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(54) **Hybrid grass**

(57) The present invention relates to a mat **(100)** for a hybrid grass surface **(500)** comprising a sheet **(50)** comprising a plurality of apertures **(60, 60')** configured for the passage of one or more roots **(304)** of natural grass **(300),** and a plurality of filaments **(200, 200')** grouped into tufts **(202, 202')** attached to said sheet **(50).** The invention further provides a kit for a hybrid grass surface **(500)** and a hybrid grass surface **(500)** comprising said mat **(100).**

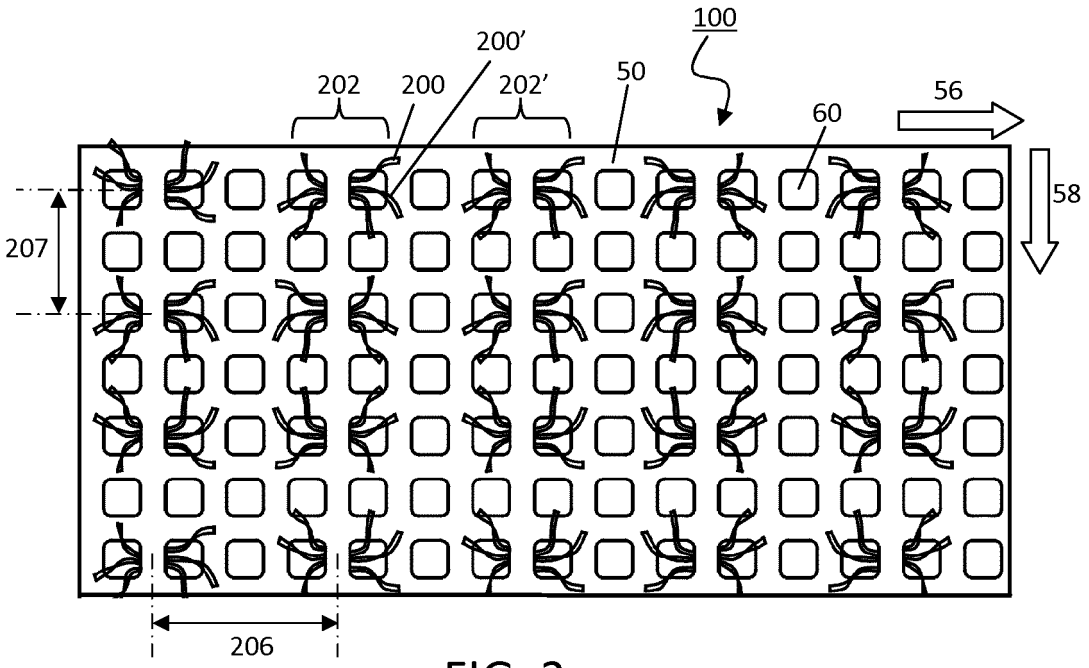

FIG. 3

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a mat for a hybrid grass surface, more particularly a mat comprising a sheet and filaments attached to the sheet (i.e. artificial grass) that can be combined with natural grass. The invention also relates to a hybrid grass surface comprising said mat, and a kit for a hybrid grass surface.

BACKGROUND OF THE INVENTION

[0002] Lawns in any weather and in any season that are subject to heavy wear sustain damage to the roots and leaves of the grass. In particular lawns used for sports need to be able to withstand heavy wear, and be amenable to rapid repair between games. In addition, they require regular maintenance through mowing which removes nutrients when the clippings are discarded.

[0003] A hybrid lawn - which is a combination of artificial grass fiber and natural grass - improves durability of the natural grass. To enhance the natural grass, sometimes the root is reinforced with loose synthetic or organic fibers. A principle disadvantage of this mat is that the ground becomes very hard after some time, rendering it unsuitable as a playing surface for certain games. Additionally, hybrid lawns are sometimes prone to the formulation of lumps caused by clumps of grass being raised above the level of the artificial grass blades; this affects ball rolling, and can interfere with running activities. Additionally, hybrid lawns appear to be more prone to disease, particular after the summer when they are placed under additional weather related stress.

[0004] The present invention aims to overcome at least some of the disadvantages of the art.

SUMMARY OF THE INVENTION

[0005] In an aspect, the invention provides a mat **(100)** for a hybrid grass surface **(500)** comprising:

- a sheet **(50)** comprising a plurality of apertures **(60, 60')** configured for the passage of one or more roots **(304)** of natural grass **(300)**, and
- a plurality of filaments **(200, 200')** grouped into tufts **(202, 202')** attached to said sheet **(50)**.

[0006] In embodiments, the apertures **(60, 60')** are arranged in a regular pattern.

[0007] In embodiments, the average size of the apertures **(60, 60')** in the plurality is between 1 mm and 5 mm.

[0008] In embodiments, at least some of the apertures **(60, 60')** are occupied the remainder being unoccupied, and the number of unoccupied apertures per occupied aperture is greater than 1.

[0009] In embodiments, the sheet **(50)** is a woven sheet made of polyethylene or polypropylene or polyester or polylactic acid, or any combination thereof.

[0010] In embodiments, the average distance (**206**) between adjacent tufts (**202, 202'**) is between 1 cm and 6 cm.

[0011] In embodiments, the mat (**100**) has a pile height **(208)** of between 4 cm and 25 cm.

[0012] In embodiments, the filaments (**200, 200'**) of a tuft (**202, 202'**) are threaded through one or two or more apertures (**60, 60'**) in the sheet (**50**), thereby attaching them to the sheet (**50**).

[0013] In embodiments, the filaments (**200, 200'**) are secured to the sheet (**50**) by melting or by an adhesive material.

[0014] In embodiments, the filaments **(200, 200')** are made at least partially, preferably entirely of polyethylene or polylactic acid, preferably polylactic acid.

[0015] The invention also relates to a kit for a hybrid grass surface comprising:

- a mat **(100)** according to any one of claims 1 to 10,
- natural grass seeds,
- infill material **(403)**,
- optionally base material **(406)**, and
- optionally stone material **(452).**

[0016] In a further aspect, the invention provides a hybrid grass surface **(500)** comprising:

- a mat **(100)** according to any one of claims 1 to 10,
- natural grass **(300)**,
- an infill section **(402)** comprising sandy infill material **(403)**,
- a sub-section **(404)** comprising sandy base material **(406)** disposed below said top layer **(402)**, and
- a drainage layer **(450)** comprising stone material **(452)** positioned below said sub-section **(404)**,

[0017] wherein the sheet **(50)** of the mat **(100)** is positioned between said infill section **(402)** and said sub-section **(404)**, and wherein the depth of said infill section **(402)** is lower than the pile height **(208)** of the mat **(100)**.

[0018] In embodiments, the density of the filaments **(202, 202')** is less than 30% of the density of the natural grass fibres.

[0019] In embodiments, the depth of the infill section **(402)** is between 3 cm and 23 cm.In embodiments, the depth of the sub-section **(404)** is between 10 cm and 25 cm.

LEGENDS TO THE FIGURES

[0020]

FIG. 1 is a schematic cross-sectional view through a mat for a hybrid grass surface according to one embodiment of the invention, comprising a sheet with a plurality of apertures, and tufted filaments attached to the sheet.

FIG. 2 is a schematic top view of a sheet, illustrating an arrangement of apertures across the sheet.

FIG. 3 is a schematic top view of a sheet as illustrated in **FIG. 3** with a plurality of tufts of filaments attached to the sheet.

FIG. 4 is a vertical cross-section through one embodiment of a hybrid grass surface according to the invention.

DETAILED DESCRIPTION OF INVENTION

[0021] Before the present method used in the invention is described, it is to be understood that this invention is not limited to particular methods, components, or products described, as such methods, components, and products may, of course, vary. It is also to be understood that the terminology used herein is not intended to be limiting, since the scope of the present invention will be limited only by the appended claims.

[0022] As used herein, the singular forms "a", "an", and "the" include both singular and plural referents unless the context clearly dictates otherwise.

[0023] The terms "comprising", "comprises" and "comprised of" as used herein are synonymous with "including", "includes" or "containing", "contains", and are inclusive or open-ended and do not exclude additional, non-recited members, elements or method steps. The terms "comprising", "comprises" and "comprised of" also include the term "consisting of". The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within the respective ranges, as well as the recited endpoints.

[0024] The term "about" as used herein when referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of +/-10% or less, preferably +/-5% or less, more preferably +/-1% or less, and still more preferably +/-0.1% or less of and from the specified value, insofar such variations are appropriate to perform in the disclosed invention. It is to be understood that the value to which the modifier "about" refers is itself also specifically, and preferably, disclosed.

[0025] Unless otherwise defined, all terms used in disclosing the invention, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. By means of further guidance, definitions for the terms used in the description are included to better appreciate the teaching of the present invention.

[0026] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment, but may. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to a person skilled in the art from this disclosure, in one or more embodiments. Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

[0027] In the present description of the invention, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration only of specific embodiments in which the invention may be practiced. Parenthesized or emboldened reference numerals affixed to respective elements merely exemplify the elements by way of example, with which it is not intended to limit the respective elements. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

[0028] With reference to **FIGs. 1** to **4**, the present invention relates to a mat (**100**) for a hybrid grass surface (**500**). A hybrid grass surface (**500**) refers to a grass surface, suitable as, for instance, a playing surface, comprising natural grass (**300**) and the instant mat (**100**), namely it is a combination of natural and artificial grass. The benefits of a hybrid grass surface (**500**) include low maintenance, all-weather playability, durability, and reduction in friction burns. Besides containing natural grass (**300**) and the instant mat (**100**), the hybrid grass surface (**500**) typically contains an infill section (**402**) comprising one or more layers of infill material (**403**). It may contain a sub-layer (**404**) below the sheet (**50**) and a drainage section (**450**) below the sub-layer (**404**) as discussed elsewhere herein.

[0029] With reference to **FIG. 1**, the mat (**100**) comprises a sheet (**50**) disposed with a plurality of apertures (**60, 60'**). An aperture (**60, 60'**) is configured for the passage of one or more roots (**304**) of the natural grass (**300**). The mat (**100**) further comprises a plurality of filaments (**200, 200'**) attached to the sheet (**50**). The mat (**100**) has an upper side (**52**), from which the filaments (**200, 200'**) protrude to form a pile, and an underside (**54**) that is opposite to the upper side (**52**).

[0030] The sheet provides a supporting base onto which the filaments (**200, 200'**) are attached and preferably formed into tufts (**202, 202'**). It also provides slow drainage barrier, allowing the passage both of water and of the grass roots.

[0031] An aperture (**60, 60'**) is a discrete passage in the sheet (**50**) that connects one (*e.g.* upper side (**52**)

surface to the other (*e.g.* underside (**54**) surface. The aperture is configured for the passage of one or more roots (**304**) of the natural grass (**300**). In other words, it allows a root (**304**) to pass from one side of the sheet (**50**) to the other side. The skilled person can readily determine a suitable aperture dimension by measuring the size of the root at one or more places, and determining a minimum size that would allow the growing root to pass. It will be appreciated that a tolerance is included to allow for an expanded root as the grass matures. As a general guidance, the size of an aperture (**60, 60'**) in the sheet (**50**) may be at least about 1 mm, such as between about 1 mm and about 5 mm, preferably at least about 2 mm, more preferably between about 2 mm and about 4 mm; the aperture size is determined across the narrowest part. For a plurality of apertures, the average size may be at least about 1 mm, such as between about 1 mm and about 5 mm, preferably at least about 2 mm, more preferably between about 2 mm and about 4 mm. The apertures (**60, 60'**) in the sheet (**50**) further contribute to the water permeability of the sheet (**50**).

[0032] The aperture may have a circular profile; however, other shapes are envisaged including oval, square, polygonal and irregular. The apertures (**60, 60'**) on a sheet (**50**) preferably all have the same shape and size. However, it is within the scope of the invention that at least two apertures have a different size.

[0033] The apertures (**60, 60'**) in the sheet (**50**) are preferably regularly disposed. For instance, they may be provided as a grid as shown in **FIG. 2.** The distance (**62**) between adjacent apertures in a first direction (**56**) (*e.g.* lengthways) may be the same or different from the distance (**64**) between apertures in a second direction (**58**) perpendicular to the first direction (*e.g.* breadthways).

[0034] The average distance (**62, 64**) between adjacent apertures (**60, 60'**) in the plurality of apertures in the sheet (**50**) in a first (**56**) and second (**58**) direction may be the same and may be between 0.1 mm and 10 mm, preferably between 1 mm and 2 mm. The average distance (**62, 64**) between adjacent apertures (**60, 60'**) in the plurality of apertures in the sheet (**50**) in a first (**56**) and second (**58**) direction may be different. The distance (**62**) between adjacent apertures in the plurality of apertures in the sheet (**50**) in a first (**56**) direction may be between 0.1 mm and 20 mm, preferably between 1 mm and 20 mm. The distance (**64**) between adjacent apertures in the plurality of apertures in the sheet (**50**) in a second (**58**) direction may be between 0.1 mm and 20 mm, preferably between 1 mm and 20 mm.

[0035] The distance is measured from the respective centers of gravities (*e.g.* the geometric center) of the apertures. The distance is preferably measured between apertures in the first direction (**56**) or the second direction (**58**).

[0036] The number of apertures per square meter in the sheet (**50**) may be between 100 000 and 300 000, preferably between 120 000 and 180 000.

[0037] The sheet (**50**) may be made of any suitable material having requisite properties of durability and non-biodegradability. The sheet (**50**) may be made at least partly, preferably essentially entirely from for example a woven or non-woven sheet, a knitted fabric, felted material or extruded web. The sheet (**50**) may be a geotextile. The apertures (**60, 60'**) in the sheet may be introduced during the weaving process in the case of a woven sheet.

[0038] In preferred embodiments, the sheet (**50**) is a woven sheet, more preferably a leno woven sheet. A leno weave, known in the art, comprises two warp yarns twisted with respect to each other and running in a first direction, and interlacing with more than one weft yarn running in a different second direction, which results in a strong yet sheer and open fabric.

[0039] A woven sheet may be made at least partly, preferably essentially entirely from synthetic fibers, such as, for example polyolefins such as polypropylene, or polyethylene, or polyester, or biological fibers, such as, for example, polylactic acid. The sheet (**50**) is preferably made from polyester, which is more stable compared to the alternative materials. The sheet (**50**) may be a geotextile.

[0040] The sheet (**50**) may have a thickness of between about 0.1 mm and about 5 mm.

[0041] The sheet (**50**) may be a three-dimensional sheet comprising at least two textile sheets (*e.g.* 2, 3, 4 or more) which are joined together and kept apart by spacer yarns. In embodiments, the sheet (**50**) is a three-dimensional sheet comprising or consisting of two outer textile sheets which are joined together and kept apart by spacer yarns. A three-dimensional fabric or spacer fabric is a specialized three-dimensional textile that uniquely facilitates air flow, breathability and lightweight shape support. Its construction, which reduces heat build-up, allows consistent air circulation and provides high moisture transfer. Additional benefits include cushioning and shock absorbency with excellent recovery properties. Specialized machinery knits or weaves at least two surfaces at the same time with interior spacing. Height of the spacer fabric can be between 1 mm and 30 mm, preferably between 3 mm and 10 mm. The advantages of the spacer fabric are the permeability for the grass roots to penetrate the fabric and grow deep roots into the ground. It would also support the artificial turf on the entire height of the spacer fabric and help the artificial turf yarns to stand straight, as well as increase the flattening recovery. Another advantage is the high moisture transfer, which allows the water from rain or from watering the natural grass to more easily drain the surface and thus avoid the creation of puddles on the field. Yet another advantage is improved shock absorbency. The filaments (**200, 200'**), equivalent to blades of grass (**302**), are attached to the sheet (**50**).

[0042] The filaments (**200, 200'**) on the sheet (**50**) are, in general, grouped into tufts (**202, 202'**). Typically, a plurality of filaments (**200, 200'**) is threaded through one or two or more apertures (**60, 60'**) in the sheet (**50**), preferably adjacent apertures, giving rise to a tuft (**202, 202'**).

In other words, at least some of the apertures (**60, 60'**) of the sheet (**50**) are occupied by filaments. The mat (**100**) comprising a sheet (**50**) and tufts (**202, 202'**) may be produced by feeding the filaments (**200, 200'**) through the needles of a tufting machine and inserting them through the sheet **50.** An example of a tufted sheet *i.e.* a mat (**100**) is shown in **FIG. 3.** The tufts (**202, 202'**) are made up by both free ends of the filaments

[0043] (**200, 200'**) projecting from one side (e.g. the upper side (**52**)) of the sheet (**50**) and are preferably secured to the opposite side (e.g. the underside (**54**)) of the sheet (**50**).

[0044] The number of filaments (**200, 200'**) per tuft (**202, 202'**) on the sheet (**50**) can vary, but generally there will be between 2 to 20, preferably 4 to 12 or 4 to 8.

[0045] The tufts (**202, 202'**) on the sheet (**50**) are preferably disposed in a regular arrangement across the sheet (**50**). An exemplary arrangement is shown in **FIG. 3** and comprises rows of tufts in a first direction (**56**) (*e.g.* lengthways). The rows are repeated in a second direction (**58**) (*e.g.* sideways) which direction perpendicular to the first direction (**56**), such that the repeated rows are mutually parallel. Tufts (**202, 202'**) in the repeated rows may be aligned or staggered.

[0046] The average distance (**206**) between adjacent tufts (**202, 202'**) on the sheet (**50**) in a first direction (**56**) (*e.g.* lengthways) may be the same or different from the distance (**207**) between adjacent tufts (**202, 202'**) in a second direction (**58**) perpendicular to the first direction (*e.g.* sideways). The average distance (**206, 207**) between adjacent tufts (**202, 202'**) on the sheet (**50**) in a first (**56**) and second (**58**) direction may be the same and may be between 1.0 cm and 6.0 cm, preferably between 1.5 cm and 3.0 cm. Preferably, the average distance (**206, 207**) between adjacent tufts (**202, 202'**) on the sheet (**50**) in a first (**56**) and second (**58**) direction may be different, most preferably it is different. The average distance (**206**) between adjacent tufts (**202, 202'**) on the sheet (**50**) in a first (**56**) direction may be between 5 mm and 15 mm, preferably between 8 mm and 12 mm. The average distance (**207**) between adjacent tufts (**202, 202'**) on the sheet (**50**) in a second (**58**) direction may be between 1.0 cm and 6.0 cm, preferably between 1.5 cm and 3.0 cm. The distance (**206, 207**) between two adjacent tufts is measured from the center (**204**) of each tuft. The distance is preferably measured between adjacent tufts in the first direction (**56**) and/or in the second direction (**58**).

[0047] The mat (**100**) may comprise 250 to 10000 tufts (**202, 202'**) per square meter of sheet (**50**), preferably between 500 and 7500, more preferably between 1000 and 5000.

[0048] At least some of the apertures (**60, 60'**) in mat (**100**) are unoccupied. By unoccupied, it is meant they do not contain filaments or other elements such as adhesive that would at least partially or fully occlude the aperture. At least some of the apertures (**60, 60'**) in sheet are occupied. By occupied, it is meant they contain mat elements such as filaments and/or adhesive that at least partially or fully occlude the aperture. According to one aspect, the at least some of the apertures (**60, 60'**) in mat (**100**) are occupied, the remainder being unoccupied. According to one aspect, the number of unoccupied apertures on the sheet (**50**) is greater than the number of occupied apertures. It is appreciated that the status (occupied/unoccupied) of the apertures refers to the mat (**100**) *per se*; while in use, an unoccupied aperture may become partially occluded with infill material, base material, grass roots etc., the status of the aperture of the mat is regarded an unoccupied. Preferably, the number of unoccupied apertures per occupied aperture is more than 1, for instance about 2, 3, 4, 6, 10, 20, 30, 50, 100 or a range between any two of the aforementioned values.

[0049] According to one aspect, the number of tufts (**202, 202'**) may not exceed the number of unoccupied (untufted) apertures (**60, 60'**) on the sheet. Preferably, there are 6, 8, 10, 12, 14, 16, 18 or 20 unoccupied (untufted) apertures (**60, 60'**) per tuft (**202, 202'**). Said unoccupied apertures are disposed around, preferably encompassing the tuft (**202, 202'**).

[0050] The filaments (**200, 200'**) may be fixedly attached or secured to the sheet (**50**). Typically, a plurality of filaments (**200, 200'**) is threaded through one or two or more apertures (**60,60'**) in the sheet (**50**), preferably adjacent apertures, giving rise to a fixed tuft (**202, 202'**).

[0051] The filaments (**200, 200'**) may be secured to the sheet (**50**) by stitching, by knitting, by melting or using an adhesive material, such as latex, foam, or a hot melt. The adhesive material may be applied to the underside (**54**) of the sheet where the filaments loop (**204,** or along a row of loops (**204**) in one or both directions. The melting process is particularly advantageous if the sheet (**50**) and the filaments (**200, 200'**) are made of the same material, or if the material of the sheet (**50**) has a greater melting point. Generally, fixing a filament by threading through one or two or more apertures (**60, 60'**) occludes said apertures.

[0052] The filaments (**200, 200'**) may be made of any suitable material providing sufficient wear resistance and/or resilience. These properties together with natural grass resemblance are the most important properties of artificial turf. The filaments (**200, 200'**) may be made at least partially, preferably essentially entirely from a polymeric material that may be synthetic or natural. The filaments (**200, 200'**) may be made at least partially, preferably essentially entirely from synthetic fibers, such as, for example, polypropylene or polyethylene (PE), such as medium density polyethylene (MDPE), high density polyethylene (HDPE) or low density linear polyethylene (LLDPE), or from biological fibers, such as, for example, polylactic acid (e.g. corn-derived polylactic acid), or any mixture thereof. The filaments (**200, 200'**) may additionally or alternatively be made of bicomponent material, e.g. a yarn with different core (e.g. PA) and shell material (e.g. PE). In embodiments, the filaments are made at

least partially, preferably essentially entirely from polyethylene. Polyethylene filaments have the advantage that they are easier to recycle and that they have a higher wear resistance than for example polypropylene fibers. They are also softer and give less skin abrasion. For a skilled person it is clear that the polyethylene contains certain additives such as UV and heat stabilisers. Optionally, it may even contain small amounts of one or more other polymers, more particularly in an amount of less than 10 % by weight, preferably less than 5 % by weight.

[0053] In preferred embodiments, the filaments are made at least partially, preferably essentially entirely from biological fibers, more preferably polylactic acid (PLA). PLA has the advantage that is environmentally friendly, since it is made from a renewable source.

[0054] The filaments (**200, 200'**) making up a tuft (**202, 202'**) may be made from the same or different materials.

[0055] The filaments (**200, 200'**) present in a tuft (**202, 202'**) may be continuous strand filaments (e.g. monotape filaments, or monofilaments) and/or fibrillated filaments. A tuft (**202, 202'**) may consist of one kind of filament such as entirely of continuous strand filaments (e.g. monotape filaments, or monofilaments) or entirely of fibrillated filaments. Alternatively, a tuft (**202, 202'**) may comprise a composite filament, each comprising a mixture of continuous strand filaments (e.g. monotape filaments, or monofilaments) and fibrillated filaments, or a mixture of continuous strand filaments (e.g. monotape filaments and monofilaments, or a mixture of continuous strand filaments with different shapes and thicknesses). In preferred embodiments, the mat (**100**) comprises continuous strand filaments, more preferably monofilaments.

[0056] Continuous strand filaments have a continuous, uninterrupted longitudinal surface, resembling blades of grass and devoid of openings or slits in the longitudinal surface. Continuous strand filaments are typically available in two sorts: monotape filaments and monofilaments.

[0057] Monotape filaments are produced by cutting an extruded film into narrow bands. The extruded film is preferably led over stretching drums to organize the molecules so that the strength of the film is increased. Instead of first producing a film, a more preferred way to produce the individual filament is to extrude them directly into the desired size so that no cutting operation is required. In this way, preferably also after a stretching step, a so-called monofilament is obtained.

[0058] A fibrillated filament is produced starting from an extruded film which is first cut into bands. In these bands longitudinal slits are made so that laterally interconnected filaments are formed. These slits can be made for example by means of a drum provided with needles (and rotated at a speed different from the speed of the film led over this drum) or teeth as disclosed in US 3496259.

[0059] A composite filament comprising a mixture of continuous strand filaments (e.g. monotape filaments, or monofilaments) and fibrillated filaments usually comprises 4 to 10, preferably 6 to 8 continuous strand filaments. It may comprise more than one fibrillated filament but preference is given to the presence of only one fibrillated filament. In order to make the composite filament, the continuous strand filament(s) and the fibrillated filaments are twined together. The word "twined" has to be understood here in its broadest meaning and includes for example also a simple twisting of the filaments. The composite filament may be twined in the S or Z direction. The number of windings (per meter) during the twining process must be limited in such a manner that the filaments will spread themselves again after the tufting process. This can be determined experimentally. The fibrillated filament(s) is preferably twined around the continuous strand filaments so that the composite filament has an outer surface which is mainly formed by the fibrillated filament(s).

[0060] A composite filament comprising a mixture of monotape filaments and monofilaments may be formed by a monotape filament twisted together with a number of monofilaments. The composite filament may comprise 1 to 6 and preferably 1 to 3 monotape filaments and 2 to 8, and preferably 4 to 6 monofilaments. The monotape filament is preferably twined around the monofilament so that the composite filament has an outer surface which is mainly formed by the monotape filament.

[0061] A filament (**200, 200'**) may have such a thickness and a width that it resembles a natural grass blade.

[0062] The width of a continuous strand filament is preferably smaller than 4 mm, more preferably smaller than 3 mm, and most preferably smaller than 2 mm, but larger than 0.8 mm, preferably larger than 1 mm. A fine, natural grass look is for example obtained when the width of a continuous strand filament comprises about 1.4 mm. The thickness of the continuous strand filaments is important to achieve the required resilience properties. Continuous strand filaments usually have a thickness of between 100 and 500 μm. Especially for polyethylene filaments, which provide less resilience than for example polypropylene filaments, the continuous strand filament has preferably a thickness larger than 250 μm, more preferably larger than 350 μm.

[0063] A fibrillated filament may have a total width of between about 8 mm and about 10 mm, preferably about 9 mm, the slits being arranged so that the interconnected filaments have a width which is preferably somewhat smaller than the width of a continuous strand filament as described above. Moreover, the slits are preferably not provided on the same mutual distances so that broader filaments are separated by narrower filaments which provide for a looser connection between the broader filaments. By selecting a smaller width of the filaments and/or a looser connection between the filaments, the filaments become immediately spread in a random manner after the tufting operation thus contributing to achieving immediately the natural look of grass. The yarn number of the fibrillated filament will normally be higher

than 2000 dtex and will usually be comprised between 5000 and 13000 dtex, and preferably between 10000 and 12000 dtex.

[0064] The thickness of a composite filament comprising a mixture of continuous strand filaments (e.g. monotape filaments, or monofilaments) and fibrillated filaments is preferably comprised between 60 and 120 μm, and more preferably between 90 and 100 μm. Since the fibrillated filament has interconnected arrangement, the thickness of the fibrillated filament may be smaller than the thickness of the continuous strand filament. A predetermined minimum thickness is however preferred in view of the increased wear resistance (mechanical wear and/or heat and UV degradation) and the increased resiliency obtained with a larger thickness. The yarn number of the composite filament will usually be larger than 9000, and preferably larger than 11000 dtex. Due to the limitations of the tufting machines, the yarn number of the composite filament will usually be smaller than 20000 and more particularly smaller than 17000 dtex. When only one fibrillated filament is present in the composite filament, it may have a larger yarn number so that the filaments are better connected with each other. The yarn number of the composite filament is preferably formed for at least 40%, more preferably for at least 50%, by the continuous strand filaments. When using a fibrillated filament with a smaller yarn number, the composite filament may contain more continuous strand filaments. The composite filament can for example be made with three fibrillated filaments, having each a yarn number of 2000 dtex. These fibrillated filaments can first be twined together and can subsequently, in a second twining operation, be twined together with continuous strand filaments.

[0065] The dimensions of the continuous strand filaments given above may apply to the monotape filaments and the monofilaments present in a composite filament. The width of the monotape filament is preferably larger than 1.5 mm, more preferably larger than 2 mm and preferably smaller than 3 mm. The thickness of monotape filament is not only important to achieve the look of natural grass, but also to achieve the required resilience properties. The monotape filament will usually have a thickness of between 100 and 150 μm, and preferably of between 100 and 120 μm. The yarn number of the monotape filament will usually be comprised between 1000 and 5000 dtex in order to resemble grass, and will more preferably be comprised between 2000 and 3000 dtex. The yarn number of the composite filament is preferably formed for at least 30%, more preferably for at least 40% by the monotape filament in view of resembling immediately as much as possible natural grass. More preferably, the yarn number of the composite filament is formed for at least 40% and at most 50% by the monotape filament. The yarn number of the composite filament will usually be higher than 8000, and preferably higher than 9000 dtex. Due to the limitations of the tufting machines, the yarn number of the composite filament will usually be smaller than 20000 and more particularly smaller than 15000 dtex.

[0066] The resilience properties of a filament are at least partly attributed to the profile of its cross-section. The cross-section is a transverse cross-section perpendicular to the central axis of a continuous strand filament.

[0067] A continuous strand filament may have a cross-section of a propeller profile, displaying a node and two arms. The node, in the centre of the continuous strand filament, may comprise the thickness previously described. The arms, starting from the node and separated from each other over 180°, may have, at the node, a thickness of between 200 to 400 μm, which gradually decreases towards the ends of the arms to a thickness in between 50 and 200 μm. The ends of the arms are curved in opposite direction over a distance of between 20 and 200 μm and over an angle of between 20° and 70°, and preferably over an angle of 45°. An alternative propeller profile may display a node and two curved arms. The node, in the centre of the continuous strand filament may comprises a thickness of between 0.4 to 0.6 mm, preferably between 0.5 to 0.6 mm, most preferably about 0.587 mm, and the length of the node may be between 1 to 3 mm, preferably between 1.5 to 2.5 mm, preferably about 2 mm. The arms, starting from the node and arranged at opposite ends of the node, may have, at the node, a thickness of 0.5 to 1 mm, which gradually decreases towards the ends of the arms to a thickness in between 0.2 and 0.5 mm, preferably 0.3 and 0.4 mm. The end of each arm may have a rounded edge with a radius of between 0.15 and 0.2 mm. The ends of the arms may be curved in opposite directions, to give a total distance between the ends of the arms of between 4 and 8 mm, preferably between 5 and 7 mm. The respective curves are preferably continuous.

[0068] Alternatively, a continuous strand filament may have a cross-section of a biconvex profile. The centre of the continuous strand filament displays the same thickness as previously described, and this thickness gradually decreases in a convex way towards the sides of the continuous strand filament, preferably to a point.

[0069] Another exemplary cross-section of a continuous strand filament is an S-like profile characterized in that the centre of the continuous strand filament is the same as previously described, but decreases gradually in a convex manner until a thickness of between 50 and 100 μm. The ends of the continuous strand filament are curved in opposite direction over a distance of between 20 and 200 μm and over an angle of between 20° and 70°, and preferably over an angle of 45°.

[0070] Yet another exemplary cross-section of a continuous strand filament is a waving profile, where the continuous strand filament has a thickness as mentioned before, which remains substantially the same over its entire width, and comprises two curves bent in opposite direction. The ends of the continuous strand filament are rounded.

[0071] A further example of a cross-section shape is a

trilobal figure with a thickness between 300 and 500 μm, and with a width of between 0,8 and 2 mm.

[0072] The above mentioned shapes are only examples of possible shapes, however, other shapes of the filaments (**200, 200'**) are envisaged.

[0073] The mat (**100**) has a pile height (**208**) of between 4 and 25 cm, more preferably between 5 and 12 cm, such as 5, 6, 7, 8, 9, 10, 11, or 12 cm. The pile height is to be determined by measuring and totalling the height of the different filaments of a number of tufts (**202, 202'**) and dividing the achieved number by the number of filaments (**200, 200'**). The height is measured vertically from the tip of the filament (**200, 200'**) to its point of contact with the sheet (**50**).

[0074] In embodiments, the mat (**100**) as taught herein comprises:

- a sheet (**50**) made of polyester, said sheet (**50**) comprising between about 120000 and about 180000 apertures (**60, 60'**) per square meter, wherein said apertures (**60, 60'**) are configured for the passage of one or more roots (**304**) of natural grass (**300**) and wherein the average distance (**62, 64**) between adjacent apertures (**60, 60'**) is between about 1 mm and about 2 mm, and

- a plurality of filaments (**200, 200'**) grouped into tufts (**202, 202'**) attached to said sheet (**50**), wherein said filaments (**200, 200'**) comprise or consist of monofilaments made of polyethylene, preferably UV-stabilized polyethylene, and wherein the number of filaments (**200, 200'**) per tuft (**202, 202'**) is about 12, wherein the mat (**100**) comprises between 1000 and 5000 tufts (**202, 202'**) per square meter of sheet (**50**), preferably about 2835 tufts (**202, 202'**) per square meter of sheet (**50**), and
  wherein the pile height (**208**) is about 7 cm.

[0075] A hybrid grass surface (**500**) according to the present invention comprises a mixture of artificial grass provided by the instant mat (**100**), and natural grass (**300**) as mentioned above.

[0076] Any natural grass is suitable for use in accordance with the present invention. Non-limiting examples of natural grass include *Lolium perenne* (commonly known as English ryegrass, winter ryegrass, or perennial ryegrass), including tetraploid *Lolium perenne, Poa pratensis* (commonly known as Kentucky bluegrass, smooth meadow-grass, or common meadow-grass), *Festuca rubra* (commonly known as red fescue or creeping red fescue), *Festuca ovina* (commonly known as sheep's fescue or sheep fescue), *Festuca arundinacea* (commonly known as tall fescue), *Deschampsia caespitosa* (commonly known as tufted hair-grass or Tussock grass), *Agrostis capillaris* (commonly known as common bent, colonial bent, or browntop) or any mixture thereof. A preferred mixture comprises *Lolium perenne,* preferably tetraploid *Lolium perenne,* and *Poa pratensis.* An exemplary mixture consists of 40% *Lolium perenne* 2n, 45% *Lolium perenne* 4n and 15% Poa pratensis. The choice of the type of natural grass may depend on the application of the hybrid grass surface (e.g. as sport lawn or ornamental lawn), the geographical location, etc.

[0077] In preferred embodiments, the natural grass (**300**) comprises tetraploid *Lolium perenne.* These grasses allow for rapid root growth even at extreme cold temperatures. The major advantages of this type of natural grass include improved drought resistance (due to the better rooting) resulting in improved turf quality after stress in summer and also in a beautiful summer color of the grass; improved disease resistance; improved germination, which starts at lower temperatures, resulting in a faster closed turf; improved growth at lower temperatures, and hence, maintenance of a beautiful lawn in autumn; and improved regrowth after injury in winter. Tetraploid *Lolium perenne* seeds are commercially available as 4TURF™ supplied by Innoseeds. The natural grass (**300**) is provided to the hybrid grass surface (**500**) upon seeding natural grass seeds in the infill section (**402**) The natural grass seeds are disposed in said infill section (**402**), most preferably between the tufts (**202, 202'**) of filaments (**200, 200'**) of the mat (**100**).

[0078] Approximately 30 to 60 grams grass seeds are sown per square meter of infill material (**403**). Typically, 250 kg of seed is sown for a surface area of 7500 m^2, the size of a football field. The grass seeds are sown at a shallow depth of between 6 and 15 mm. The grass seeds are preferably sown by a seed spreader device. Then a thin layer of between 6 and 15 mm of for example fertilized earth is spread evenly over the seeds. The earth is flattened on top, and then well watered.

[0079] The infill section (**402**) of the hybrid grass surface (**500**) is disposed above the sheet (**50**). The infill section (**402**) is disposed between the tufts (**202**), and more preferably between filaments (**200, 200'**) of the mat (**100**), on top of the sheet (**50**). The depth of the infill section (**402**) is preferably less than the pile height (**208**) of the mat (**100**). The depth of the infill section (**402**) may be 60, 70, 75, 80, 85, 90, 92, 94, 96, 98 or 99 % of the height (**208**) of the pile of the mat (**100**), between 60 and 100%, preferably between 75 and 99%, more preferably between 80 and 95% of the height (**208**) of the pile of the mat (**100**). Such configuration results in a free pile height (**210**) of between about 1.5 and about 2 cm of the filaments (**200, 200'**) of the hybrid grass surface (**500**)The infill section (**402**) may be between 3 and 23 cm deep, preferably between 5 and 10 cm deep. The infill section (**402**) may comprise one or more layers.

[0080] The infill section (**402**) comprises one or more layers of infill material (**403**). Any substrate that allows the growth of natural grass may be used as infill material (**403**). The substrate is preferably granulated. The average diameter of the granulated particles in the substrate is between 0 and 10 mm, preferably between 0 and 5 mm; typically the diameter of a granulated particle has lower limit of 0.005 mm. The granule size can be meas-

ured through CIFanalysis.

[0081] The infill material (**403**) typically comprises sand. Sand absorbs water, which is necessary for the growth of natural grass.

[0082] The infill material (**403**) may further comprise fertilizers, which are also needed for the optimal growth of natural grass. Fertilizers include nutrients for natural grass, which allow an optimal growth. Nitrogen, phosphorus, and potassium are referred to as primary nutrients and are preferably supplied periodically to turf through fertilizer applications. Calcium, magnesium, and sulfur, the secondary nutrients, are needed only occasionally in the form of fertilizer or lime. Micronutrients such as iron, manganese, zinc, boron, copper, molybdenum, and chlorine are required only in minute amounts and are rarely supplied to turf grasses through fertilization. The infill material (**403**) typically comprises phosphorus (preferably between 10 and 20 mg/100 g infill material), kali (preferably between 15 and 30 mg/100 g infill material), and magnesium (preferably between 7 and 15 mg/100 g infill material).

[0083] The infill material (**403**) preferably has a pH between 6.5 and 7.2. At this pH natural grass can optimally grow, the availability and absorption of nutrients is optimal, and it guarantees the structure of the infill material (**403**).

[0084] In embodiments, the infill material (**403**) comprises:

- between about 10 and about 30 % (v/v), preferably about 20 % (v/v) sand,
- between about 40 and about 60 % (v/v), preferably about 50 % (v/v) washed sand (sand with smooth edges) with a granule size of between 0 to 10 mm, preferably between 0 to 5 mm, and
- between about 20 and about 40 % (v/v), preferably about 30 % (v/v) lava sand (porous sand) with a granule size of between 0 to 10 mm, preferably between 0 to 5 mm.

[0085] The sub-section (**404**) of the hybrid grass surface (**500**) is disposed below the sheet (**50**).

[0086] The sub-section (**404**) may be between 10 and 25 cm deep, preferably between 15 and 20 cm deep. The sub-section (**404**) may comprise one or more layers.

[0087] The sub-section (**404**) comprises one or more layers of base material (**406**). Any substrate that allows the growth of natural grass, in particular that allows the passage of the grass roots (**304**), may be used as base material (**406**). It also provides a foundation that supports the mat (**100**).

[0088] The infill section (**402**) and the sub-section (**404**) preferably comprise the same material. It is also envisaged that the infill material (**403**) of the infill section (**402**) differs from the base material (**406**) of the sub-section (**404**). For example, the sheet (**50**) may be positioned on a naturally occurring sandy substrate, which may be considered as base material (**406**) of the sub-section (**404**). The sheet (**50**) may then be provided with an infill material (**403**) as described above as infill section (**402**).

[0089] The drainage layer (**450**) is provided below the sub-section (**404**). The roots (**304**) of the natural grass (**300**) may penetrate into the drainage layer (**450**). The drainage layer (**450**) typically comprises stone material (**452**). The stone material may comprise fine crushed stone, coarse crushed stone, lava material, or any mixture thereof. The particles of fine crushed stone may have a D50 (median grain size) of between 0 and 10 mm, more preferably between 0 and 4 mm. The particles of coarse crushed stone may have a D50 (median grain size) of between 0 and 40 mm, more preferably between 0 and 20 mm.

[0090] The depth of the drainage layer (**450**) may be between 5 and 25 cm, preferably between 10 and 20 cm. With reference to **FIG. 4**, a hybrid grass surface or lawn (**500**) according to the present invention comprises a mat (**100**) as shown in **FIG. 1** comprising a plurality of tufts (**202, 202'**) of filaments (**200, 200'**) attached to a sheet (**50**), and natural grass (**300**) disposed between the tufts (**202**) of the mat (**100**). The sheet (**50**) is positioned on top of a sub-section (**404**) of base material (**406**) and is provided with an infill section (**402**) of infill material (**403**). The hybrid grass (**500**) may further comprises a drainage layer (**450**) comprising stone material (**452**), which is positioned below said sub-section (**404**). Following the provision of infill material (**403**) on the sheet (**50**), natural grass seeds can be sown in the infill material (**403**) of the infill section (**402**) ideally between the tufts (**202**) of the mat (**100**).

[0091] The density of the filaments (**200, 200'**) in the hybrid grass (**500**) is preferably lower than 30%, more preferably between 20% and 30%, of the density of the natural grass fibers (**302**). The density here means the number of filaments compared with the total number of filaments and blades of natural grass.

[0092] In a further aspect, the present invention relates to a kit for a hybrid grass surface (**500**) comprising one or more of the following:

- a mat (**100**) according to the present invention, comprising a sheet **50** with a plurality of apertures (**60, 60'**), and tufts (**202, 202'**) of filaments (**200, 200'**) attached to the sheet (**50**),
- natural grass seeds,
- infill material (**403**),
- optionally base material (**406**), and
- optionally stone material (**452**).

[0093] The hybrid grass surface (**500**) may further comprise a pipe system comprising *e.g.* means for drainage of water, means for irrigation, or means for temperature regulation. Temperature regulation is desirable in particular during cold periods so as to thus obtain a lawn that can be played on by sportspeople without the risk of unwanted injuries, in particular caused by a slippery surface. Temperature regulation may take place by using

solar energy, for example.

[0094] The hybrid grass surface (**500**) may further comprise an electrical system for temperature regulation. The mat may comprise a set of electrical heating filaments in the hybrid grass surface (**500**).

[0095] The pipe system, in particular the pipe system comprising means for drainage of water, may be positioned within or below the drainage layer (**450**).

[0096] The hybrid grass surface according to the invention combines the advantages of both: natural grass surfaces, including good playability and reduction in friction burns, and artificial grass surfaces, including low maintenance, all-weather playability, and durability. In particular, there is an improved drought resistance. Owing to the better rooting of the grass species, the turf is much more resistant to drought, since the grass may benefit more from soil moisture. This means improved turf quality after stress in the summer, and also creates a consistent and even summer color of the grass throughout the year. There is also improved disease resistance; under stress situations, the natural grass fairs better than the standard English grasses, are better resistant to diseases such as red thread among others, and thus ensures a better winter color of the grass. There is also improved germination. There is also improved growth in the autumn when the temperature is lower. There is also improved regrowth after injury in winter. Besides this, lump formation typically observed in hybrid grasses of the art is avoided.

[0097] The hybrid grass surface stabilizes the top surface, protects the grass from damages and enhances evenness of the surface. The green turf yarn enhances the green appearance of the field and gives it a more natural and healthy look. It ensures unrestricted drainage and water retention in the field. On a natural grass field the maximum playing hours per year is limited to 300 hours. With the hybrid grass, playing hours per year is increased to 800-1000 hours. Maintenance will be the same as for an ordinary natural grass field.

EXAMPLES

[0098] The following samples of about 6 square meters (about 3 m x about 2 m) are installed and tested for wear:

Sample 1 (hybrid grass surface): A mat according to an embodiment of the present invention is provided. The mat comprises a sheet comprising a plurality of apertures configured for the passage of one or more roots of natural grass and a plurality of filaments grouped into tufts attached to said sheet. The sheet is made of 100% polyester. The average distance between adjacent apertures in the plurality of apertures in the sheet is between 1 mm and 2 mm. The number of apertures per square meter in the sheet is between about 120 000 and about 180 000. Straight monofilaments are attached to the sheet by tufting. The tufting yarn is made of UV-stabilized polyethylene, and has a weight of about 750 g/square meter. The monofilaments are grouped into tufts of about 12 filaments/tuft. There are about 2835 tufts/square meter. The height of one filament is about 70 mm.

Natural grass comprising a mixture of two kinds of *Lolium perenne* (40% *Lolium perenne 2n* and 45% *Loium perenne 4n*) and *Poa pratensis* (15%) is disposed between the tufts of the mat.

Sample 2 (control, natural grass surface): The same natural grass mixture as in sample 1 is used as a control.

Wearing of the grass (for example, wearing during sport activities) is simulated and tested by using a rolling device that is pulled across the grass. The rolling device is essentially a cart comprising a chassis on which 2 large rollers (each 50 cm in diameter, and length of about 1.5 meter) are mounted, wherein the rolling surface of each roller is disposed with metal studs. This cart is dragged over the grass, whereby the rotary speed of one of the rollers is slightly smaller than the other, which has the same speed as the cart. The cart is repeatedly pulled forward and backwards over the sample field; two lengths being counted as one cycle. The sample field is divided into 5 areas, which are tested with respectively, 300, 600, 900, 1200 and 1500 cycles per week. The grass is further tested on the following parameters: density, color, disease resistance, germination and emergence under lower temperatures, wear tolerance. The hybrid grass surface of the invention shows superior properties compared with a natural grass surface.

Claims

1. A mat **(100)** for a hybrid grass surface **(500)** comprising:

   - a sheet **(50)** comprising a plurality of apertures **(60, 60')** configured for the passage of one or more roots **(304)** of natural grass **(300)**, and
   - a plurality of filaments **(200, 200')** grouped into tufts **(202, 202')** attached to said sheet **(50).**

2. The mat **(100)** according to claim 1, wherein the apertures **(60, 60')** are arranged in a regular pattern.

3. The mat **(100)** according to claim 1 or 2, wherein the average size of the apertures **(60, 60')** in the plurality is between 1 mm and 5 mm.

4. The mat **(100)** according to any one of claims 1 to 3, wherein at least some of the apertures **(60, 60')** are occupied the remainder being unoccupied, and the number of unoccupied apertures per occupied aperture is greater than 1.

5. The mat **(100)** according to any one of claims 1 to 4, wherein the sheet **(50)** is a woven sheet made of polyethylene or polypropylene or polyester or polylactic acid, or any combination thereof.

6. The mat (**100**) according to any one of claims 1 to 5, wherein the average distance (**206**) between adjacent tufts (**202, 202'**) is between 1 cm and 6 cm.

7. The mat **(100)** according to any one of claims 1 to 6, having a pile height **(208)** of between 4 cm and 25 cm.

8. The mat (**100**) according to any one of claims 1 to 7, wherein the filaments (**200, 200'**) of a tuft (**202, 202'**) are threaded through one or two or more apertures (**60, 60'**) in the sheet (**50**), thereby attaching them to the sheet (**50**).

9. The mat (**100**) according to any one of claims 1 to 8, wherein the filaments (**200, 200'**) are secured to the sheet (**50**) by melting or by an adhesive material.

10. The mat **(100)** according to any one of claims 1 to 9, wherein the filaments **(200, 200')** are made at least partially, preferably entirely of polyethylene or polylactic acid, preferably polylactic acid.

11. A kit for a hybrid grass surface comprising:

- a mat **(100)** according to any one of claims 1 to 10,
- natural grass seeds,
- infill material **(403)**,
- optionally base material **(406)**, and
- optionally stone material **(452).**

12. A hybrid grass surface **(500)** comprising:

- a mat **(100)** according to any one of claims 1 to 10,
- natural grass **(300)**,
- an infill section **(402)** comprising sandy infill material **(403)**,
- a sub-section **(404)** comprising sandy base material **(406)** disposed below said top layer **(402)**, and
- a drainage layer **(450)** comprising stone material **(452)** positioned below said sub-section **(404)**,

wherein the sheet **(50)** of the mat **(100)** is positioned between said infill section **(402)** and said sub-section **(404)**, and wherein the depth of said infill section **(402)** is lower than the pile height **(208)** of the mat **(100).**

13. The hybrid grass surface **(500)** according to claim 12, wherein the density of the filaments **(202, 202')** is less than 30% of the density of the natural grass fibres.

14. The hybrid grass surface **(500)** according to any one of claims 12 or 13, wherein the depth of the infill section **(402)** is between 3 cm and 23 cm.

15. The hybrid grass surface **(500)** according to any one of claims 12 to 14, wherein the depth of the sub-section **(404)** is between 10 cm and 25 cm.

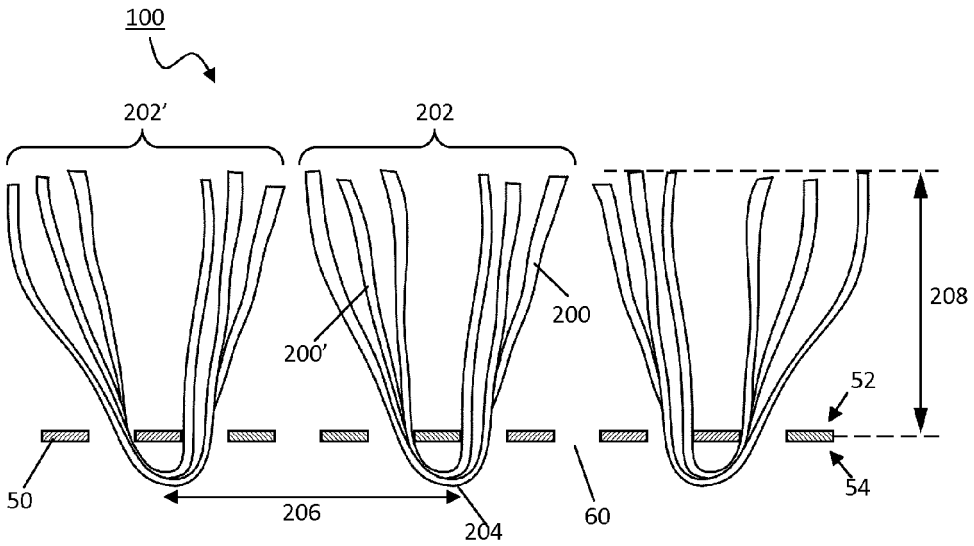

FIG. 1

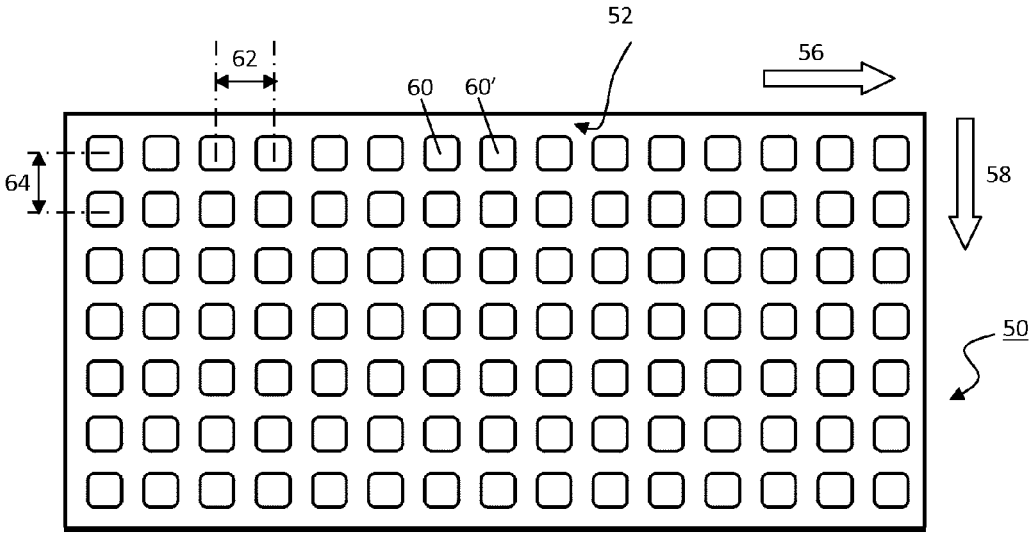

FIG. 2

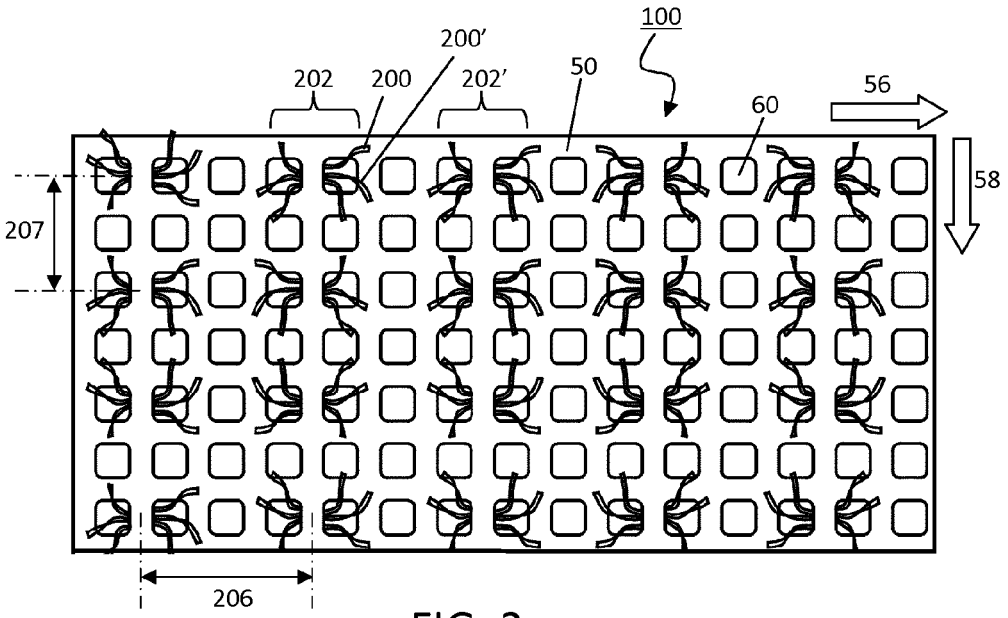
100
200'
202
200
202'
50
60
56
58
207
206

FIG. 3

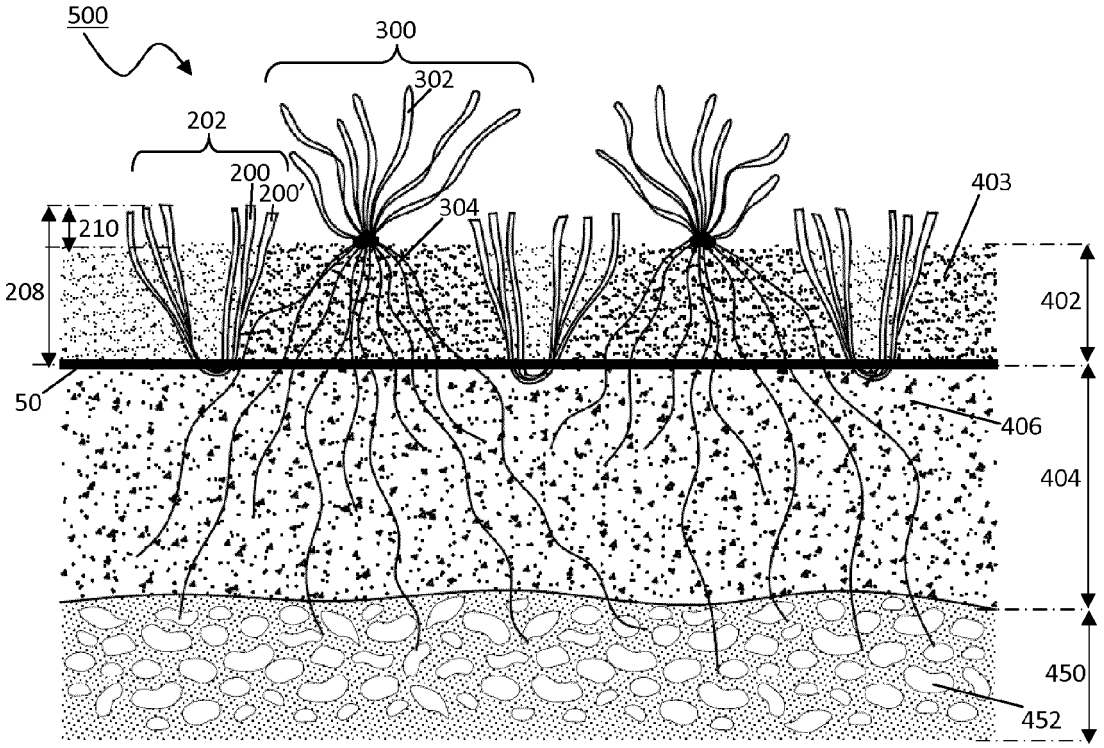
500
300
302
202
200
200'
304
403
210
208
402
50
406
404
450
452

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 19 5828

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 May 2015	Flores Hokkanen, P

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