(19) **DANMARK**

(10) **DK/EP 2435505 T3**

Patent- og
Varemærkestyrelsen

(12) # Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***B 29 C 70/38 (2006.01)*** ***B 29 L 31/34 (2006.01)*** ***C 08 J 5/04 (2006.01)*** ***C 08 J 5/24 (2006.01)*** ***H 01 Q 1/42 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2015-01-05**

(80) Dato for Den Europæiske Patentmyndigheds
bekendtgørelse om meddelelse af patentet: **2014-10-08**

(86) Europæisk ansøgning nr.: **10728793.0**

(86) Europæisk indleveringsdag: **2010-05-20**

(87) Den europæiske ansøgnings publiceringsdag: **2012-04-04**

(86) International ansøgning nr.: **FR2010050978**

(87) Internationalt publikationsnr.: **WO2010136703**

(30) Prioritet: **2009-05-29 FR 0953582**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**

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(54) Benævnelse: **Dielektrisk præimprægneret bånd til et radom**

(56) Fremdragne publikationer:
EP-A1- 0 357 006
EP-A1- 1 693 180
WO-A1-2008/128708
DE-A1- 3 421 196
US-A- 4 353 769
US-A- 5 849 234
US-A- 6 028 565

PREIMPREGNATED DIELECTRIC TAPE FOR RADOME

The invention relates to the field of radomes made of composites.

A radome is placed, most of the time, on a flying machine or vehicle (in certain cases also on terrestrial or maritime vehicles or installations) and protects a radar from external stresses. These stresses are, in particular, environmental and meteorological (rain, wind, wet heat, salt fog, etc.) stresses to which thermal stresses in storage and in service (generally from -60°C to +150°C or even above +350°C) are added. The term radome includes the electromagnetic windows, which are small radomes, generally placed under the wings of flying machines.

A radome is generally domed or conical and is generally located on the nosecone of said machine or vehicle. It must be highly resistant to impacts, to shocks and vibrations, to pressure and to aerodynamic loads and have dielectric properties compatible with the presence of the radar, that is to say, it must be as transparent as possible to electromagnetic waves. Such a composite radome comprises dielectric fiber and a dielectric matrix. These radomes are usually manufactured by impregnating a fibrous sock structure or produced by drape forming a planar fabric. In planar fabric drape forming technology, a planar fabric is cut into several pieces that are assembled on the surface of a mold of the desired shape. This involves a large loss of material and a high labor cost. The superposition of the various layers is difficult to reproduce. In sock technology a weft yarn is passed between warp yarns, the warp yarns being set aside as the weave progresses in order to follow the reduction in diameter as the apex of the dome or cone is approached. The parts of the warp yarns not incorporated into the weave represent a significant loss of material. Here too, the reproducible production of a shape correctly following the desired dimensions is difficult. The composite is then produced by an RTM or thermoforming (press, autoclave) process. Another technique used is drape forming of a prepreg (a resin-impregnated planar fabric cut to shape) followed by an oven and autoclave treatment. With these technologies the scrap rate and material loss rate are particularly high. The loss of raw material is around 20% and may rise to greater than 50%. The economic impact is particularly significant when expensive reinforcements such as, in particular, quartz fiber or D-glass are used. In addition, asymmetric and nonaxisymmetric radomes are very difficult to produce by these techniques. With conventional or Jacquard weaving, a nonaxisymmetric shape is in fact extremely difficult to produce. With drape forming, uniform thicknesses are difficult to obtain on a nonaxisymmetric part.

The filament winding technique has been little used for many years for radome parts because it is difficult with this technology to reinforce the composite part in all the required directions, which greatly limits the final mechanical properties of the part.

The invention solves the aforementioned problems. According to the invention, the idea was to use fiber placement technology to produce a dielectric radome. With this technique, a programmed machine places, onto a mold and in a precise predetermined position, a length of tape preimpregnated with resin and then cuts it, after which the machine places, in another position, another length of the same prepreg tape and then also cuts it, and so on. The resin has sufficient tack for the tape, placed with this technique, to adhere to the point where it was placed by the machine and preserves well the shape of what supports it. The length of each placed strand of tape generally ranges from 1 to 300 cm. Because of the finite length of each strand it is possible to produce a radome very precisely, whether it is a body of revolution or not, since this technique, makes it possible for surfaces that curve in all directions, like domes, to be closely followed. A surface is curved in all directions at a given point if any tangent to the surface at this point touches the surface only at this given point.

The invention firstly relates to a tape comprising dielectric fiber preimpregnated with a dielectric resin. All the dielectric constants and dielectric loss tangents in the present application are given at 20°C and 9.375 GHz. The fiber contained in the tape has a dielectric constant of between 2 and 7 and a dielectric loss tangent of between 1×10^{-5} and 3×10^{-2} (it will be recalled that dielectric constants and dielectric loss tangents are dimensionless numbers). The resin contained in the tape has a dielectric constant of between 2 and 5 and a dielectric loss tangent of between 1×10^{-4} and 3×10^{-2}.

The tape has a dielectric constant of between 2 and 7 and a dielectric loss tangent of between 1×10^{-4} and 3×10^{-2}. Its dielectric constant is preferably less than 3.5. The dielectric constant and the dielectric loss tangent of the tape are a consequence of the dielectric constants and the dielectric loss tangents of the tape's constituents (fibers and resin) and these constants are therefore chosen depending on those required for the tape.

The invention firstly relates to a continuous tape comprising a fibrous structure comprising continuous or discontinuous fiber and a resin that is tacky at a temperature ranging from room temperature to 300°C, said tape having at 20°C and 9.375 GHz a dielectric constant of between 2 and 7 and a dielectric loss tangent of between 1×10^{-4} and 3×10^{-2}, said fibrous structure being rigid enough for said tape to have a rigidity of between 5° and 30° at a temperature at which said resin is tacky, the rigidity of the tape being measured with a 15 cm long rectilinear segment, a 5-cm piece of which is placed on the edge of a horizontal surface, the remaining 10 cm being unsupported progressively sagging until it stabilizes to make an angle to the horizontal, said angle characterizing the rigidity of the tape.

Before being incorporated into the tape according to the invention, the fiber may be assembled into continuous yarns made up of continuous filaments. Before being incorporated into the tape according to the invention, the fiber may also be assembled into continuous yarns made up of discontinuous fibers. A discontinuous fiber has a length generally ranging from 200 µm to 50 cm. Above 50 cm in length, the fiber is generally called a continuous fiber (or continuous yarn in the case of combining several contiguous continuous fibers). The tape may also contain both continuous and discontinuous fiber.

For the impregnated tape to be suitable for the fiber placement process, it needs to be rigid enough at the chosen fiber placement temperature, otherwise it is difficult to control the fiber placement process. To measure this rigidity 5 cm of a piece of tape 15 cm long (and, in particular, 6.35 mm wide) is placed flat on the edge of a horizontal surface. Therefore 10 cm of the tape is not supported by said surface and hangs, to a greater or lesser extent, in the air. It is the angle made between the 10-cm long segment of tape (containing uncured resin) that hangs in the air and the horizontal which is measured and characterizes the rigidity of the tape. This angle is between 5° and 30° and preferably between 8° and 22°.

The choice of reinforcing fiber is made depending on the thermal, dielectric and mechanical stress tolerances. This fiber may particularly be a silica-based fiber, i.e. one containing more than 50 wt% of SiO_2 as is the case for glass (E-, D-, S2-, R-, low K-, low Dk-glass), silica fiber (comprising more than 90 wt% of SiO_2) or quartz fiber (comprising more than 95 wt% of SiO_2) especially that marketed under the brand name Quartzel by Saint-Gobain Quartz S.A.S. Aramid fiber, high-density polyethylene (HDPE), polyetherimide (PEI), polyetheretherketone (PEEK) and polytetrafluoroethylene (PTFE) may also be used. The tape may also comprise several fiber types, for example quartz fiber and polyester fiber.

The resin may be thermosetting or thermoplastic. It is generally thermosetting and is preferably an epoxy or a cyanate ester. The resin may also be made of bismaleimide (BMI), polyimide, PEEK, PEI, polyphenylene sulfide (PPS) or polyester.

Table 1 below gives the properties of a few fibers that may be used to produce the tape according to the invention.

Table 1: Reinforcing fibers

Fiber	**Density (g/cm^3)**	**Dielectric constant**	**Dielectric loss tangent**	**Young's modulus (GPa)**	**Tensile strength**	**Elongation**
HDPE	0.97	2.2	0.0003	100	2700	3.5
PEI	1.22	3.5	0.01	4	100	30
PEEK	1.3	3.1	0.004	3.5	793	20
Aramid	1.45	3.85	0.012	160	2400	1.5
PTFE	2.1	2.08	0.0001	2.5	359	19
D-glass	2.14	4	0.0026	55	2500	4.5
Silica (Quartzel)	2.2	3.78	0.0001	72	3600	4 to 7 %
S2-glass	2.46	5.2	0.006	87	4890	5.7
R-glass	2.54	6	0.005	86	4400	5.2
E-glass	2.59	6.13	0.004	73	3400	4.5
Low K-glass		4.5 - 5	0.0053			

Table 2 below gives the properties of several resins that may be used to produce the tape according to the invention.

Table 2: Resins

Resin	T_g (°C)	Density (g/cm^3)	Dielectric constant	Dielectric loss tangent	Resin type
Epoxy	120 - 200	1.1 - 1.4	2.9 - 3.4	0.02	Thermosetting
Cyanate ester	190 - 290	1.1 - 1.4	2.7 - 2.9	0.002 - 0.005	Thermosetting
BMI	220 - 280	1.25	2.9 - 3.2	0.009 - 0.01	Thermosetting
Polyimide	250 - 350	1 - 1.35	2.8 - 3.2	0.005 - 0.014	Thermosetting
PEEK	250 - 300	1.26 - 1.32	3.2 - 3.3	0.004	Thermoplastic
PEI	170 - 200	1.27	3.2	0.01	Thermoplastic
PPS	200 - 240	1.30	3.2	0.001 - 0.0013	Thermoplastic

The fiber content in the tape is generally greater than 30 vol% and generally less than 80 vol%.

The resin formulation, optional additives (for example a plasticizer like polyethylene glycol adipate) and the fibrous structure are chosen in order to obtain an impregnated tape possessing a rigidity of between 5° and 30° and preferably between 8° and 22°.

The rigidity is measured, at the temperature (for example at room temperature, for example 20°C) at which the fiber is to be placed, on the tape impregnated with tacky resin (therefore uncured in the case of a thermosetting resin).

The rigidity of the tape is essentially governed by, on the one hand, the rigidity of the fibrous structure and, on the other hand, by the viscosity of the resin. The lack of consistency of one of these two ingredients may be compensated for by increasing that of the other. For a given resin, it may be possible to provide a fibrous structure that is rigid enough for the final tape to indeed have the desired rigidity.

By way of indication, the rigidities of certain textile structures, having the same external dimensions and density, are given below in order of rigidity, from the most rigid to the least rigid: woven structure > braided structure > knitted structure > roving. Moreover, the greater the weight per unit area of the structure the more rigid it is. Moreover, a plain weave will be more rigid than a twill weave which will be more rigid than a satin weave.

The formulation of the resin may also be used to increase the rigidity of the final tape. As a general rule, for a given amount of polymer in the resin the viscosity of the resin, and therefore the rigidity of the final tape, may be increased by increasing the molecular weight of said polymer. The viscosity of the resin may also be reduced by increasing the amount of plasticizer, lubricant or monomer (and, more generally, the amount of low molecular weight molecules) that the resin contains. Therefore, for a given fibrous structure incorporated into a tape with generally greater than 30 vol% of fibers, the rigidity of the tape may be increased by increasing the proportion of high molecular weight molecules in the resin. This also amounts to increasing the viscosity of the resin, a compromise needing to be found between the ease with which the fibers are impregnated and the rigidity of the tape.

The tape must be tacky at the fiber placement temperature. The tack may, in particular, be influenced by varying the amount of lubricant or plasticizer in the resin. An increase in the amount of lubricant or plasticizer reduces the tack. An example of a possible lubricant is an alkylbenzene whether alkoxylated or not. Mixtures of lubricant compounds can also be used. By promoting slip between polymer chains, lubricants also often have a plasticizing effect.

A tape according to the invention, having at the same time and at a given temperature the desired tack and the desired rigidity, may be produced by combining a resin tacky at said temperature with a sufficiently rigid fibrous structure in order for tape to attain the targeted rigidity.

The tape generally has a width of between 1 and 100 mm and a thickness ranging from 0.1 to 0.5 mm. The width of the tape more generally ranges from 3 to 24 mm and is, very commonly, 6.35 mm. The tape may be a roving, a woven, a nonwoven or a knit. In the case of a woven tape, the weft may be cut or uncut because of the use of a shuttle. In the case of a roving, this may be a direct or indirect roving. In a direct roving, fibers are gathered directly beneath the bushings into a roving and the roving is continuously impregnated (in the shed) with resin using, for example, the anhydrous size technique. In the case of a thermosetting resin, this resin may, for example, be applied onto the roving with the aid of two rollers, the first applying the base polymer of the resin and the second applying the hardener. In an indirect roving, fibers are first formed by bushings and various fibers are gathered into a roving, next this roving is wound onto a reel which may be stored. At a later date the roving is impregnated with resin, as in the case of the direct roving, after unwinding the reel of roving.

The invention also relates to a process for manufacturing the tape according to the invention, comprising the fiberization of quartz fibers followed by impregnation of said fibers with an anhydrous size, said impregnation comprising the application of a first liquid component comprising a polymer, and if necessary a silane (to obtain a good interface between the fiber and the polymer), and then the application of a second liquid component comprising a polymer hardener, the fibers then being assembled into a roving and coiled, an interlayer (generally a plastic sheet such as Mylar, or a PE or PTFE) generally being placed between each layer so as to limit adhesion of layers to one another. In this process, it is unnecessary to pass via an intermediate step of forming a cake. To produce a quartz fiber, one end of a silica rod less than 7 mm in diameter, generally 2 to 6 mm in diameter, may, for example, be melted and attenuated in an oxy-propane burner in order to create a filament with a diameter of less than 0.5 mm. This filament may then be attenuated again in the flame of a second oxy-propane burner. The quartz filaments thus obtained generally have a diameter of less than 50 µm optimally centered on 9 µm, for example being between 5 and 15 µm. This process does not require bushings.

Generally, the tape is kept on a reel before use in the fiber placement technique. The tape contains the resin that subsequently acts as the matrix of the future composite.

In the case of a thermosetting resin, the resin contains the hardener which will cause, after the fiber placement by machine, the solidification of the matrix by polymerization or crosslinking. To ensure that the tape does not harden before use, it is generally kept cold, generally at a temperature between -5 and -25°C and more generally around -16°C. In the case of a thermosetting resin, the tape strands are generally placed at a temperature below 40°C, generally at room temperature, generally between 10 and 40°C. The resin hardens when the composite structure is submitted to a heat treatment (generally at between 80°C and 220°C) for curing by polymerization or crosslinking.

In the case of a thermoplastic resin, the prepreg tape is generally kept at room temperature. With the fiber placement technique, the tape is applied hot, at a temperature at which the tape has a tack suitable for this technique. Thermoplastic resins requiring high temperatures to soften them and make them tacky are generally employed in order for the final composite to be able to withstand the temperatures it meets in service, these being lower than those employed during the placement of the strands of tape.

When used, the tape is applied with the fiber placement technique at a temperature at which it has tack sufficient for the strands placed by the fiber placement machine to adhere to and preserve the shape of that onto which they are placed (whether the mold or the tape segments that have previously been placed). This technique especially allows various strands of tape to be crossed or at least to be placed in very different directions. The tape according to the invention is continuous and flexible enough to be wound onto a reel. For forming by fiber placement by machine, the tape is unwound, placed so as to be formed, and cut by said machine. The tape is thus tacky enough to adhere during forming but not so tacky that the unwinding of the reel is hindered. The temperatures at which the reel is unwound and at which the strands of tape are placed are optimized so as to attain these tack or an absence of tack properties.

After the fibers have been placed, the resin is cured by heating the final material to a cure temperature.

A thermoplastic resin, the glass transition temperature T_g of which is between 80 and 250°C, may be used. In the case of a thermoplastic resin, the resin is applied, during fiber placement, at a temperature higher than T_g, the return to a temperature causing it to cure. Here again, it suffices to allow the formed part to return to room temperature (generally between 10 and 40°C).

The invention also relates to a process for manufacturing a multi-curvature composite by the fiber placement technique comprising the placement of the tape according to the invention onto a multi-curvature mold and the cutting thereof, said placement and cutting being carried out at a temperature at which the tape exhibits simultaneously tack and a rigidity ranging from 5 to 30°, followed by curing of the resin. In particular, the mold may comprise regions the surfaces of which are curved in all directions.

The invention also relates to the composite produced by the process according to the invention.

This composite may, in particular, be a radome, possibly of a flying machine.

Figure 1 shows the method used to characterize the tape according to the invention. A 5-cm piece of the tape 1 impregnated with uncured resin, as the resin will be in the final material (in fact, at the fiber placement temperature), is placed onto a surface 2. Firstly it is placed straight and the unsupported part of the tape sags a finite amount. The tangent 4 to the tape 1 passing through its end 3 unsupported by the surface 2 is drawn. The rigidity is expressed by the angle 5 made by the tangent 4 to the horizontal plane of the surface 2.

Example 1:

A quartz fiber tape was woven, with a narrow fabric shuttle loom, with a satin weave of 8/280 g/m^2 from C9 33X2 Quartzel QS1318 fiber. This technology allows cut selvedges to be avoided, which may cause problems with the marriage of the various tapes side by side. The tape was produced with a width of 6.35 mm. This tape was then impregnated with an epoxy resin or a cyanate ester resin in a fiber content of 60 vol%. A resin that is very suitable for this type of impregnation is a cycloaliphatic resin such as Araldite CY 184, sold by Huntsman: its viscosity is 700 - 900 mPa.s. This system may be used with a modified cycloaliphatic anhydride hardener. Aradur HY 1235, sold by Huntsman, is a good candidate for this type of application. The resin/hardener mixture is in an amount of 60/40 by weight. A high molecular weight resin may be added, for example PY 307-1 (an epoxy), to make the structure more rigid, compatible with the rigidity requirements of the fiber placement process. This type of thermosetting composition allows very fluid solutions to be used for the impregnation. The tape is then kept cold at -16°C. With a mixture of 80% PY 307-1, 10% CY 184 and 10% Aradur HY 1235, a tape with a rigidity of 15° at 20°C was obtained. The amount of impregnation was 40 vol%. There was enough tack at 20°C. Fiber placement machines could use the impregnated tape directly.

Example 2

A 5/280 g/m^2 satin weave/68-tex C9 E-glass yarn tape was woven with a Muller™ narrow fabric needle loom. With this technology the selvedges are cut. The tape was produced with a width of 6.35 mm. The tape was then impregnated with an epoxy or a cyanate ester resin giving a fiber content of 60 vol%. The impregnation resin used was a novolac epoxy that had an average viscosity of between 30,000 and 50,000 mPa.s at 20°C, for example Araldite PY 307-1. Epon 828 sold by Hexion may also be used. The product is used with one of the following catalysts: Actiron NX 3 (2,4,6-tris(dimethylaminomethyl)phenol) or NX 91 (benzyldimethylamine) sold by Synthron-Protex. With a mixture of 60% Araldite PY 307-1, 18.5% Araldite DY-D, 18.5% Araldite DY-E and 3% Actiron NX 3, a tape with a rigidity of 13° was obtained. The amount of impregnation was 40 vol%. There was enough tack. The tape was kept cold at -16°C. Fiber placement machines could use the impregnated tape directly.

Example 3

A 5/280 g/m^2 sating weave/68-tex C9 E-glass yarn fabric was woven with a rapier loom. The fabric was then impregnated with cyanate ester resin giving a fiber content of 65 vol%. For example, the resin AroCy L-10 sold by Huntsman is used. The latter is mixed with a thermoplastic powder such as a polysulfone (Udel P-1800), a polyethersulfone (Victrex 5003P), a polyetherimide (Ultem 1000), a thermoplastic polymide (Matrimid 5218) or epoxy resins, for example a glycidyl epoxy resin. A catalyst system based on a copper, cobalt or zinc carboxylate is used as a catalyst for the curing of the resin. This type of composition allows very fluid systems that are advantageous for fiber placement. A high molecular weight resin may be added, for example AroCy B-50, to make the structure more rigid, compatible with the rigidity requirements of the fiber placement process. The impregnated fabric is then cut to form a tape of the width required for fiber placement. The tape is generally produced with a width of 6.35 mm. With a mixture of 60% AroCy B-50 and 40% AroCy L-10, a tape with a rigidity of 20° at 20°C was obtained with an amount of impregnation of 35 vol%. There was enough tack. The tape was then kept cold at -16°C. Fiber placement machines could use the impregnated tape directly.

Example 4

An assembled roving was produced from Low Dk-glass yarn. The number of roving ends was calculated to obtain the roving width required for the fiber placement. The roving was then impregnated with a PTFE dielectric resin. With 50 vol% fiber content, a rigidity of 10° could be obtained. Fiber placement of PTFE resin based fibers is difficult at 20°C due to the PTFE having little tack at 20°C. The tape was then kept at room temperature. Fiber placement machines could use the impregnated tape directly.

Example 5

An S2-glass direct roving was fabricated directly after the fiberization of the reinforcing material in the specified width. The roving was then impregnated with a dielectric resin of the polyimide type. There was enough tack. The tape was then kept cold at -16°C. Fiber placement machines could use the impregnated tape directly.

Example 6

A Quartzel quartz fiber direct roving was fabricated directly after the fiberization of the reinforcing material in the specified width. This roving was impregnated just after the fiberization with an anhydrous size system composed of a constituent A and a constituent B. Constituent A was a mixture of PY 307-1 epoxy resin and A-1128 silane (ratio 95/5) and Constituent B was a mixture of Actiron NX-91 hardener and an ethylhexyl adipate plasticizer (ratio 95/5). These constituents were heated to 40°C to fluidize them. The levels of fluidity sought were less than 30,000 mPa.s and even less than 10,000 mPa.s. With this type of composition, a tape with an impregnation amount of 50 vol% had a rigidity of 25° at 20°C. The tape was tacky enough. The tape was then kept cold at -16°C. Fiber placement machines could use the impregnated tape directly.

Example 7

A fiber tape was impregnated with a polyester resin using the so-called "Tow Impregnation of Unidirectional Fiber Preform" technology. The tape was then kept cold at -16°C. The tape was tacky enough. Fiber placement machines could use the impregnated tape directly.

Examples 8 to 13

In all cases, a 24×80 tex C14 quartz roving with a QS1318 size was used as the fibrous structure. The fiber content in the tape was 60 vol% (40 vol% resin). The flexibility (the inverse of rigidity) at 20°C of the final tape was assigned an estimated value ranging from 0 (maximum rigidity) to 10 (very flexible). A flexibility of 1 to 3 substantially corresponded to a rigidity of between 5 and 30°. The results are shown in Table 3.

Table 3

POLYMER	**BRAND (SUPPLIER)**	Ex. 8	Ex. 9	Ex 10.	Ex. 11	Ex. 12	Ex. 13
Epoxy phenol novolac	Araldite PY 307-1 (Huntsman)	60	58			24	
Polybutadiene (MW 1200) diglycidyl ether	PolyBD 600 (Sartomer)			60	48	24	21
Cycloaliphatic epoxy	Araldite CY 205 (Huntsman)						24
MONOMER							
Cyclohexanedimethanol diglycidyl ether	Araldite DY-C (Huntsman)			18.5	24.5	24.5	19
Butanediol diglycidyl ether	Araldite DY-D (Huntsman)	18.5	18				18
Lauryl glycidyl ether	Araldite DY-E (Huntsman)	18.5	18	18.5	24.5	24.5	
PLASTICIZER							
Ethylhexyl adipate	Ethylhexyl adipate						15
CATALYST							
Tri(dimethylaminomethyl)phenol	Actiron NX 3 (Synthron-Protex)	3	6	3	3	3	3
RESULT	**FLEXIBILITY (0 to 10)**	1	3	9	8	5	6

PATENTKRAV

1. Fortløbende bånd, som omfatter en fibrøs struktur, der omfatter kontinuerlige eller diskontinuerlige fibre og en harpiks, som er klæbrig ved en temperatur gående fra stuetemperatur til 300 °C, hvor båndet ved 20 °C og 9,375 GHz har en dielektricitetskonstant på mellem 2 og 7 og en dielektrisk tabstangent på mellem $1\cdot10^{-4}$ og $3\cdot10^{-2}$, hvor den fibrøse struktur er tilstrækkelig rigid til, at båndet har en stivhed på mellem 5 og 30° ved en temperatur, ved hvilken harpiksen er klæbrig, hvor stivheden af båndet er målt med udgangspunkt i et retlinjet segment med en længde på 15 cm, hvoraf 5 cm er anbragt på kanten af en vandret overflade og de 10 cm, som ikke er understøttet, giver efter for at danne en vinkel med det vandrette, hvilken vinkel karakteriserer stivheden af båndet.

2. Bånd ifølge det foregående krav, kendetegnet ved, at dets dielektricitetskonstant er mindre end 3,5.

3. Bånd ifølge det foregående krav, kendetegnet ved, at dets bredde er på mellem 1 og 100 mm, og dets tykkelse går fra 0,1 til 0,5 mm.

4. Bånd ifølge det foregående krav, kendetegnet ved, at dets bredde går fra 3 til 24 mm.

5. Bånd ifølge ét af de foregående krav, kendetegnet ved, at det indeholder mellem 30 og 80 volumenprocent fibre.

6. Bånd ifølge ét af de foregående krav, kendetegnet ved, at dets stivhed er på mellem 8° og 22°.

7. Bånd ifølge ét af de foregående krav, kendetegnet ved, at det omfatter fibre omfattende mere end 50 vægtprocent SiO_2.

8. Bånd ifølge det foregående krav, kendetegnet ved, at det omfatter fibre omfattende mere end 90 vægtprocent SiO_2.

9. Bånd ifølge ét af de foregående krav, kendetegnet ved, at harpiksen er af epoxytypen eller cyanatestertypen.

10. Fremgangsmåde til fremstilling af et bånd ifølge ét af de foregående krav, hvilken fremgangsmåde omfatter fibrering af kvartsfibre efterfulgt af en imprægnering af disse fibre med en vandfri indfedtning ved påføring af en første flydende komponent omfattende en polymer og så påføring af en anden flydende komponent omfattende en polymerhærder, hvor fibrene derpå sammenføjes og opvikles som forgarn (roving).

11. Fremgangsmåde til fremstilling af et kompositmateriale, som omfatter krumninger, ved hjælp af fiberplaceringsteknikken omfattende på en form, som omfatter krumninger, at placere og afskære bånd ifølge ét af de foregående båndkrav, hvor placeringen og afskæringen udføres ved en temperatur, ved hvilken båndet samtidig er klæbrigt og har en stivhed gående mellem 5 og 30°, fulgt af hærdning af harpiksen.

12. Fremgangsmåde ifølge det foregående krav, kendetegnet ved, at formen omfatter zoner, hvor overfladen er krummet i alle retninger.

13. Kompositmateriale frembragt ved fremgangsmåden ifølge ét af de to foregående krav.

14. Radom i et kompositmateriale ifølge det foregående krav.

15. Flyveindretning omfattende radomet ifølge det foregående krav.

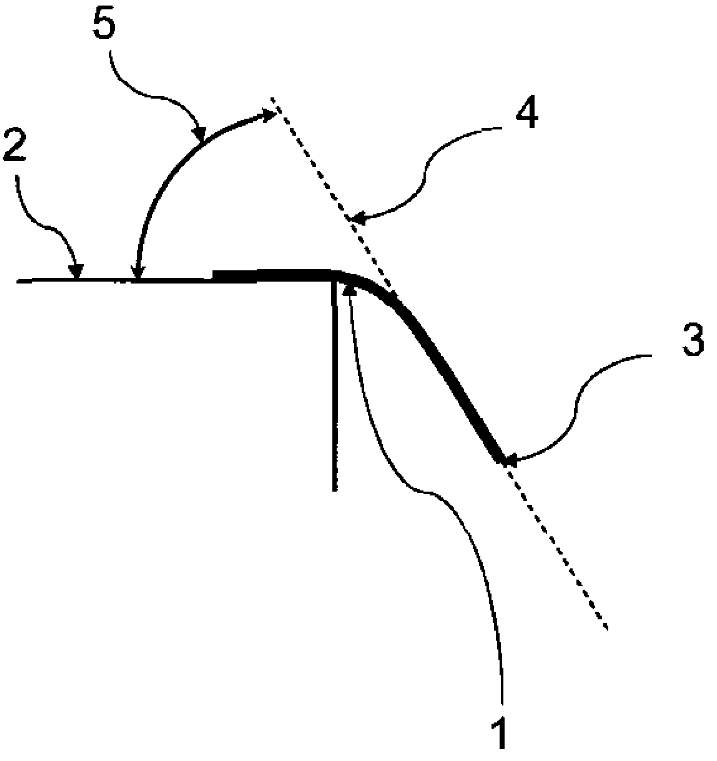

Fig 1