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(54) **Antenna radome**

Antennengehäuse

Radome d'antenne

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(73) Proprietor: **Cobham Advanced Composites Limited**
Stevenage
Hertfordshire SG1 2DH (GB)

(72) Inventors:
- **McNair, Peter A. C.**
  Stevenage
  Hertfordshire SG1 2DH (GB)
- **Baker, Claire**
  Stevenage
  Hertfordshire SG1 2DH (GB)

(74) Representative: **Haley, Stephen**
Gill Jennings & Every LLP
Broadgate House
7 Eldon Street
London EC2M 7LH (GB)

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Description

[0001] Antenna housings are an essential part of most radar and/or communication/control systems, providing protection for antennas from the environment, necessary aerodynamic characteristics and improved RF stealth.
[0002] The term "radome" generally refers to housings for an antenna or collection of antennas. Antennas generally do not "look" through every part of a radome and the area through which signals are passed (transmitted and/or received) is termed the "electromagnetic window". In order to ensure optimum electrical performance, the design and/or material of this electromagnetic window may differ compared to more structural parts of a radome.
[0003] Thermosetting composite materials are currently used for the manufacture of high performance radomes, such as aircraft nose cones. At the top end of electrical and mechanical performance of known materials are quartz fibre reinforced cyanate ester composites. These are very high cost materials. In certain situations where a trade-off on electrical performance can be made, lower cost glass fibre reinforced epoxy composites are used.
[0004] For some radomes, the electrical performance of quartz cyanate ester is not sufficient and for these radomes, providing the mechanical performance can be met, PTFE (polytetrafluoroethylene) may be used. However, the use of PTFE often sacrifices mechanical performance. Where mechanical performance cannot be met with a solid PTFE radome, it may be possible to use a hybrid build, where PTFE is used in the window area but the radome structure is of a stronger material, but again a trade-off must be made in this case.
[0005] The present invention seeks to overcome the aforementioned problems.
[0006] EP-A-0155599 discloses a radome.
[0007] According to the present invention there is provided a housing for an antenna, the housing comprising:

an electromagnetic window portion through which electromagnetic signals are passed in use, **characterised in that** a layer of a wall of the electromagnetic window is formed from self reinforced polypropylene (PP-PP).

[0008] Furthermore, the present invention provides the use of self reinforced polypropylene (PP-PP) in a housing for an antenna.
[0009] Self reinforced polypropylene (PP-PP) is a new material which has certain mechanical and electrical properties, the implementation of which leads to low cost mass, high performance radomes. Because of these properties, PP-PP can be used in all or part of a radome build, including the electromagnetic window area. Although the mechanical properties of PP-PP are known in other technical fields, there has, until now, been no suggestion that the electrical properties of this material could also be beneficial, nor that such properties can be exploited in the field of antenna housing design.
[0010] Examples of the present invention are described below with reference to the accompanying drawings in which:

Figure 1 a shows a cross-sectional view of an example of an antenna housing of a known shape;
Figure 1b shows a perspective view of an example of an antenna housing of a known shape;
Figure 2a shows an example of an antenna housing according to the present invention which comprises a single-layer self reinforced polypropylene (PP-PP) wall;
Figure 2b shows an example of an antenna housing according to the present invention which comprises multiple layers, including outer layers of self reinforced polypropylene (PP-PP) wall;
Figure 2c shows an example of an antenna housing according to the present invention which comprises multiple layers, including outer layers and a core layer of self reinforced polypropylene (PP-PP) wall, where the core layer is thicker than the structural foam layers; and
Figure 2d shows an example of an antenna housing according to the present invention which comprises multiple layers, including outer layers and a core layer of self reinforced polypropylene (PP-PP) wall, where the core layer is thinner than the structural foam layers.

[0011] Self reinforced polypropylene (PP-PP) is an example of a new generation of "self reinforced polymers", which have resulted from recent developments in the thermoplastics industry. In this type of composite material the reinforcement fibre is a highly aligned polymer, which is chemically similar or identical to the matrix material. According to the present invention, PP-PP is used in antenna housings ("radomes"), in which electrical and mechanical properties must be optimised whilst minimising cost.
[0012] Standard grade PP-PP material contains carbon black to protect against UV degradation of the polymer. The introduction of carbon black through the bulk of the material is not desirable for radomes because it increases electrical loss: carbon heats up in response to electromagnetic radiation and the strength of transmitted and received electromagnetic signals is correspondingly diminished. Hence, for radome applications non-carbon loaded PP-PP material is appropriate in such cases.
[0013] For most applications, protection against UV degradation is necessary for radomes and is typically achieved

either by introduction of a pigmented surface film, by introduction of an alternative additive (either to the radome material itself or to a surface layer such as a paint), or by painting the radome, as opposed to the use of carbon black containing PP-PP. Optimisation of this finishing and protection scheme may form part of the product development cycle and testing for radomes. For radomes in vehicle applications (where frictional forces, arising as the radome shears the air, generate static charges) a relatively thin surface layer of carbon is preferable as a static dissipative layer, which is, for example, introduced as a carbon containing film. Painting is also an option and is typical for current radome designs. The use of thermoplastic films to provide a surface finish is possible in PP-PP applications.

[0014] A relatively small number of radome applications do not require high performance (e.g. low frequency, short range applications) and in this case the radome may be produced with standard, lower cost, carbon-containing PP-PP.

[0015] The approximate electrical properties of non-carbon loaded PP-PP are provided below. The measured properties are comparable to PTFE (polytetrafluoroethylene). Table 1 below gives measured electrical properties for known radome materials and PP-PP, for a typical radome operational frequency of 10 GHz.

Table 1

	Dielectric constant	Electrical Loss
PP-PP	2.1	0.0015
PTFE	2.05	0.001
Quartz/ Cyanate Ester	3.2	0.005
E Glass/ Epoxy	4.0	0.02

[0016] From an electrical point of view the dielectric constant and electrical loss are important design parameters. An electromagnetic wave takes longer to pass through a given region with a dielectric constant greater than unity (1), than through the same region of air. The delay is proportional to the refractive index of the material (which in turn equals the square root of the dielectric constant). This delay is particularly significant when considering the performance of a curved radome, in which different parts of an incident electromagnetic field are potentially delayed by different amounts, leading to defocussing effects and/or beam deflection.

[0017] From the above comments, it follows that these effects are proportional to the refractive index. An ideal radome material (which does not exist) would have a dielectric constant of 1, equivalent to air for practical purposes. Materials with dielectric constants closest to 1 are generally best in terms of a radome design, which is why PTFE and PP-PP are attractive radome materials in terms of their electrical properties.

[0018] The electrical loss provides a measure of the proportion of electromagnetic energy lost as heat. "Lossy" radome materials reduce the strength of transmitted and received electromagnetic signals, necessitating higher power transmitters and/or lower noise receivers. Although all radome materials are lossy to some degree, materials such as PTFE and PP-PP are described as "low loss" and offer superior performance.

[0019] PP-PP represents a bridge in mechanical properties between the "conventional" radome materials of e.g. glass fibre reinforced plastics and homogenous polymers such as PTFE and PP. PP-PP radomes are suitable for a number of semi-structural applications. PP-PP is also a relatively low cost material, and can be used to manufacture radomes where PTFE has been ruled out due to poor mechanical performance. The properties of self reinforced polypropylene are compared with glass epoxy in the Table 2 below:

Table 2

	PTFE	Self reinforced Polypropylene	Glass epoxy (for Comparison)
Density (g/ cm^3)	2.14	0.92	2
Dielectric Constant @ 10 GHz	2.05	2.1	4.1
Dielectric Loss @ 10 GHz	0.001	0.0015	0.02
Tensile Modulus (GPa)	0.3 - 0.8	4.2	25
Tensile Strength (MPa)	20 - 30	120	350
Flexural Modulus (MPa)	350 - 650	3.5	28

(continued)

	PTFE	Self reinforced Polypropylene	Glass epoxy (for Comparison)
Maximum Use Temperature (°C)	260	~100	~130
Melting Temperature (°C)	N/a degrades at ~400	175	n/a
Cost/ m^2 for 0.5 mm thick material or equivalent)	£12 / m^2 (approximated)	£2.5 / m^2	£12 / m^2

[0020] Radomes range in size from smaller than egg-cups to large geodesic dome structures such as ground stations, and are used in fields such as vehicle applications (including ground based and air vehicles).

[0021] Figure 1 a shows a cross-section through an example of a radome wall 1 (for example, for use as a nose cone for a missile / fast jet application). Figure 1b illustrates an example of a more complex radome shape 2. The use of PP-PP is not limited to any particular class of radome shape.

[0022] As shown in Figure 2a, the simplest radome wall is a single layer 3 of PP-PP material, referred to as a "solid" radome. This type of radome may be appropriate when operation at a single frequency, low frequency or over a relatively narrow band of frequencies is required.

[0023] Better electrical performance is typically obtainable by using a sandwich structure in which the radome wall comprises more than one layer of distinct material, as shown in Figures 2b to 2d. Typical radome wall builds comprise three layers as shown in Figure 2b. Such a radome wall comprises a first PP-PP outer layer 4, a structural foam layer 5, and a second PP-PP outer layer 6, and is referred to as an "A-sandwich". Further radome examples, shown in Figures 2c and 2d, have five layers in total. This includes a first PP-PP outer layer 4, a first structural foam layer 7, a PP-PP core 8, a second structural foam layer 9, and a second PP-PP outer layer 6, and is referred to as a "C-sandwich". Other builds are possible, for example further multi-layer designs. The one or more structural foam layers 5, 7, 9 have excellent electrical performance (they comprise mostly air), but poor mechanical performance.

[0024] The example of Figure 2c, where the core layer is thicker than the structural foam layers, is referred to as a "fat" C-sandwich; an alternative form of the C-sandwich build is one in which the central core is thinner, for example as shown in Figure 2d; this is sometimes referred to as a "thin" C-sandwich.

[0025] The layer thicknesses are selected in order to optimise the radome performance over a range of incident angles and operating frequencies. The layer thicknesses depend on the electrical (specifically the dielectric) properties of the wall materials. The two main approaches are (a) to make the radome as thin as possible (known as an "electrically thin" radome) and (b) to tune the radome in some way (in the same way that anti-reflection films are used in optics, for example in the blooming of camera lens surfaces). The use of PP-PP in radomes does not limit the radomes to operation at a particular frequency.

[0026] One exemplary technical field in which the present invention may be employed is as a satellite communication radome for commercial aircraft. The radome wall builds of Figures 2a to 2d are preferably optimised for operation in the frequency band 10.95 to 12.75 GHz (Television Receive Only (TVRO) satellite band) and 0 to 75 degrees angle of incidence. The builds typically range in thickness from approximately 11 mm (solid wall) to approximately 18.2 mm. Actual build dimensions depend on frequency and the use of PP-PP in radomes does not limited the radome to specific dimensions.

[0027] The layer thicknesses are determined so as to optimise the electrical performance of the radome. In general terms the inclusion of more layers (i.e. A-sandwich and C-sandwich) gives better electrical performance than the simplest solid build, particularly over a wider bandwidth (range of operating frequencies). Similarly, C-sandwich builds give better potential electrical performance than the A-sandwich builds.

[0028] PP-PP can be used for any one or more of the layer(s) within any radome build. In particular, builds which involve PP-PP and other materials e.g. Kevlar® or quartz cyanate ester are possible.

Claims

1. A housing (1) of an antenna, the housing comprising:

an electromagnetic window portion through which electromagnetic signal are passed in use, **characterised in that** a layer (3) of a wall of the electromagnetic window is formed from self reinforced polypropylene PP-PP.

2. A housing (1) according to claim 1, wherein the housing is arranged to house multiple antennas.

3. A housing (1) according to claim 1 or 2, wherein the self reinforced polypropylene PP-PP is non-carbon loaded self-reinforced polypropylene.

4. A housing (1) according to any preceding claim, wherein the electromagnetic window portion further comprises means for protecting the self reinforced polypropylene PP-PP against ultraviolet degradation.

5. A housing (1) according to claim 4, wherein the means for protecting the self reinforced polypropylene PP-PP against ultraviolet degradation comprises a surface layer, the surface layer further comprising one of a pigmented surface film and a painted surface layer.

6. A housing (1) according to claim 5, wherein the surface layer includes carbon.

7. A housing (1) according to any preceding claim, wherein the electromagnetic window portion is curved.

8. A housing (1) according to any preceding claim, wherein the housing is substantially conical in shape.

9. A housing (1) according to any preceding claims, wherein the electromagnetic window comprises multiple layers.

10. The housing (1) according to claim 9, wherein the multiple layers includes two outer layers of self reinforced polypropylene PP-PP formed on either side of a first foam layer.

11. The housing (1) according to claim 10, the housing further comprising a core layer of self reinforced polypropylene PP-PP and a second foam layer, the electromagnetic window is arranged such that the self reinforced polypropylene (PP-PP) core layer is formed between the first and second foam layers.

12. The use of self reinforced polypropylene PP-PP in a housing (1) for an antenna.

13. The use of self reinforced polypropylene PP-PP in an electromagnetic window portion, through which signals are passed in use, of a housing for an antenna.

Patentansprüche

1. Gehäuse (1) einer Antenne, umfassend:

   eine elektromagnetische Fensterpartie, durch welche im Betrieb elektromagnetische Signale fließen, **dadurch gekennzeichnet, dass** eine Schicht (3) einer Wand des elektromagnetischen Fensters aus selbstverstärktem Polypropylen PP-PP ausgebildet ist.

2. Gehäuse (1) nach Anspruch 1, wobei das Gehäuse zur Aufnahme mehrerer Antennen angeordnet ist.

3. Gehäuse (1) nach Anspruch 1 oder 2, wobei das selbstverstärkte Polypropylen PP-PP ein nicht-leitfähiges selbstverstärktes Polypropylen PP-PP ist.

4. Gehäuse (1) nach einem der vorhergehenden Ansprüche, wobei das elektromagnetische Fenster weiter ein Mittel zum Schutz des selbstverstärkten Polypropylens PP-PP gegen Ultraviolettschädigung umfasst.

5. Gehäuse (1) nach Anspruch 4, wobei das Mittel zum Schutz des selbstverstärkten Polypropylens PP-PP gegen Ultraviolettschädigung eine Oberflächenschicht aufweist, die entweder einen pigmentierten Oberflächenfilm oder eine lackierte Oberflächenschicht umfasst.

6. Gehäuse (1) nach Anspruch 5, wobei die Oberflächenschicht Kohlenstoff enthält.

7. Gehäuse (1) nach einem der vorhergehenden Ansprüche, wobei die elektromagnetische Fensterpartie gebogen ist.

8. Gehäuse (1) nach einem der vorhergehenden Ansprüche, wobei das Gehäuse im Wesentlichen kegelförmig ist.

9. Gehäuse (1) nach einem der vorhergehenden Ansprüche, wobei das elektromagrietische Fenster mehrfache Schichten aufweist.

10. Gehäuse (1) nach Anspruch 9, wobei die mehrfachen Schichten zwei Außenschichten von selbstverstärktem Polypropylen PP-PP umfassen, die auf beiden Seiten einer ersten Schaumstoffschicht ausgebildet sind.

11. Gehäuse (1) nach Anspruch 10, weiter umfassend eine Kernschicht aus selbstverstärktem Polypropylen PP-PP und eine zweite Schaumstoffschicht, wobei das elektromagnetische Fenster so angeordnet ist, dass die Kernschicht aus selbstverstärktem Polypropylen PP-PP zwischen der ersten und der zweiten Schaumstoffschicht ausgebildet ist.

12. Anwendung von selbstverstärktem Polypropylen PP-PP in einem Gehäuse (1) für eine Antenne.

13. Anwendung von selbstverstärktem Polypropylen PP-PP in einer elektromagnetischen Fensterpartie eines Gehäuses für eine Antenne, durch welche im Betrieb Signale fließen.

Revendications

1. Dôme (1) pour antenne comprenant:

   une fenêtre électromagnétique faisant partie du dôme, à travers laquelle passent des signaux électromagnétiques en cours d'usage, **caractérisé en ce qu'**une couche (3) de paroi de la fenêtre électromagnétique est réalisée en polypropylène PP-PP auto-renforcé.

2. Dôme (1) selon la revendication 1, **caractérisé en ce que** le dôme est destiné à recevoir plusieurs antennes.

3. Dôme (1) selon la revendication 1 ou 2, **caractérisé en ce que** le polypropylène PP-PP auto-renforcé est un polypropylène auto-renforcé non chargé carbone.

4. Dôme (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fenêtre électromagnétique faisant partie du dôme comporte par ailleurs des moyens de protection du polypropylène PP-PP auto-renforcé contre la dégradation par les rayons ultraviolets.

5. Dôme (1) selon la revendication 4, **caractérisé en ce que** les moyens de protection du polypropylène PP-PP auto-renforcé contre la dégradation par les rayons ultraviolets comportent une couche superficielle, cette couche superficielle comprenant une pellicule superficielle pigmentée et une couche superficielle peinte.

6. Dôme (1) selon la revendication 5, **caractérisé en ce que** la couche superficielle comprend du carbone.

7. Dôme (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fenêtre électromagnétique faisant partie du dôme est courbée.

8. Dôme (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le dôme est de forme essentiellement conique.

9. Dôme (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fenêtre électromagnétique comporte des couches multiples.

10. Dôme (1) selon la revendication 9, **caractérisé en ce que** les couches multiples comportent deux couches extérieures de polypropylène PP-PP auto-renforcé formées de part et d'autre d'une première couche de mousse.

11. Dôme (1) selon la revendication 10, **caractérisé en ce que** le dôme comporte par ailleurs une couche intérieure de polypropylène PP-PP auto-renforcé et une deuxième couche de mousse, la fenêtre électromagnétique étant disposée de manière à ce que la couche intérieure de polypropylène PP-PP auto-renforcé soit formée entre les première et deuxième couches de mousse.

12. Utilisation de polypropylène PP-PP auto-renforcé dans un dôme (1) pour antenne.

13. Utilisation de polypropylène PP-PP auto-renforcé dans une fenêtre électromagnétique faisant partie d'un dôme pour antenne, à travers laquelle passent des signaux électromagnétiques en cours d'usage.

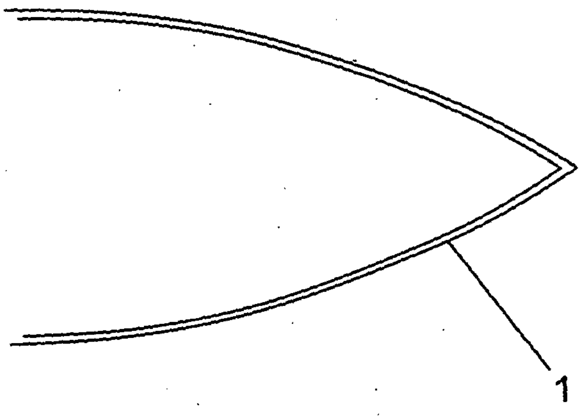

Figure 1a

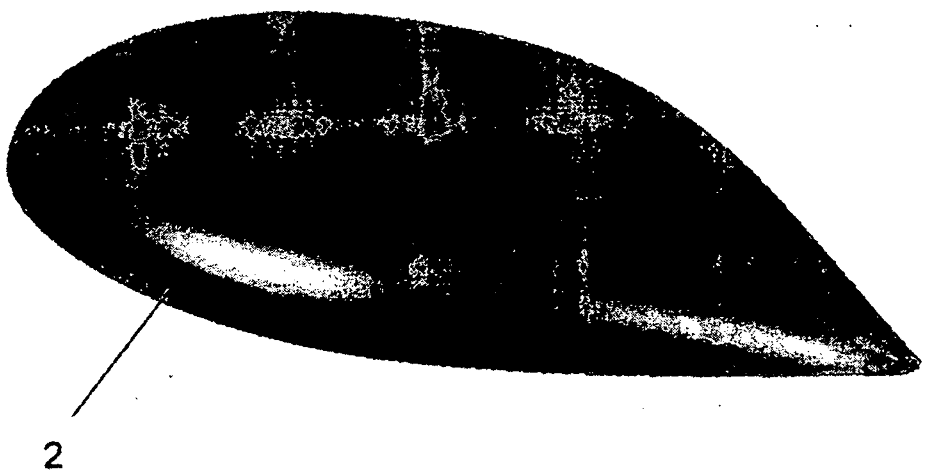

Figure 1b

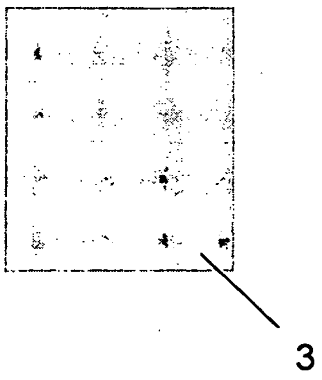

Figure 2a

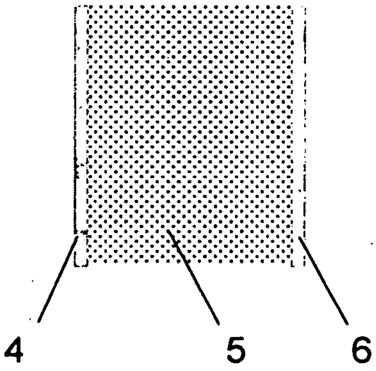

Figure 2b

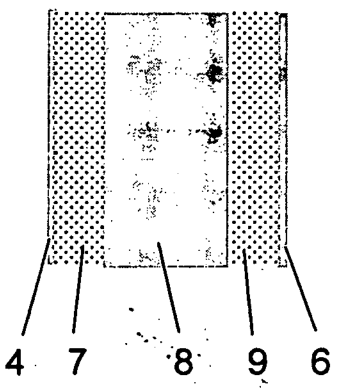

Figure 2c

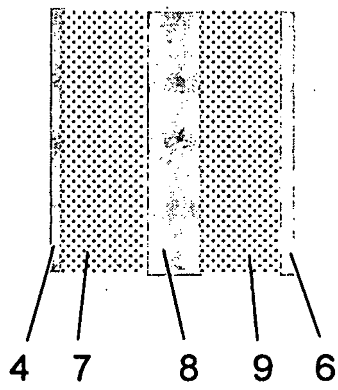

Figure 2d

REFERENCES CITED IN THE DESCRIPTION

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