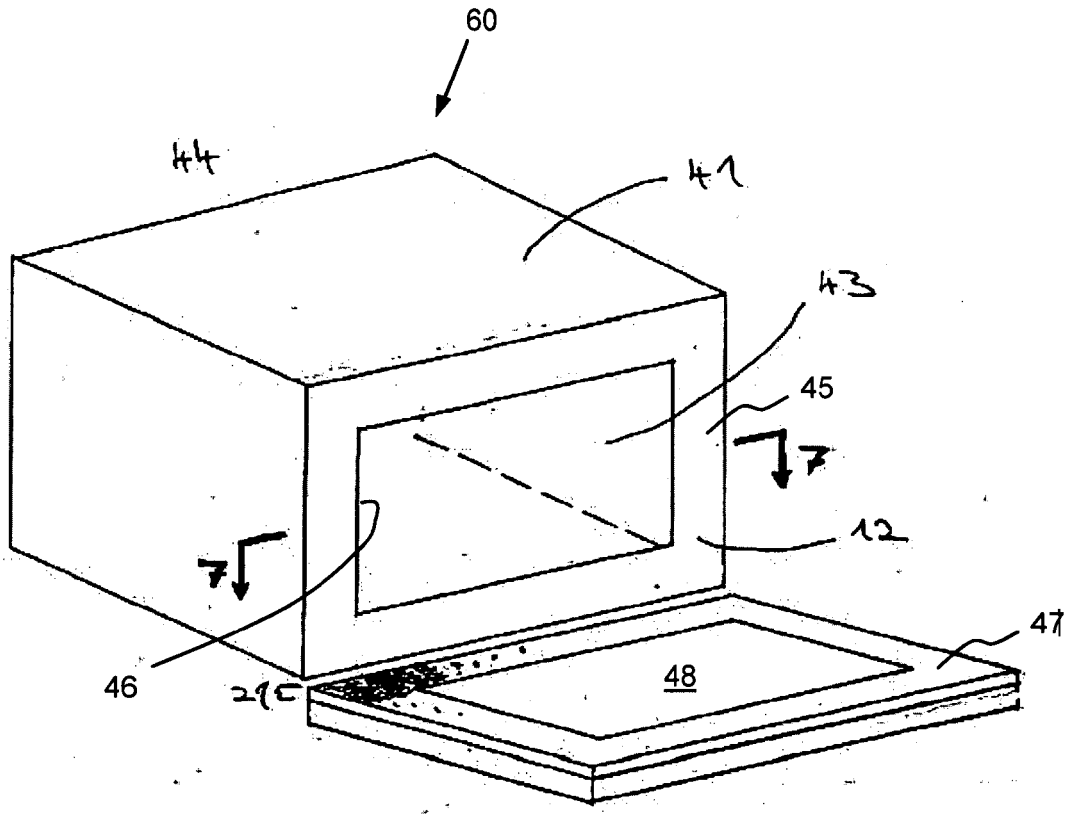


Fig. 6

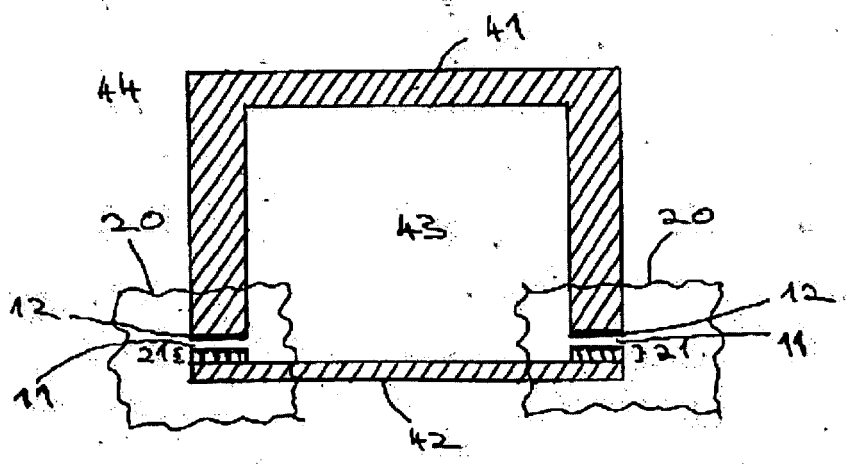


FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 01 1391

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 0 430 694 A1 (NIPPON ELECTRIC CO [JP]) 5 June 1991 (1991-06-05) * column 1, line 2 - line 9 * * figures 9A-9D * * column 7, line 37 - column 8, line 39; figures 10,11 *	1-18	INV. H01P3/12 H05B6/76
Y	DEBASIS DAWN ET AL: "A Novel Electromagnetic Bandgap Metal Plate for Parallel Plate Mode Suppression in Shielded Structures" IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, IEEE SERVICE CENTER, NEW YORK, NY, US, vol. 12, no. 5, May 2002 (2002-05), XP011066851 ISSN: 1531-1309 * page 166, left-hand column, line 1 - page 167, left-hand column, line 3; figures 1,4 *	1-18	
A	DAN SIEVENPIPER ET AL: "High-Impedance Electromagnetic Surfaces with a Forbidden Frequency Band" IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 47, no. 11, November 1999 (1999-11), XP011037787 ISSN: 0018-9480 * page 2059, left-hand column, line 1 - page 2060, left-hand column, line 27 * * figures 1,6 *	1-18	TECHNICAL FIELDS SEARCHED (IPC) H01P H05B H05K

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 November 2006	PASTOR JIMENEZ, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 01 1391

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	CENTOLA F ET AL: "Alternatives to gaskets in shielding an enclosure" 2002 IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY. EMC. SYMPOSIUM RECORD. MINNEAPOLIS, MN, AUG. 19 - 23, 2002, INTERNATIONL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY, NEW YORK, NY : IEEE, US, vol. VOL. 1 OF 2, 19 August 2002 (2002-08-19), pages 205-209, XP010603224 ISBN: 0-7803-7264-6 * page 205, left-hand column, line 18 - line 30 * * page 205, right-hand column, line 16 - page 206, left-hand column, line 2; figures 1,2 * * page 207, right-hand column, line 4 - line 34 * -----	1-18	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 November 2006	PASTOR JIMENEZ, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 01 1391

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

07-11-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0430694 A1	05-06-1991	DE 69018943 D1	01-06-1995
		DE 69018943 T2	23-11-1995
		US 5160806 A	03-11-1992

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6825741 B2, Chappell **[0005]**