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

(11) **EP 3 660 208 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.06.2020 Bulletin 2020/23

(21) Application number: **19154074.9**

(22) Date of filing: **29.01.2019**

(51) Int Cl.:
D06N 3/00 *(2006.01)* ***E01C 13/08*** *(2006.01)*
D06N 7/00 *(2006.01)* ***F21V 33/00*** *(2006.01)*
F21S 8/02 *(2006.01)* ***G09F 9/00*** *(2006.01)*
D01F 1/10 *(2006.01)* ***G09F 19/22*** *(2006.01)*

(84) Designated Contracting States:
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 RS SE SI SK SM TR
Designated Validation States:
MA

(30) Priority: **28.11.2018 US 201862772108 P**

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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) ARTIFICIAL TURF WITH OPAQUE FACE YARN AND TRANSLUCENT THATCH YARN FIBERS

(57) The invention relates to an artificial turf (200, 400, 500, 600, 800, 900) comprising translucent thatch yarn fibers (104) and opaque face yarn fibers (102) that are integrated in a carrier (106).

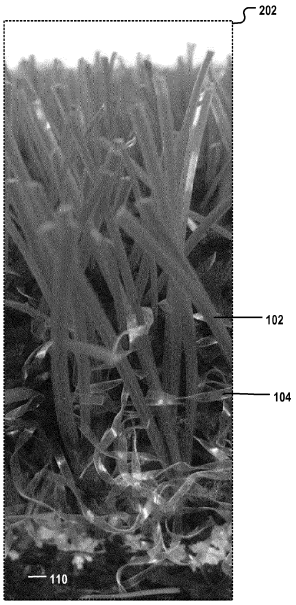

Fig. 3

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Description

Field of the invention

[0001] The invention relates to the field of synthetic surfaces and the production thereof, and more particularly to artificial turf.

Background and related art

[0002] Artificial turf or artificial grass is surface that is made up of fibers that are used to replace grass. The structure of the artificial turf is designed such that the artificial turf has an appearance that resembles grass. Typically, artificial turf is used as a surface for sports such as soccer, American football, rugby, tennis, golf, or for other playing fields or exercise fields. Furthermore, artificial turf is frequently used for landscaping applications. An advantage of using artificial turf is that it eliminates the need to care for a grass playing or landscaping surface, such as regular mowing, scarifying, fertilizing, and watering.

[0003] Some artificial turf types are known that comprise a combination of different types of fibers, e.g., fibers of two different lengths. For example, US patent application US 6,299,959 B1 describes synthetic grass having both surface forming nontextured fibers and textured thatch zone forming fibers to add resilience and to lock in rubber granules that are distributed more densely near the base of the fibers. In one embodiment of this arrangement, the covering rubberlike particles are used to stabilize the synthetic surface fibers in their upright position.

[0004] However, applicant has observed that the process of producing artificial turf containing two or more fibers of different types is very complex, expensive, and error-prone. In particular, if the artificial turf is to contain a pattern of two or more colors (for example, if field markings, a club logo, or similar are to be integrated into the artificial turf during the manufacturing process), the manufacturing process becomes difficult and expensive: in this case it is necessary to replace the fiber currently being mechanically integrated with another fiber of the desired color at the edges where a color transition takes place. This fiber substitution must be carried out for all fiber types used and must be coordinated with great precision. Otherwise, the color transitions appear frayed and blurred. If coordination is not successful, rejects or a product with blurred color transitions will result. But even if the coordination of the color-related change of all fiber types is successful and a sharp color transition is achieved, the material consumption is still higher for multicolor artificial turf and the rejects produced are higher than for monochrome artificial turf. This is because the machines that integrate the fibers into the fabric usually "consume" a certain part of fiber for the purpose of clamping a fiber into the machine. This fiber part will not be integrated into the artificial turf. Hence, the production of artificial turf comprising a multicolor pattern and two or more different fiber types is technically difficult and leads to increased production costs even in the case of a correct and precisely orchestrated change of all fiber types.

Summary

[0005] It is an object of the invention to provide for an improved artificial turf and methods for producing the same. The problem is solved by the features as specified in the independent claims. Embodiments of the invention are given in the dependent claims. The embodiments and examples described herein can freely be combined with each other unless they are mutually exclusive.

[0006] In one aspect, the invention relates to an artificial turf comprising a carrier, translucent thatch yarn fibers integrated in the carrier, and opaque face yarn fibers integrated in the carrier.

[0007] Said features may be advantageous because the production process may be simplified enormously, rejects can be avoided, and production costs can be reduced. Because the thatch yarn fibers are translucent, they allow the light reflected by the face yarn fibers to pass through. The color impression of the thatch yarn fibers thus corresponds at least largely to the color impression of the face yarn fibers. The face yarn fibers s are opaque, i.e., they essentially do not allow ambient light to pass through but reflect it, whereby the reflection typically takes place in such a way that, depending on the wavelength, part of the incident light is absorbed, while another part is reflected. The wavelength of the part of the light reflected by the opaque face yarn fibers determines the color impression of the face yarn fibers. The color impression of the thatch yarn fibers is also determined by the wavelength of the part of the light reflected by the face yarn fibers, since the thatch yarn fibers are translucent, i.e., they allow the incident light to pass through completely or to a large extent. Embodiments of the invention may be advantageous because it is no longer necessary to change the yarn spools when manufacturing artificial turf areas where a color transition occurs. The same single thatch yarn fiber bobbin can be used for the entire surface of the artificial turf. A color change therefore only requires a change of yarn during the integration of the face yarn fibers. Since the thatch yarn fibers are translucent, they have no influence on the color impression of the artificial turf, so the same translucent yarn can be used over the entire surface of the artificial turf to integrate the thatch yarn fibers into the carrier. The coordination effort during the production of the artificial turf may thus be considerably lower. The production of rejects can be avoided or at least reduced, and yarn consumption may also be reduced, as the same yarn spool can be used to integrate all thatch yarn fibers across all color transitions.

[0008] In another advantageous aspect, the manufacturing process may be accelerated, because in some manufacturing processes or plants the yarn change still requires human interaction, which not only increases the

susceptibility to errors, but also slows down the production process. By avoiding yarn change actions during the integration of the thatch yarn fibers, the manufacturing process may be accelerated.

[0009] According to embodiments, the length of the thatch yarn fibers is smaller than the length of the face yarn fibers.

[0010] This can be advantageous because the greater length of the face yarn fibers additionally enhances their optical dominance over the shorter thatch yarn fibers. For example, the face yarn fibers can be several millimeters or even several centimeters longer than the thatch yarn fibers. In some embodiments, the thatch yarn fibers can also be partially or completely covered by filler material. All this can contribute to the beneficial effect that the color impression of artificial turf is essentially based exclusively on the face yarn fibers, not on the thatch yarn fibers. The thatch yarn fibers may fulfill a mechanical function, e.g., make the turf more elastic and retain filler material but do not make their own contribution to the color or color-based design of artificial turf.

[0011] According to embodiments, the translucent thatch yarn fibers are transparent.

[0012] This may be advantageous, because in contrast to translucent fibers that scatter incident light (essentially without changing the wavelength), transparent fibers may transmit incident light essentially without changing the wavelength and without changing direction. This means that not only the approximate color impression, but also the contours and other optical features of the face yarn fibers, may be more strongly accentuated. The contribution of the thatch yarn fibers to the color impression or overall optical impression of the artificial turf may additionally be reduced. As a result, the color transitions in the manufactured artificial turf may appear even clearer and sharper.

[0013] According to embodiments, the artificial turf comprises two or more subregions. All face yarn fibers contained in a subregion have the same color that is different from the color of the face yarn fibers contained in all subregions adjacent to that subregion.

[0014] According to embodiments, the two or more subregions form a color pattern. The color pattern can be selected, for example, from a group comprising a logo of an organization, field markings and regions defined by the field markings, symbols of a game, a pattern representing a text or an image, or combinations thereof.

[0015] According to embodiments, the face yarn fibers comprise one or more pigments.

[0016] According to embodiments, the thatch yarn fibers are free of pigments. This may be advantageous, because pigments may directly as well as indirectly cause a scattering of light (turning a transparent fiber into a merely translucent fiber). Applicant has observed that some of the pigments, e.g., phthalocyanine green, act as nucleating agents, which boost the formation of microcrystals in the polymer material of the fiber. The pigments may induce heterogeneous nucleation in the fiber. Hence, the pigments as well as the microcrystals induced by the pigments may result in a scattering of light. However, in general a transparent fiber is considered more desirable than a merely translucent fiber because the "optical contribution" of a transparent fiber to the look of artificial turf is smaller, and color borders of complex color patterns may be sharper and clearer if the thatch yarn fibers are transparent and not just translucent.

[0017] According to embodiments, the thatch yarn fibers and/or the face yarn fibers are selected from a group comprising polyethylene (PE) fibers, polyamide (PA) fibers, and polypropylene (PP) fibers. In particular, the fibers can be PE fibers or fibers comprising a mixture of PE and PA, e.g., a blend of PE and PA. For example, the fibers can be PE fibers comprising threadlike regions of PA that increase the rigidity of the fibers.

[0018] According to embodiments, the thatch yarn fibers and/or the face yarn fibers are texturized. Texturization of fibers may increase the elasticity of the artificial turf, because the texturized fibers may have a damping and cushioning effect. In an additional beneficial aspect, the texturization may result in a random orientation of the fibers, thereby improving the ball-rolling properties and ensuring that the trajectory of a rolling or bumping ball is a straight line.

[0019] According to preferred embodiments, the face yarn fibers are non-texturized and the thatch yarn fibers are texturized.

[0020] According to embodiments, the thatch yarn fibers comprise a nucleating agent. The face yarn fibers are free of the nucleating agent or comprise a smaller amount of the nucleating agent than the thatch yarn fibers.

[0021] Applicant has observed that some pigments, e.g., phthalocyanine green and phthalocyanine blue, act as a nucleating agent. Hence, these pigments act as seeds for microcrystals that may form when the fiber is manufactured or further processed. For example, when a polymer mass is extruded to form a polymer film or monofilament used for manufacturing a fiber, or when a fiber is stretched, the nucleating agent will boost the creation of polymer microcrystals. Such crystals may scatter light that passes through the fiber. If a fiber comprises a large quantity of a nucleating agent, the microcrystals formed in their vicinity will scatter the light and make a fiber nontransparent. The fiber may still be translucent if the majority of light beams entering the fiber with the nucleating agent can leave the fiber without a significant change of the wavelength composition, but the fiber may not be transparent anymore because the light entering the fibers is scattered and leaves the fiber in many different, random directions.

[0022] According to embodiments, the nucleating agent is a salt of hexahydrophthalic acid, in particular a calcium salt of hexahydrophthalic acid.

[0023] According to embodiments, the nucleating agent is an organic acid, an organic acid ester or organic acid salt. For example, the nucleating agent can be a sorbic acid ester or a sorbic acid salt such as sodium

sorbate, potassium sorbate, and calcium sorbate, or a salicylic acid salt such as sodium salicylate. According to a further embodiment, the nucleating agent is a mixture of zinc-stearate and a calcium salt of 1,2-cyclohexane-dicarboxylic acid. For example, the mixture can comprise about 30-40 %, e.g. about 34% by weight the zinc-stearate, the rest of the mixture consisting of the 1,2-cyclohexane-dicarboxylic acid.

[0024] Said features may be advantageous because organic acid salts have been observed to be easily distributable homogeneously within the polymer mass used for manufacturing the fibers. Providing a polymer fibers with a homogeneous dispersion of nucleating agent molecules may be advantageous, because the microcrystals forming at the nucleating agent molecules are dispersed homogeneously also. In effect, the homogeneous dispersion of crystals will reduce light scattering and may provide for fibers that are not only translucent, but also transparent.

[0025] According to embodiments, the nucleating agent is a colorless substance.

[0026] According to embodiments, the thatch yarn fibers comprise the nucleating agent in an amount of 0.01 % to 2.0 % by weight of the fibers. Preferably, the thatch yarn fibers comprise the nucleating agent in an amount of 0.1 % to 1.0 % by weight of the fiber. In particular, the thatch yarn fibers comprise the nucleating agent in an amount of about 0.2% by weight of the fiber.

[0027] This may be advantageous, because a polymer fiber that is free of a pigment and that comprises the above mentioned substances as the nucleating agent preferably within an amount range as specified above will be transparent. In an additional beneficial aspect, artificial turf fibers comprising a nucleating agent will have an increased surface roughness thanks to the crystals formed at the surface. Hence, when the fibers are incorporated in the carrier and are optionally partially embedded in a liquid PU- or latex-based backing that later solidifies, the fibers are fixed more strongly in the carrier and the optional backing.

[0028] In an additional beneficial aspect, calcium salt of hexahydrophthalic acid is colorless, i.e., it does not generate a color impression that is recognizable by the human eye.

[0029] According to embodiments, the thatch yarn fibers are free of a light absorbing substance (such as e.g. light absorbing pigments or fillers) and are free of a nucleating agent. This may have the advantage that the production costs are reduced and the resulting thatch yarn fibers are still translucent (but typically not transparent).

[0030] In a further aspect, the invention relates to a layered surface structure comprising a display layer and an artificial turf placed on top of the display layer. For example, the artificial turf that is placed on top of the display layer can solely comprise translucent, e.g., transparent, fibers and be free of any opaque fibers. According to embodiments, the artificial turf that is placed on top of the display layer is an artificial turf comprising opaque and translucent fibers as described in accordance with embodiments and examples of an artificial turf described herein and as illustrated, for example, in figures 1-6. The display layer comprises one or more display elements adapted to emit light signals toward the artificial turf.

[0031] For example, the display elements can be electronic display elements. The display elements can be adapted and configured to visually represent and display information, e.g., information provided by one or more control units that are operatively coupled to the display elements.

[0032] In a further aspect, the invention relates to a method of manufacturing an artificial turf. The method comprises providing a carrier, integrating translucent thatch yarn fibers in the carrier, and integrating opaque face yarn fibers in the carrier.

[0033] In a further aspect, the invention relates to a method of manufacturing a layered surface structure. The method comprises providing a display layer comprising one or more display elements and placing an artificial turf comprising translucent fibers on top of the display layer. The electronic display elements are adapted to emit light signals toward the artificial turf.

[0034] For example, the artificial turf that is placed on top of the display layer can solely comprise translucent, e.g., transparent, fibers and be free of any opaque fibers.

[0035] According to embodiments, the artificial turf that is placed on top of the display layer is an artificial turf comprising opaque and translucent fibers according to any one of the embodiments and examples described herein.

[0036] A "translucent fiber" (also called diaphanous fiber) as used herein is a fiber made of material that has the physical property of allowing light to pass through the material without being scattered. On a macroscopic scale (one where the dimensions investigated are much larger than the wavelength of the photons in question), the photons can be said to follow Snell's Law.

[0037] A "transparent fiber" as used herein is a fiber made of material that has the physical property of allowing light to pass through, but does not necessarily (again, on the macroscopic scale) follow Snell's law; the photons can be scattered at either of the two interfaces, or internally, where there is a change in index of refraction.

[0038] Translucency (also called translucence or translucidity) is a superset of transparency. A translucent medium allows the transport of light, while a transparent medium not only allows the transport of light but also allows for image formation. Transparent materials appear clear, with the overall appearance of one color, or any combination leading up to a brilliant spectrum of every color. The opposite property of translucency is opacity.

[0039] An "opaque fiber" as used herein is a fiber made of a material that does not transmit light. Many such substances have a chemical composition that includes what are referred to as absorption centers. Many substances are selective in their absorption of white light frequencies.

They absorb certain portions of the visible spectrum while reflecting others. The frequencies of the spectrum that are not absorbed are either reflected or transmitted for our physical observation. This is what gives rise to color. The attenuation of light of all frequencies and wavelengths is due to the combined mechanisms of absorption and scattering.

[0040] A "subregion of an artificial turf' as used herein is a defined region within the artificial turf that is characterized by a particular color. For example, all face yarn fibers contained in a subregion can have the same color that is different from the color of the face yarn fibers contained in all subregions adjacent to that subregion. For example, an artificial turf may comprise a color pattern that corresponds to the flag of the United States. This pattern would consist of 7 red subregions and 6 white subregions having the form of stripes that represent the 13 founding states, a blue subregion in the upper left corner and 50 additional subregions within the blue subregion in the form of white stars that symbolize states of the USA. Hence, the color pattern representing the flag of the USA would consist of 63 subregions, and any artificial turf comprising this pattern would comprise at least 64 subregions (any subregion of the artificial turf not covered by the flag corresponds to the 64^{th} subregion).

[0041] A "pigment" as used herein is a material that changes the color of reflected or transmitted light as the result of wavelength-selective absorption. According to preferred embodiments, a pigment is a material that humans have chosen and developed for coloring other materials. In particular, the materials used as pigments can have special properties that make them useful for coloring other materials, e.g., a high-tinting strength relative to the materials it colors, chemical stability in solid form at ambient temperatures, thermal stability at increased process temperature (e.g., the temperature used in the extrusion process), etc. A pigment can be an inorganic or organic chemical substance.

[0042] A "texturized fiber" as used herein is a fiber that was subjected to a texturizing process. A texturizing process is the process by which fibers, in particular synthetic fibers, are modified to change their texture - the physical appearance of the fiber. Texturizing techniques can include bulking (where thermoplastic fibers are twisted, heat- set, and untwisted) or crimping and coiling, among others. Some texturizing approaches take advantage of the thermoplastic nature of synthetic fibers and use it to set texturized features in place. These modifications will also affect the eventual fabric and fibers may be folded, looped, coiled, or crinkled. Texturizing can reduce the "synthetic" appearance of a finished good comprising a textured fiber.

[0043] A "nucleating agent" as used herein is a substance adapted to promote the crystallization of polymers, in particular of semicrystalline polymers. This effect can be achieved by presenting a heterogeneous surface to the polymer melt. Nucleation starts with small, nanometer-sized areas where, as a result of heat motion, some chains or their segments occur parallel. Those seeds can either dissociate, if thermal motion destroys the molecular order, or grow further, if the grain size exceeds a certain critical value. Crystallization of polymers is a process associated with partial alignment of their molecular chains. These chains fold together and form ordered regions called lamellae, which compose larger spheroidal structures named spherulites.

[0044] A "layered surface structure" as used herein is a manmade flooring structure comprising at least two layers. The term "manmade" includes "machine-made" and means that the layered surface structure is not merely a soil structure that has formed naturally. The layered surface structured can be fabricated at the use site, e.g., by installing each of the multiple layers at the use site one after another. Alternatively, the layered surface structure can be fabricated at a plant and can then be transported to and installed at the use site. Mixed approaches are also possible. For example, it is possible to clean and level the base layer at the use site, which may consist of soil or sand. Then, multilayered surface structure tiles that may have been manufactured in a plant can be applied on top of the leveled base layer and connected with each other. Finally, one or more coatings may be applied. Then, multilayered surface structure tiles that may have been manufactured in a plant can be applied on top of the leveled base layer and connected with each other. Finally, one or more coatings may be applied. Alternatively, different parts of the multilayer surface structure are produced in different factories and are then combined and installed at the use site. For example, a first company may manufacture display tiles comprising one or more electronic display devices and a second company may manufacture artificial turf. The display tiles are installed at the use site and connected with each other to form the display layer. Then, the artificial turf is applied on top of the display layer, thereby forming the layered surface structure.

[0045] A "carrier" as used herein is a material that is adapted for integrating fibers, e.g., artificial turf fibers, into the material, thereby providing mechanical stability to the fibers. For example, the carrier can be a sheet-like structure, e.g., a mesh of natural and/or synthetic fibers.

[0046] A "display element" as used herein is a device or device component that is adapted to display information and emit light signals. For example, the electronic device can be an optical device or an electronic device. Preferably, the display elements are installed and/or are configured to emit the light signals selectively or predominantly in an "upward direction," i.e., in the direction to the artificial turf that lies on top of the display layer comprising the display elements. A display element can be, for example, an LED spot, an LED panel, an OLED light source, an LCD display, or similar. A display element can be configured to visually represent - alone or in combination with other display elements contained in the same display layer - a particular piece of information, e.g.,

graphical information that specifies the contours and colors of a logo or other pattern.

[0047] A "display layer" as used herein is a layer of a surface structure that comprises one or more display elements. In some embodiments, the display layer comprises or is operatively coupled to one or more control units of the display elements. The control units are configured to graphically represent and display information via the display elements contained in the display layer to the users of the layered surface structures (i.e., the players) and preferably also to the audience.

Brief description of the drawings

[0048] In the following, embodiments of the invention are explained in greater detail, by way of example only, making reference to the drawings in which:

Figure 1 depicts a 3D model of an art artificial turf according to an embodiment of the invention.

Figure 2 depicts a cross-sectional view of an artificial turf according to an embodiment of the invention.

Figure 3 depicts a region of figure 2 in greater detail.

Figure 4 depicts an artificial turf according to a further embodiment.

Figure 5 depicts an artificial turf according to a further embodiment.

Figure 6 depicts an artificial turf according to a further embodiment.

Figure 7A depicts a flowchart of a method of producing artificial turf according to an embodiment of the invention.

Figure 7B depicts a flowchart of a method of producing a layered surface structure according to an embodiment of the invention.

Figure 8 depicts tuft rows of an artificial turf according to an embodiment of the invention.

Figure 9 depicts tuft rows of an artificial turf according to a further embodiment of the invention.

Figure 10 depicts a layered surface structure according to an embodiment of the invention.

[0049] **Figure 1** depicts a virtual 3D model 100 of an art artificial turf according to an embodiment of the invention. It comprises straight, non-texturized face yarn fibers 102 having a pile height L3, and a zone of texturized thatch yarn fibers 104. The thatch yarn fibers have a height L2 that is shorter than the height L3 of the face yarn fibers. The difference between the height of the face yarn fibers and of the thatch yarn fibers is depicted as "L1." The thatch yarn fibers and face yarn fibers are integrated into a carrier structure 106, e.g., a fiber mesh. The fiber mesh can be made of synthetic and/or natural fibers. In some embodiments, the fiber mesh is created by interweaving the face yarn fibers with each other such that the forming of the mesh and the integration of the face yarn fibers is performed in a single operation. According to other embodiments, the carrier mesh 106 is provided first and the fibers 102, 104 are integrated into the existing carrier mesh 106 in subsequent steps.

[0050] Optionally, the artificial turf can comprise a backing layer below the carrier 106 (not shown). The backing layer may consist of polyurethane (PU) or latex and may be used for firmly fixing the fibers 102, 104 in the carrier 106.

[0051] In the embodiment depicted in figure 1, the artificial turf further comprises infill 110. The infill can be, for example, an elastic granulate such as rubber granulate, cork granulate, etc., and/or inelastic particles such as sand or zeolite or a mixture thereof.

[0052] The whole artificial turf comprising the fibers 102, 104, the carrier 106, the optional filler and the backing (if any) can be placed on top of a base layer 108. The base layer can also be referred to as "ground layer" or "substrate layer." For example, the base layer can be made of concrete, soil, stone, or similar. It is also possible that the base layer is a manmade flooring layer, e.g., a layer comprising electronic elements such as LED panels or other display devices. The manmade layer can also be an elastic layer, e.g., a PU layer comprising rubber particles.

[0053] The face yarn fibers in the artificial turf model 100 have a green color such that natural grass fibers are faithfully reproduced. The thatch yarn fibers in the 3D model are depicted in a brighter color in order to better illustrate their height, position, and texturization. However, figure 1 merely depicts a virtual model. The thatch yarn fibers of an artificial turf according to embodiments of the invention actually are translucent and hence cannot be identified as clearly as indicated in the computer-generated model depicted in figure 1.

[0054] **Figure 2** is a photo of a cross-sectional view of an actual artificial turf 200 according to another embodiment of the invention. The artificial turf 200 comprises red, non-texturized face yarn fibers 102 and translucent, colorless, texturized thatch yarn fibers 104. In addition, the artificial turf comprises infill granules 110 in the form of rubber granules. The rubber granules can be coated and the coating can comprise pigments, e.g., dark or brownish pigments to give the color impression of sand or soil. The filler material 110 can likewise be, for example, a sand-rubber-granule mixture. The infill may fill free space between thatch yarn fibers and/or face yarn fibers.

The infill height can be smaller than the thatch yarn length L2, or can be a height between L2 and L3. In one embodiment, the upper surface of the infill layer is one or more cm below the pile height L3. Thanks to a combination of face yarn fibers and thatch yarn fibers, the infill granules are stabilized and are protected from being delocalized by a ball or other object hitting the surface of the artificial turf.

[0055] The texturization of the thatch yarn fibers may result in a random orientation of the thatch yarn fibers and an intertwining of the face yarn fibers and the thatch yarn fibers. This may help to mechanically fix the infill granules between the thatch yarn fibers, thereby reducing the loss of infill material that may be caused by rainfall, wind, and impacting objects, e.g., a ball or a foot of a player. The thatch yarn fibers depicted in figure 2 are not only translucent but also transparent.

[0056] The thatch yarn fibers can be textured or non-textured. Likewise, the face yarn fibers can be textured or nontextured fibers. The texturization of fibers, in particular of the thatch yarn fibers 104, may provide for a random orientation of the textured fibers in the artificial turf. This provides an artificial turf with a more homogeneous surface that increases the predictability and directional stability of any object rolling or sliding over the surface of the artificial turf.

[0057] Figures 1 and 2 show the texturized thatch yarn fibers 104 in their relaxed, default state. The length of the fibers in this state is shorter than in a stretched, expanded state, due to their texturization.

[0058] The fibers 102, 104 can be monofilaments or split film tapes or bundles of monofilaments or split film tapes. Preferably, the fibers of the face yarn are made of a mixture of PE/PA with compatibilizer as disclosed in EP 3122942. Surprisingly PE/PA monofilaments have the following advantages in this context: the PE provides for a soft, elastic surface that protects the skin of the players from injury. The PA increases the rigidity and thus ensures that the fibers re-erect after being trampled down. If the fiber is a textured fiber, the use of a PE/PA mixture or blend may ensure that the texturing has more long term stability even if subjected to mechanical stress and weathering (sunshine).

[0059] According to some embodiments, the thatch yarn fibers can be made of PE monofilaments (in particular LLDPE) or another material as it is less stressed both mechanically and by weathering. Moreover, thatch yarn lacking PA may shrink more if exposed to heat. This effect may be used for generating an artificial turf with two types of texturized fibers that are adapted to form a thatch yarn zone of a clearly defined, uniform fiber height L2, and for generating face yarn fibers having a defined, uniform fiber height L3 although the face yarn fibers may be texturized.

[0060] The thatch yarn fibers and the face yarn fibers can be made of the same type of polymer, e.g., PE, or of a mixture of miscible polymers, or a polymer mixture of immiscible polymers. For example, the polymer mixture used for generating the face yarn or thatch yarn fibers can be a three-phase system, wherein the polymer mixture comprises a first polymer, a second polymer, and a compatibilizer. The first polymer and the second polymer are immiscible. The first polymer forms polymer beads surrounded by the compatibilizer within the second polymer as disclosed in EP 3122942 the entirety of which being expressly herein incorporated by reference. The second polymer may be a PE and the first polymer can be PA. The polymer mixture used for generating the first fibers to be turned into thatch yarn fibers can be made of PE that is free of any PA. The PA beads may provide some stability and rigidity to the fibers, thereby reducing the ability of the second fibers to contract, e.g., in response to heat.

[0061] The face yarn fibers and thatch yarn fibers can be integrated into the carrier, e.g. by gluing, weaving, or tufting the fibers into the carrier.

[0062] The face yarn fibers 102 define the pile height L3 of the artificial turf and provide the rolling resistance for the rolling ball. The thatch yarn fibers 104 serve the purpose of holding or immobilizing the infill, if any, and prevent or reduce splashing and limit redistribution of the infill when the artificial turf is in use, thereby preventing an uneven distribution of the infill.

[0063] **Figure 3** depicts a region 202 of figure 2 in greater detail. Figure 3 illustrates that the thatch yarn fibers of some embodiments are not only translucent, but also transparent, meaning that not only the color of the face yarn fibers, but also the contours of the face yarn fibers are visible through a thatch yarn fiber.

[0064] **Figure 4** depicts an artificial turf 400 according to a further embodiment. The artificial turf 400 comprises non-texturized face yarn fibers 102 and texturized thatch yarn fibers 104.

[0065] **Figure 5** depicts an artificial turf 500 according to a further embodiment. The artificial turf 500 comprises texturized face yarn fibers 102 and texturized thatch yarn fibers 104.

[0066] **Figure 6** depicts an artificial turf 600 according to a further embodiment. The artificial turf 500 comprises texturized face yarn fibers 102, texturized thatch yarn fibers 104, and a filler 110 that is mechanically stabilized by the face yarn fibers and the thatch yarn fibers.

[0067] The side of the carrier 106 from which the fibers 102, 104 protrude is referred to herein as the "upper side" of the carrier/of the artificial turf, while the other side, where only u-shaped portions of the fibers forming tuft knots and/or a secondary backing may be visible, is referred to herein as the "lower side" of the artificial turf.

[0068] **Figure 7A** depicts a flowchart of a method of producing artificial turf 200, 400, 500, 600, 800, 900 according to an embodiment of the invention.

[0069] In step 702, a carrier 106 is provided. The carrier can be a textile carrier, e.g., a fiber mesh made of synthetic and/or natural fibers. The carrier can be provided by feeding the carrier into a machine that is configured for integrating fibers into the carrier. The machine can

be, for example, a tufting machine.

[0070] In step 704, translucent thatch yarn fibers 104 are integrated in the carrier. For example, the thatch yarn fibers can be tufted, knitted, woven, glued, or otherwise integrated into or attached to the carrier.

[0071] In step 706, opaque face yarn fibers 102 are integrated in the carrier. For example, the face yarn fibers can be tufted, knitted, woven, glued, or otherwise integrated into or attached to the carrier.

[0072] In some embodiments, the face yarn fibers are integrated earlier than the thatch yarn fibers. In other embodiments, the thatch yarn fibers are integrated earlier than the face yarn fibers. In still other embodiments, the face yarn fibers and the thatch yarn fibers are integrated basically at the same time. For example, the thatch yarn fibers and the face yarn fibers can be tufted into the carrier by different tufting machine or by a tufting machine comprising two or more different tufting needles.

[0073] According to embodiments, the integration of the fibers is performed such that the machine or machine component that performs the integration of the face yarn fibers replaces the face yarn having a first color that was previously used for integration by another face yarn having a second color when the machine crosses a subregion border of the artificial turf. The machine or machine component that performs the integration of the thatch yarn fiber maintains (does not replace) the thatch yarn that was previously used for integration by another thatch yarn when the machine crosses a subregion border of the artificial turf.

[0074] This may significantly ease and accelerate the process of integrating fibers when manufacturing artificial turf that comprises complex patterns of multiple different colors.

[0075] **Figure 7B** depicts a flowchart of a method of producing a layered surface structure 950 as depicted, for example, in figure 9.

[0076] In step 750, a display layer 952 comprising one or more display elements is applied.

[0077] The display layer can be installed on a base layer made of a natural material such as soil, wood, or stone or on top of a base layer made of another type of material such as concrete, polyurethane, acrylic resin or similar. The layered structure can be an indoor or an outdoor flooring, e.g., a playing surface of a sports field or playground. In particular, the surface structure can be an interactive playing surface, e.g., an interactive gym floor, soccer floor, golf course, tennis field, or similar. The application of the display layer can comprise installing the display elements at the use site, e.g., connecting the display elements with one or more control units and with a power source.

[0078] Then in step 752, an artificial turf is applied on top of the display layer. The artificial turf is an artificial turf as described herein for embodiments and examples of the invention and as depicted, for example, in figures 2, 3, 4, 5, 6, 8, and 9. The artificial turf can be placed directly on top of the display layer. Alternatively, one or more translucent, preferably transparent material layers can be applied on top of the display layer before the artificial turf is applied. For example, a glass layer or a polymer foil layer can be applied in order to better protect sensitive electronic components of the display elements from impacting objects.

[0079] The display elements can be electronic display elements adapted to visually represent and display information and emit light signals in the direction to the artificial turf, i.e., in an upward direction. In some embodiments, the display elements are configured to emit light in basically all directions. However, preferably, the display elements are configured to emit the majority of the light in basically an upward direction to save energy and costs. It needs to be ensured that at least the players using the surface structure and also the audience can see the light intensity and/or color pattern generated by the light emitted by the display elements.

[0080] **Figure 8** depicts tuft rows 802, 804 of an artificial turf 800 according to an embodiment of the invention. In the depicted embodiment, texturized face yarn fibers and texturized thatch yarn fibers are tufted in straight parallel rows. Thatch yarn fiber rows ("B"), 802 and face yarn fiber rows ("A") 804 are alternating in the plane of the artificial turf. The face yarn fibers are longer than the thatch yarn fibers. The fibers are integrated into the carrier mesh by a tufting process, whereby bundles of fibers of the same type are tufted into the carrier and are then cut. Each row 802, 804 comprises only fibers of one particular type, i.e., either thatch yarn fibers or face yarn fibers.

[0081] The distance between tufting rows of the same fiber type can be e.g., 1.9 cm and can be about 0.95 cm between neighboring rows of face/thatch yarn.

[0082] **Figure 9** depicts another artificial turf 900 wherein texturized face yarn fibers and texturized thatch yarn fibers are tufted in parallel, zigzag rows. Thatch yarn fiber rows 902 and face yarn fiber rows 904 are alternating in the plane of the artificial turf. Each row comprises only fibers of one particular type, i.e., either thatch yarn fibers or face yarn fibers.

[0083] Using texturized face yarn fibers reduces the anisotropy of the roll resistance of the artificial turf. Zigzag rows are particularly advantageous in this context as they reduce the anisotropy of the roll resistance of the artificial turf even more.

[0084] According to further embodiments ("mixed type tuft rows," not shown), face yarn fibers and thatch yarn fibers are tufted in parallel, mixed type (or "mixed") rows. Each row comprises a mixture of both texturized face yarn fibers and texturized thatch yarn fibers. For example, each row may comprise a mixture of thatch yarn fiber bundles and face yarn fiber bundles. Alternatively, each row may comprise a mixture of face and thatch yarn fibers that are individually tufted into the carrier. Still alternatively, each row may comprise tuft bundles respectively comprising a mixture of thatch yarn fibers and face yarn fibers.

[0085] **Figure 10** depicts a layered surface structure 950 according to an embodiment of the invention. The surface structure comprises a display layer 952 and an artificial turf 960 on top of the display layer.

[0086] The display layer comprises a plurality of display elements 954, e.g., LED light spots or stripes. Each of the display elements can be connected to one or more control units, e.g., one or more remote or local control computers. The control units cause the display elements to light up to display patterns of different light intensity and/or color on. These patterns can relate to line markings for different sports. For example, the display elements can be LED lights underneath a transparent or translucent layer, e.g., a glass floor. The dynamic displaying of the line markings may allow supporting many different types of sports such as tennis, handball, volleyball, basketball, and badminton by a single playing surface structure. For example, the display layer can comprise a plurality of single glass panels layered with foil and comprising bright LED or OLED spots or stripes whose intensity and/or color can be controlled by the control unit(s) individually.

[0087] The artificial turf 960 comprises translucent fibers 956. Preferably, the fibers 956 are transparent fibers, e.g., transparent PE fibers that can be texturized or non-texturized fibers. According to some embodiments, all fibers 956 of the artificial turf 960 are translucent, e.g., transparent, fibers. This may have the advantage that the light emitted by the display layer is not, or not significantly, weakened or absorbed by the artificial turf. However, this type of artificial turf is not suited for representing and comprising a graphical pattern, e.g., a logo, because the fibers basically do not modify the wavelength composition of the light passing through the fibers. According to other embodiments, the artificial turf comprises the transparent fibers 956 in addition to opaque fibers. For example, the artificial turf 950 can be an artificial turf as described herein for embodiments and examples of the inventive artificial turf, e.g., a turf 100, 200, 400, 500, 600, 800, 900 illustrated in figures 1, 2, 4, 5, 6, 8, and 9. This may have the advantage that some patterns can be generated by the display layer while other patterns can be generated based on color differences of the opaque face yarn fibers. For example, the color of the pigments of different face yarn fibers can be used for defining permanent patterns in the artificial turf, e.g., line markings or a logo of a club owning the surface structure 950 while the light emitted selectively by some display elements of the display layer may define line markings that may be changed dynamically based on the type of game to be played. However, it is also possible that the line markings, for example, are defined permanently via pigment differences of face yarn fibers and the display elements are used for displaying dynamically modifiable patterns such as the logo of the invited club, an ad, a text with information for visitors, or the like.

[0088] The face yarn fibers 102 of the artificial turf 200 may absorb some of the light emitted by the display elements 954, but a significant portion of the light will pass through the artificial turf layer because the translucent thatch yarn fibers ensure that the light is not completely absorbed or blocked by the face yarn fibers. The thatch yarn fibers, in particular if textured, will occupy space and thus ensure that some regions of the artificial turf allow light to pass through.

Listofreferencenumerals

[0089]

100	3D model of artificial turf
102	face yarn fibers
104	thatch yarn fibers
106	carrier
108	base layer
110	filler material
L2	length of thatch yarn fibers
L3	length of face yarn fibers
L1	difference of L2 and L3
200	artificial turf
202	selected region of artificial turf 200
400	artificial turf
500	artificial turf
600	artificial turf
702-706	steps
750-752	steps
800	artificial turf
802	tuft row comprising thatch yarn fibers
804	tuft row comprising face yarn fibers
900	artificial turf
902	tuft row comprising thatch yarn fibers
904	tuft row comprising face yarn fibers
950	layered surface structure
952	display layer
954	display element
956	translucent fiber
960	artificial turf

Claims

1. An artificial turf (200, 400, 500, 600, 800, 900) comprising:

   - a carrier (106);
   - translucent thatch yarn fibers (104) integrated in the carrier; and
   - opaque face yarn fibers (102) integrated in the carrier.

2. The artificial turf of claim 1, wherein the length of the thatch yarn fibers is smaller than the length of the face yarn fibers.

3. The artificial turf of any one of the previous claims, wherein the translucent thatch yarn fibers are trans-

parent.

4. The artificial turf of any one of the previous claims, wherein the artificial turf comprises two or more subregions, wherein all face yarn fibers contained in a subregion have the same color, which is different from the color of the face yarn fibers contained in all subregions adjacent to that subregion.

5. The artificial turf of any one of the previous claims, wherein the two or more subregions form a color pattern being selected from a group comprising:

- a logo of an organization;
- field markings and regions defined by the field markings;
- symbols of a game; and
- a pattern representing a text or an image.

6. The artificial turf of any one of the previous claims, wherein the face yarn fibers comprise one or more pigments.

7. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers are free of pigments.

8. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers and/or the face yarn fibers are selected from a group comprising polyethylene fibers, polyamide fibers, and polypropylene fibers.

9. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers and/or the face yarn fibers are texturized.

10. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers comprise a nucleating agent and the face yarn fibers are free of the nucleating agent or comprise a smaller amount of the nucleating agent than the thatch yarn fibers.

11. The artificial turf of claim 10, wherein the nucleating agent is an organic acid, an organic acid ester or organic acid salt.

12. The artificial turf of claim 10 or 11, wherein the nucleating agent is a salt of hexahydrophthalic acid, sorbic acid or salicylic acid, in particular a calcium salt of hexahydrophthalic acid.

13. A layered surface structure (950) comprising:

- a display layer (952); and
- an artificial turf (960, 200, 400, 500, 600, 800, 900) comprising translucent fibers (956), the artificial turf being placed on top of the display layer;

wherein the display layer comprises one or more display elements adapted to emit light signals toward the artificial turf.

14. The layered surface structure (950) of claim 13, the artificial turf being an artificial turf (200, 400, 500, 600, 800, 900) according to any one of claims 1-12.

15. A method of manufacturing an artificial turf (200, 400, 500, 600, 800, 900) comprising:

- providing (702) a carrier (106);
- integrating (704) translucent thatch yarn fibers (104) in the carrier; and
- integrating (706) opaque face yarn fibers (102) in the carrier.

16. A method of manufacturing a layered surface structure (950) comprising:

- providing (750) a display layer (952) comprising one or more display elements;
- placing (752) an artificial turf (960, 200, 400, 500, 600, 800, 900) comprising on top of the display layer;

wherein the display elements are adapted to emit light signals toward the artificial turf.

Amended claims in accordance with Rule 137(2) EPC.

1. An artificial turf (200, 400, 500, 600, 800, 900) comprising:

- a carrier (106);
- translucent thatch yarn fibers (104) integrated in the carrier; and
- opaque face yarn fibers (102) integrated in the carrier, wherein the length of the thatch yarn fibers is smaller than the length of the face yarn fibers, and wherein the translucent thatch yarn fibers are transparent.

2. The artificial turf of claim 1, wherein the artificial turf comprises two or more subregions, wherein all face yarn fibers contained in a subregion have the same color, which is different from the color of the face yarn fibers contained in all subregions adjacent to that subregion.

3. The artificial turf of any one of the previous claims, wherein the two or more subregions form a color pattern being selected from a group comprising:

- a logo of an organization;
- field markings and regions defined by the field

markings;
- symbols of a game; and
- a pattern representing a text or an image.

4. The artificial turf of any one of the previous claims, wherein the face yarn fibers comprise one or more pigments.

5. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers are free of pigments.

6. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers and/or the face yarn fibers are selected from a group comprising polyethylene fibers, polyamide fibers, and polypropylene fibers.

7. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers and/or the face yarn fibers are texturized.

8. The artificial turf of any one of the previous claims, wherein the thatch yarn fibers comprise a nucleating agent and the face yarn fibers are free of the nucleating agent or comprise a smaller amount of the nucleating agent than the thatch yarn fibers.

9. The artificial turf of claim 8, wherein the nucleating agent is an organic acid, an organic acid ester or organic acid salt.

10. The artificial turf of claim 8 or 9, wherein the nucleating agent is a salt of hexahydrophthalic acid, sorbic acid or salicylic acid, in particular a calcium salt of hexahydrophthalic acid.

11. A layered surface structure (950) comprising:

- a display layer (952); and
- the artificial turf according to claim 1, the artificial turf being placed on top of the display layer;

wherein the display layer comprises one or more display elements adapted to emit light signals toward the artificial turf.

12. A method of manufacturing an artificial turf (200, 400, 500, 600, 800, 900) comprising:

- providing (702) a carrier (106);
- integrating (704) translucent thatch yarn fibers (104) in the carrier; and
- integrating (706) opaque face yarn fibers (102) in the carrier, wherein a length of the thatch yarn fibers is smaller than a length of the face yarn fibers, and wherein the translucent thatch yarn fibers are transparent.

13. A method of manufacturing a layered surface structure (950) comprising:

- providing (750) a display layer (952) comprising one or more display elements;
- placing (752) the artificial turf manufactured by the method according to claim 12 on top of the display layer;

wherein the display elements are adapted to emit light signals toward the artificial turf.

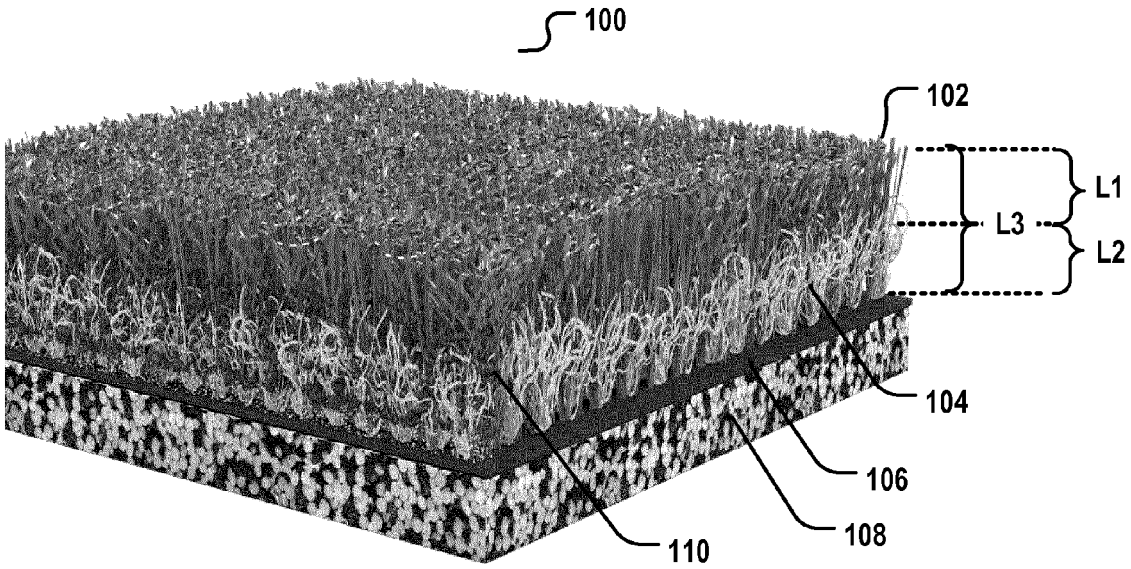

Fig. 1

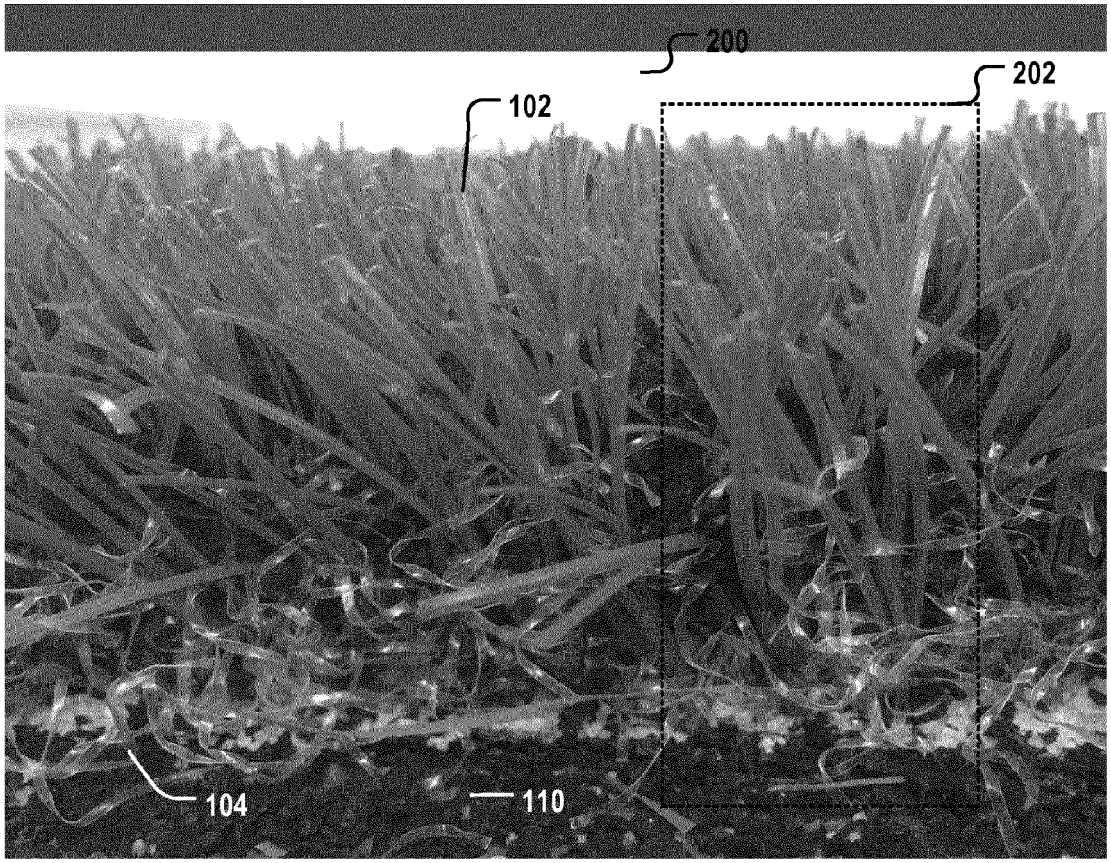

Fig. 2

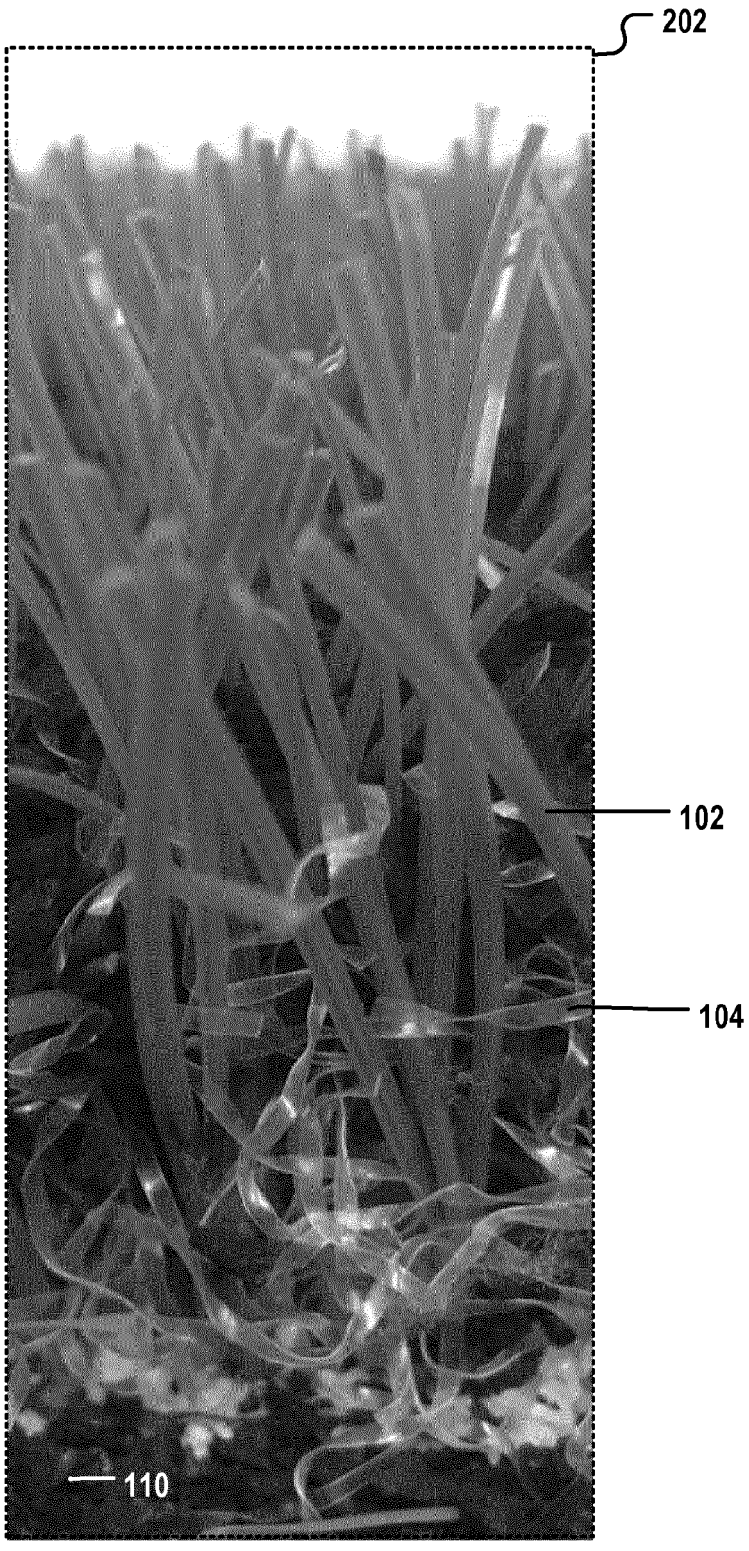

Fig. 3

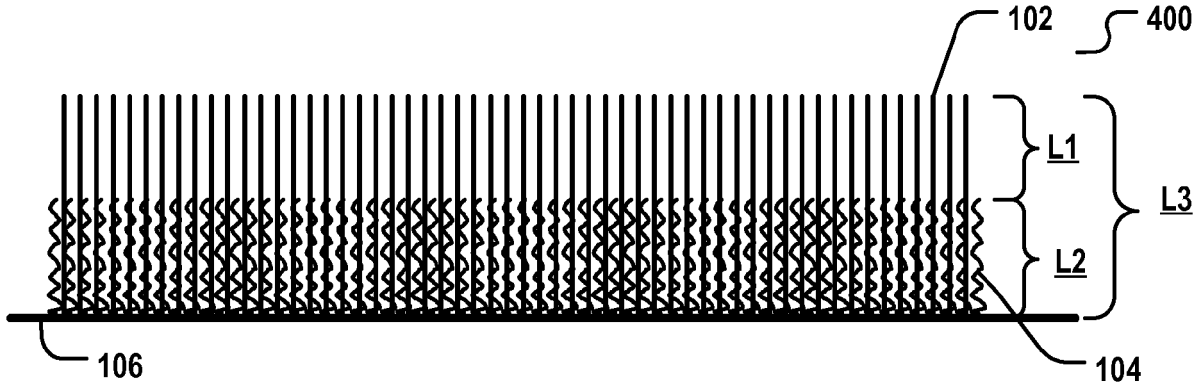

Fig. 4

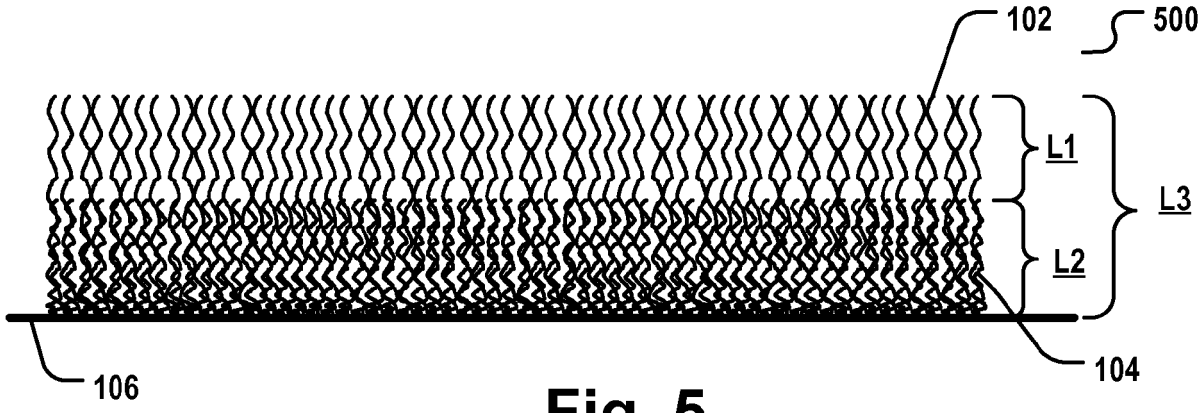

Fig. 5

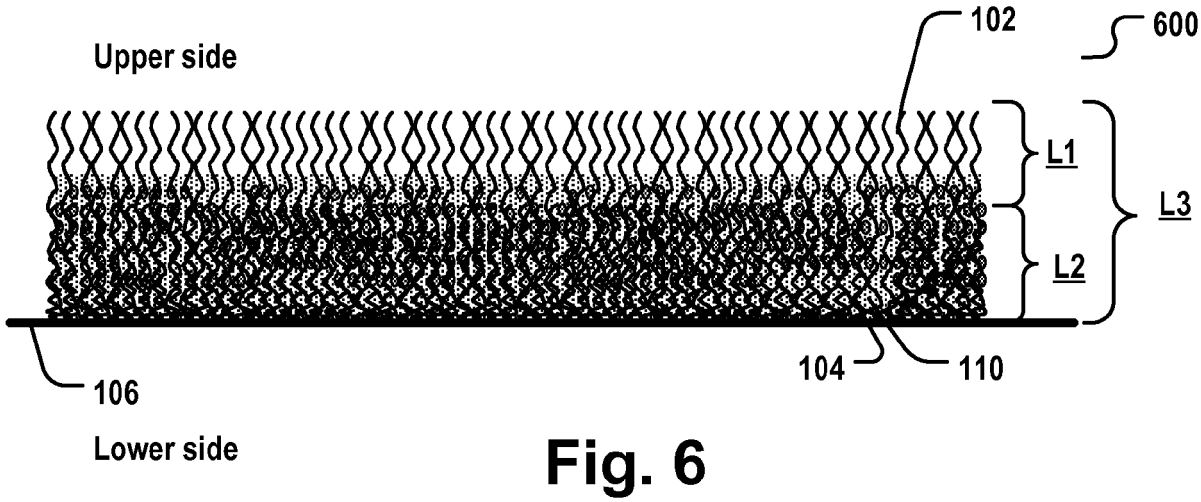

Fig. 6

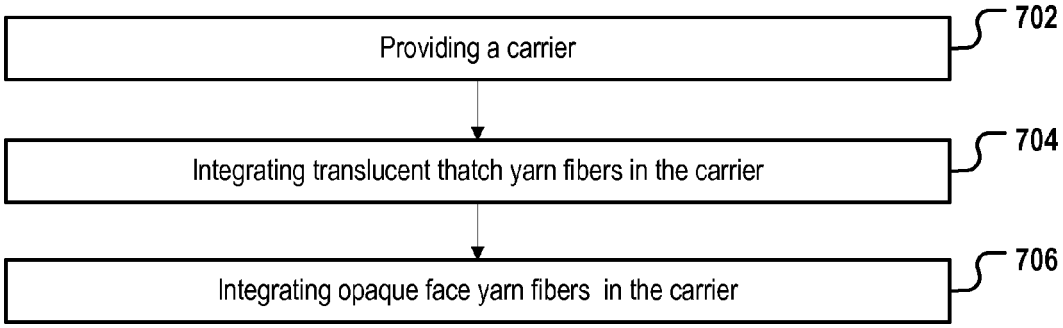

Fig. 7A

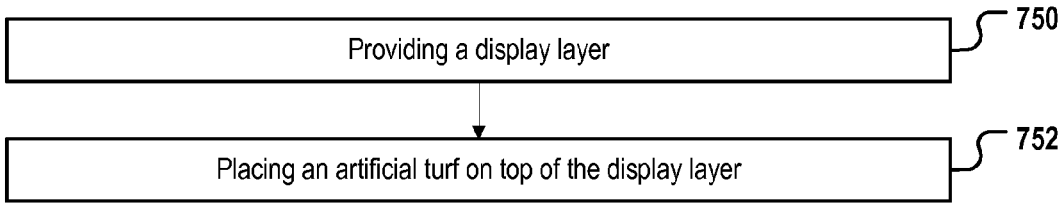

Fig. 7B

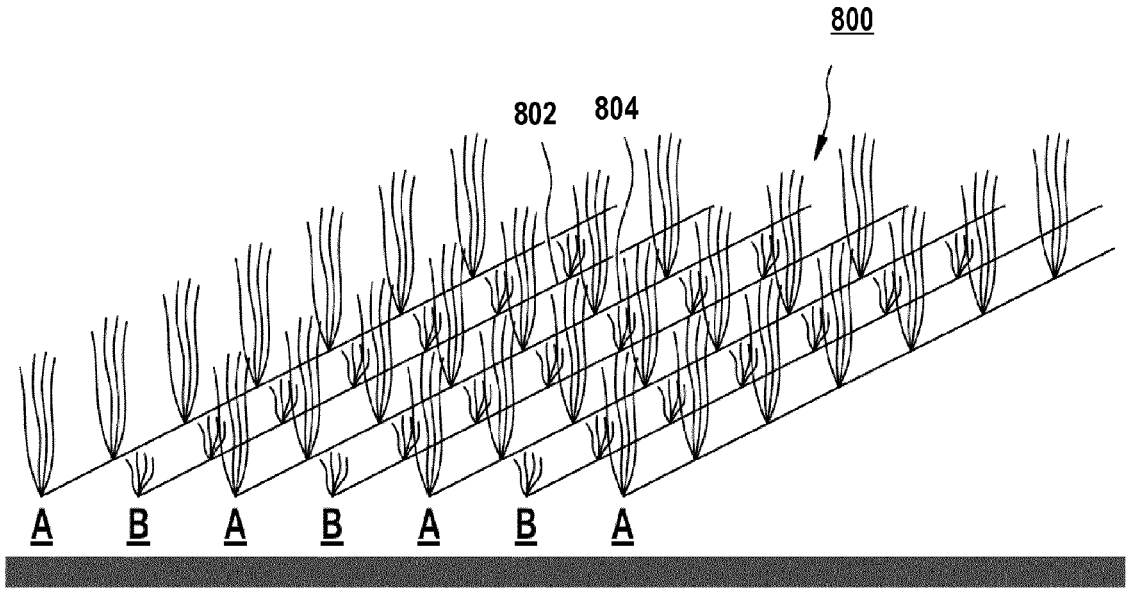

Fig. 8

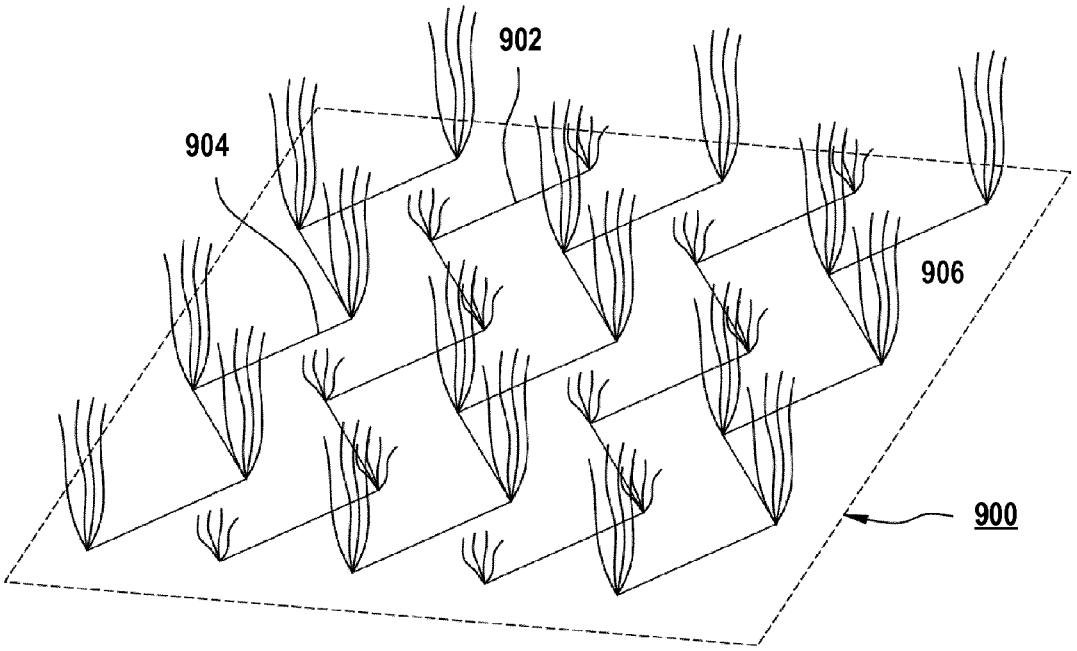

Fig. 9

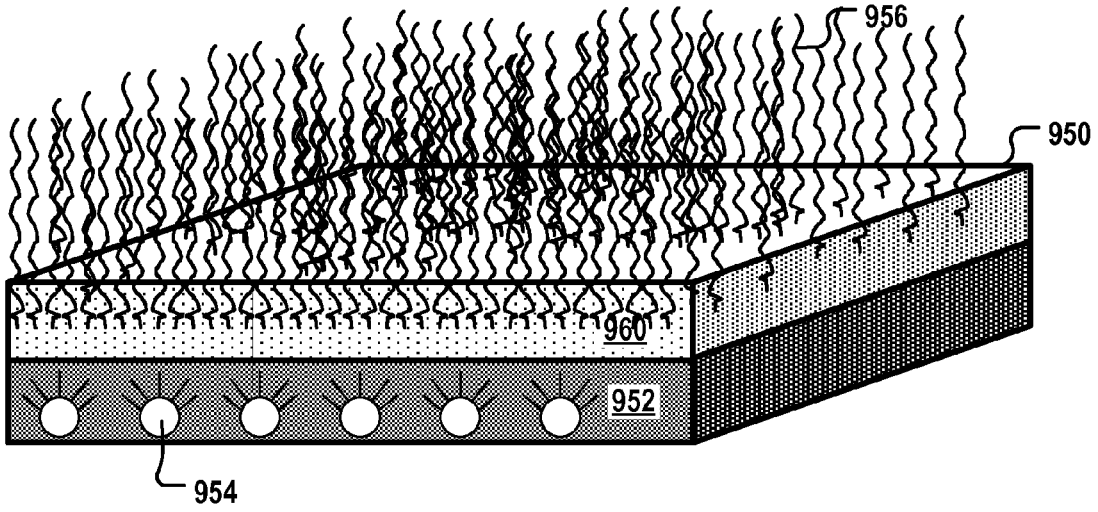

Fig. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 19 15 4074

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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
The Hague	21 June 2019	Barathe, Rainier

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EUROPEAN SEARCH REPORT

Application Number
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