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(54) **METHOD FOR PRODUCING A SURFACE OF A COMPONENT, SAID SURFACE HAVING REDUCED DRAG AND COMPONENT WITH REDUCED DRAG**

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(57) **ABSTRACT**

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§ 371 (c)(1),
(2), (4) Date: **Jan. 3, 2014**

A method for the production of a riblet film, having at least one surface that reduces airflow resistance involves the provision of a metal film that is structured using a mechanical treatment.

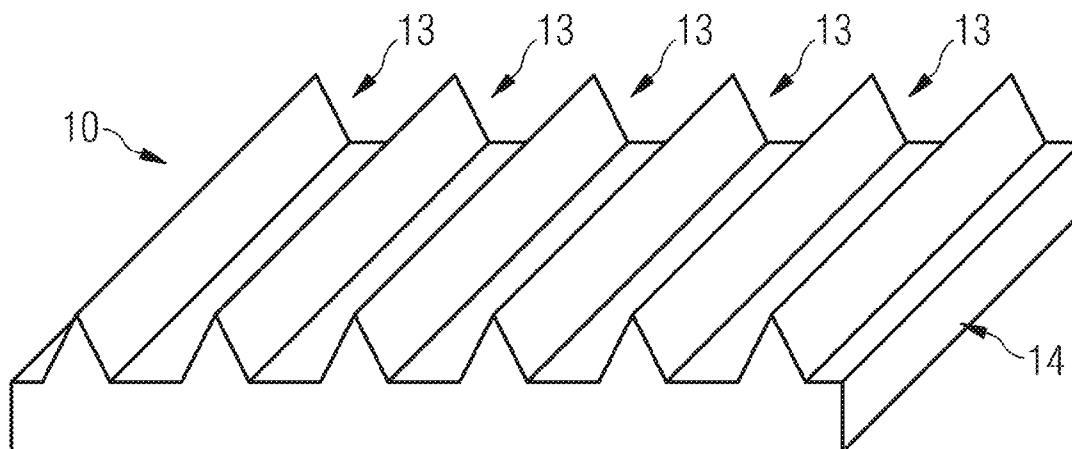


FIG 1

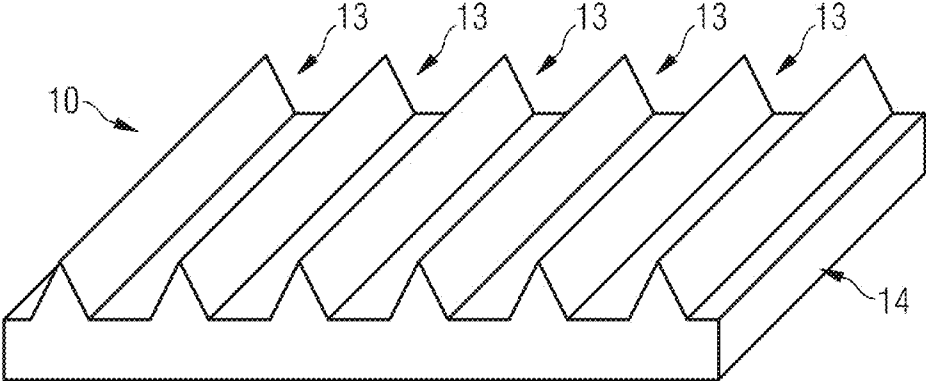


FIG 1a

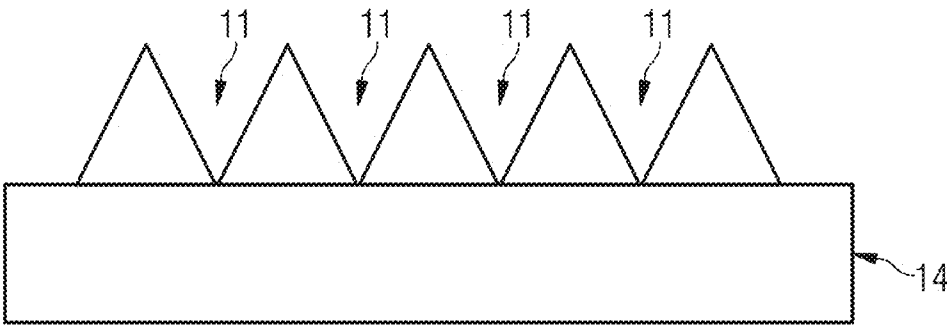


FIG 1b

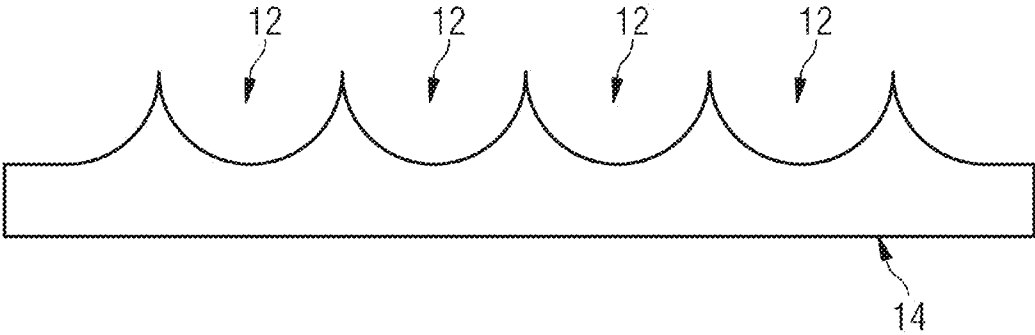


FIG 1c

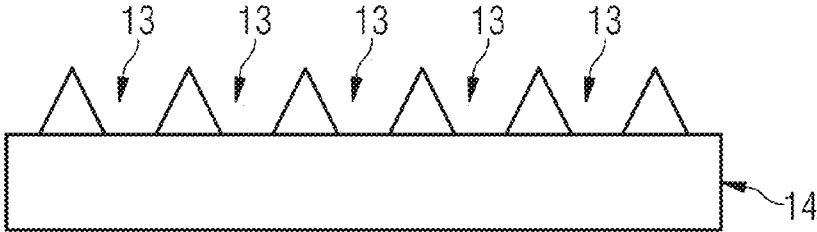


FIG 2

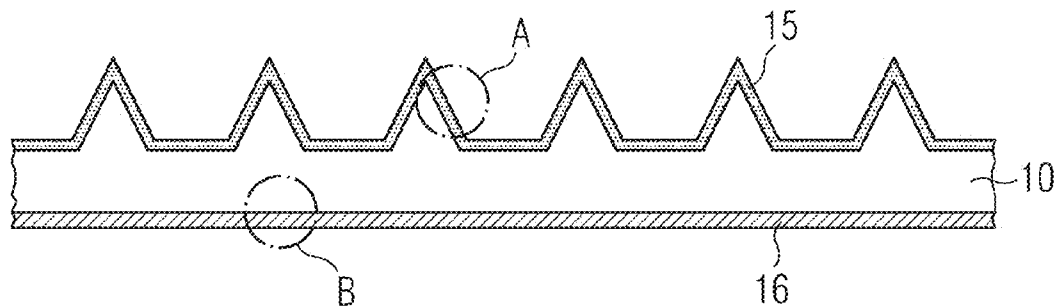


FIG 3a

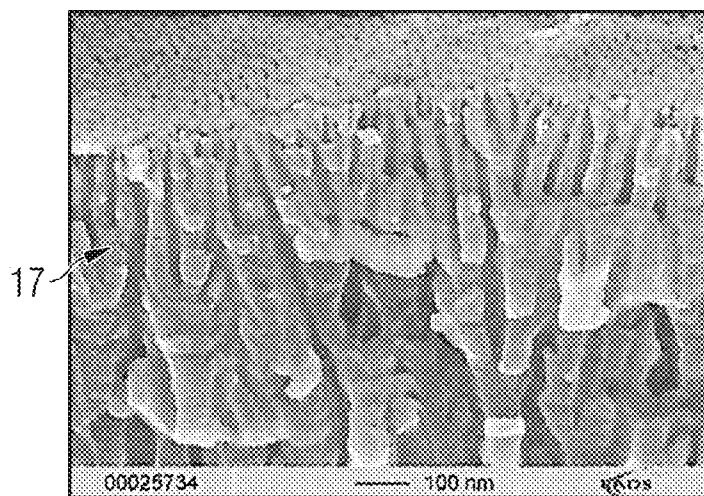


FIG 3b

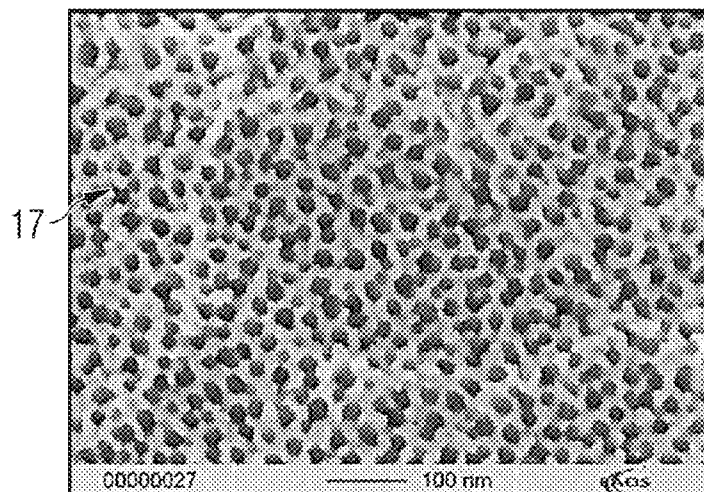


FIG 4a

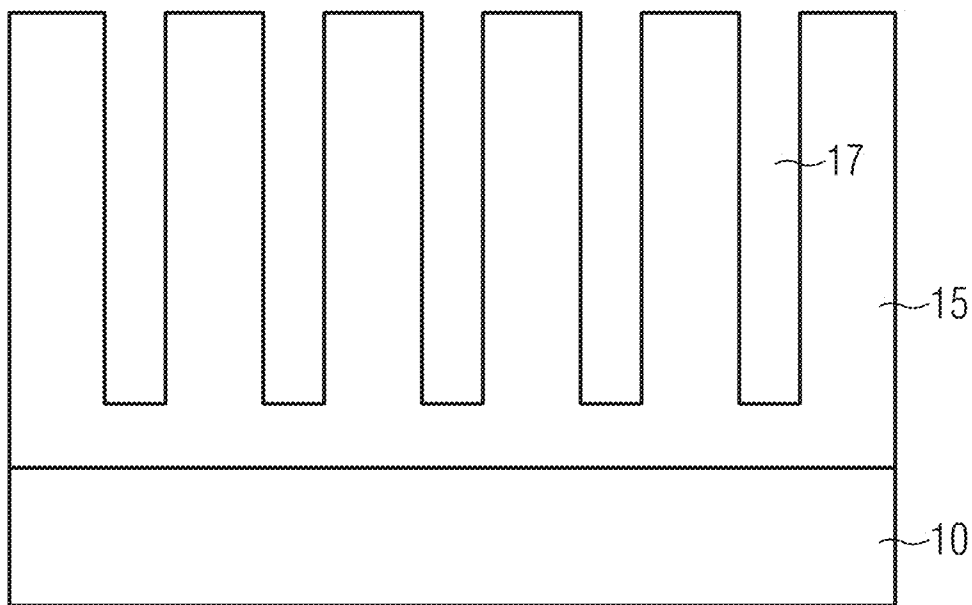


FIG 4b

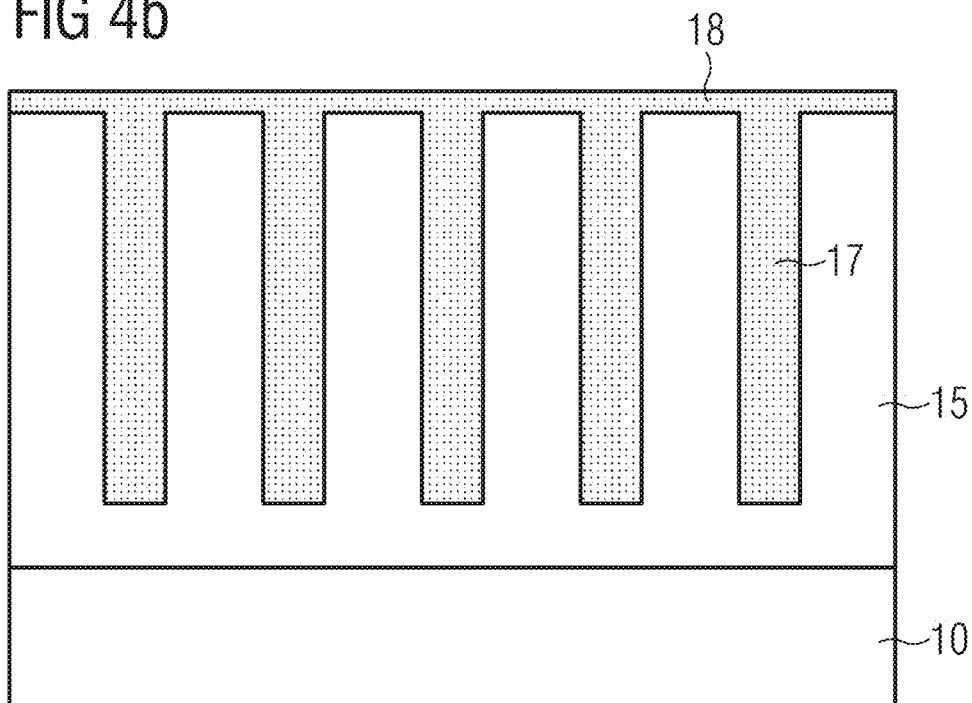


FIG 5

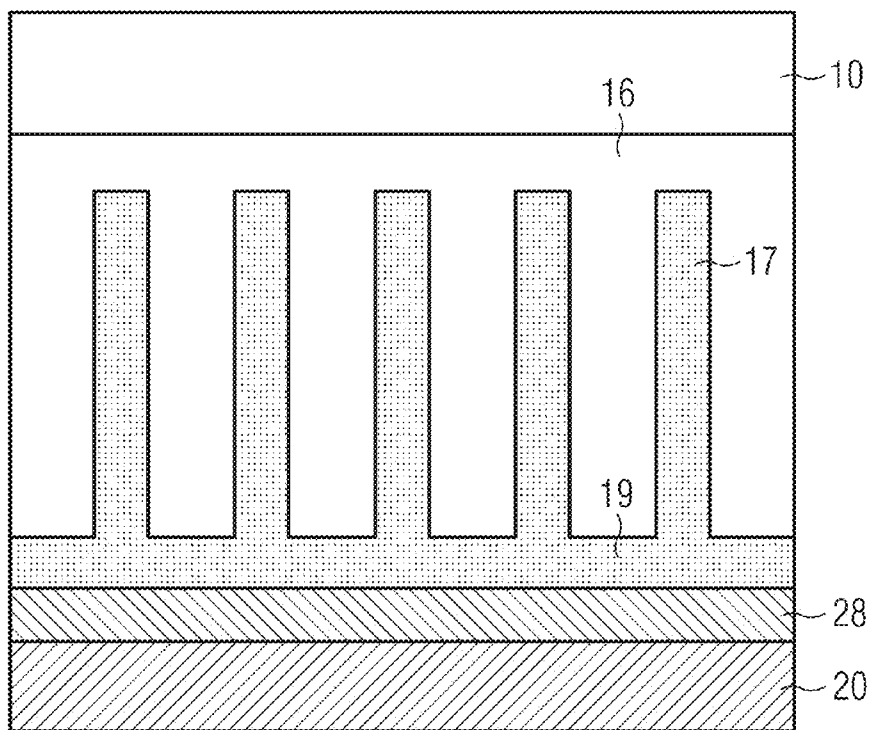


FIG 6

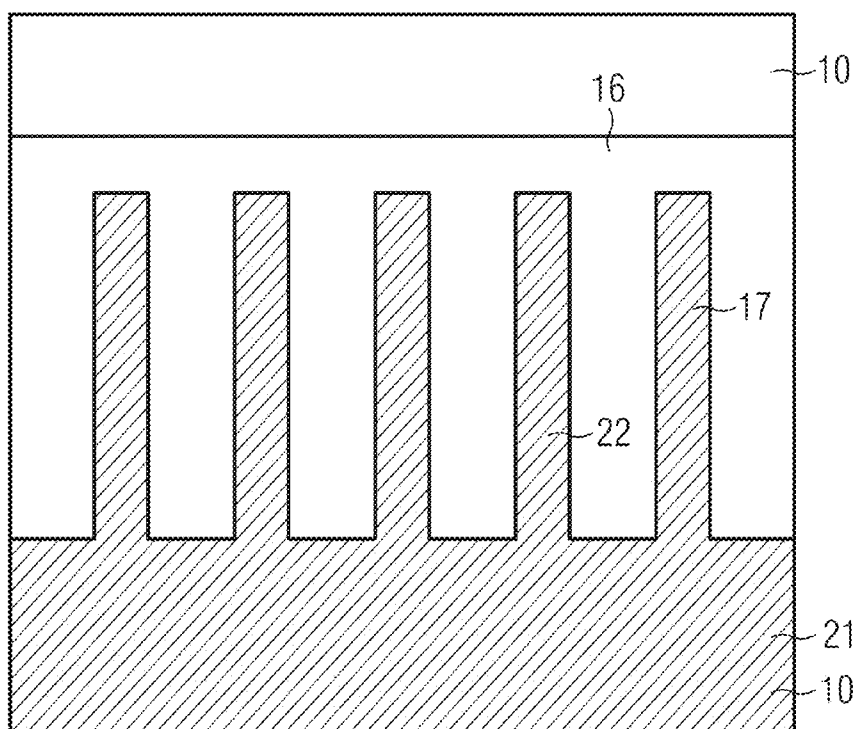


FIG 7

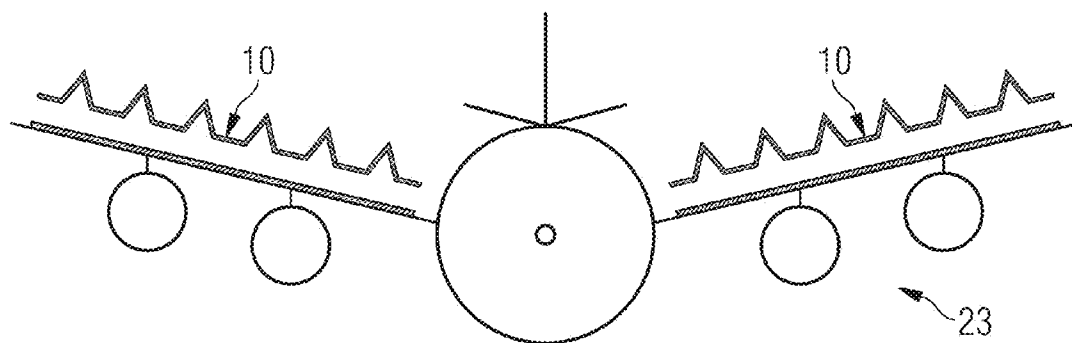
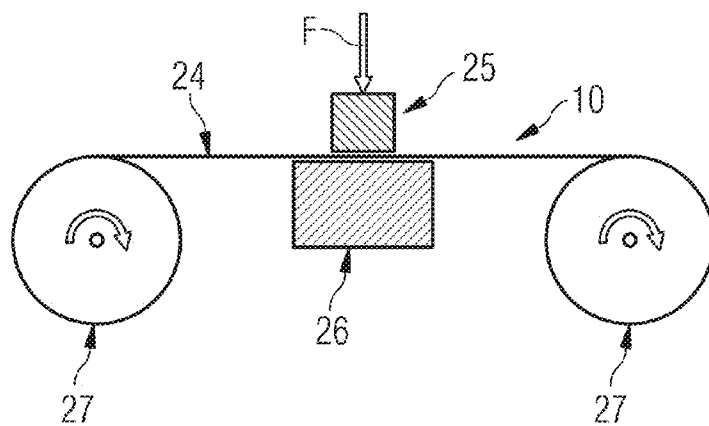


FIG 8



**METHOD FOR PRODUCING A SURFACE OF
A COMPONENT, SAID SURFACE HAVING
REDUCED DRAG AND COMPONENT WITH
REDUCED DRAG**

**BACKGROUND AND SUMMARY OF THE
INVENTION**

[0001] Exemplary embodiments of the present invention relate to a method for the production of a surface of a component with reduced airflow resistance. In particular, the component in this case is a structural component, such as is found in aircraft, helicopters, or flying bodies. After the method is carried out, the surface of the component has a reduced airflow resistance.

[0002] The reduction of fuel consumption and the reduction of emissions of carbon dioxide/nitrogen oxide (CO₂/NO_x) are important goals, particularly for the airplane industry or the automobile industry. In addition to lightweight construction for the purpose of reducing weight, and improving the degree of efficiency of engines, the reduction of airflow resistance is an essential component in the attempt to reach this goal.

[0003] Methods for the production of surfaces that reduce the airflow resistance thereof are known. It has been known for a long time, and proven in oil channel experiments, that the resistance of liquid or gaseous media flowing over solid surfaces can be reduced by a suitable structuring of the surfaces. The structuring of the solid surface in this case has different shapes and sizes. The article "Experiments on drag-reducing surfaces and their optimization with adjustable geometry" from Bechert, D. W. et al in the Journal of Fluid Mechanics, Vol. 338, pp. 59-97, 1997 discloses gluing a structured plastic film to a body.

[0004] Based on this, airplane companies such as Airbus and Boeing have carried out experiments in which plastic films with a corresponding structuring, from the 3M Company, were glued onto the outer surface of an aircraft. In flight tests with a large airplane, 70% of the surface of which carried such plastic films glued thereon, it was possible to demonstrate a reduction in resistance of 2% (Szodruch J., Dziomba, B., Aircraft Drag Reduction Technologies, 29th Aerospace Science Meeting, Reno, Nevada, 07-10 Jan. 1991). This led to a savings of fuel of 1.5% (Roberts J. P., Drag Reduction: An Industrial Challenge, Special Course on Skin Friction Drag Reduction, AGARD Report 786, 1992.) Calculated up to the average life of an aircraft, this is a fuel savings of approx. 10,000 tons of kerosene.

[0005] The structured plastic films used to date, however, not only are deficient in their mechanical resistance, but also demonstrate degradation of the plastic film and the adhesive with which the plastic films are adhered to the aircraft. A result of the deficient mechanical resistance is, by way of example, the rounding of the tip radius of sawtooth-shaped structures, which can lead to a mitigation of the friction-reducing effect. (Hage, W., Zur Widerstandsverminderung von dreidimensionalen Ribletstrukturen und anderer Oberflächen, Dissertation TU Berlin 2004). The degradation can also lead to the plastic films becoming detached during operation.

[0006] It is also known to produce solid metallic bodies with a surface structuring of a suitable size. By way of example, German patent document DE 10314373A1 disclose a fine-casting method by means of which turbine blades made of titanium aluminides (TiAl) are produced with a structured

surface. By way of example, the structuring of metallic surfaces using laser treatment or grinding is known from Oehlert et. al., Exploratory Experiments on Machined Riblets for 2-D Compressor Blades, Proceeding of IMECE2007, 2007 ASME International Mechanical Engineering Congress and Exposition, Nov. 11-15, 2007 Seattle, Wash., USA.

[0007] Such a direct structuring of aircraft structures by means of casting processes or machining methods (structuring by laser, or micromachining, etc.) is, however, neither technically nor economically possible at the surface sizes required for aircraft, helicopters, or other flying devices.

[0008] Moreover, aircraft or helicopters made of fiber-reinforced plastic (FRP) must be specially protected against lightning strikes. For this purpose, current-conducting metal meshes made of copper or bronze are used, laminated into the FRP structure. Metal inserts that are also laminated into the structure—so-called "expanded foils"—are also used for this purpose. It is known that damage caused by lightning is greater with greater thickness of the organic, non-conducting layer of matrix resin and paint over the embedded metal insert.

[0009] Exemplary embodiments of the present invention are directed to a component having a reduced airflow resistance when a fluid flows over the same, the component overcoming the disadvantages of the prior art and being able to be utilized in a cost-effective manner, with low technical complexity.

[0010] Exemplary embodiments of the present invention are directed to a metal film structured such that a metallic riblet film results. Riblets are microscopically small grooves on the surface of the metal film. The riblet film is applied to a component in order to reduce the airflow resistance thereof. In particular, if the riblet film is used on the component, the riblets are oriented substantially parallel to the local flow. The use of the riblet film creates a mechanically resistant and long-term durable surface of the component.

[0011] In other words, the invention provides the outer surface of the component, regardless of the size shape or, properties thereof, with properties such that the airflow resistance is reduced, and the mechanical resistance of the outer surface is increased by the riblets. By applying the riblet film to the component, the airflow resistance is reduced. In this case, it is possible that the riblet film is applied both to metal (alloy) components and to fiber composite components. Both the thickness of the riblet film and the structure thereof can be adapted to the component, and the size and shape of the riblets, as well as the thickness of the riblet film, are variable. It is advantageous that the thickness of the riblet film is less than 500 μm, and advantageously between 50-400 μm, particularly at least 200 μm. The thickness of the riblet film ensures a simple adaptation to the respective component shape with the least possible weight.

[0012] Exemplary embodiments of the present invention also provide a method of producing a riblet film, wherein at least one surface of the riblet film reduces the airflow resistance. A metal film of any size and shape is subjected to a mechanical treatment, wherein a structuring of the metal film is carried out such that a riblet film is produced. The riblet film has riblets on at least one of its surfaces. The riblets are arranged in such a manner that they significantly reduce the airflow resistance when a fluid flows over the same. The riblets are preferably arranged with an orientation along the direction of flow of the fluid. At least one surface of the riblet

film is subjected to a surface treatment such that a multi-functional layer is produced on the surface.

[0013] The metal film is made of a material having at least all of the light metals in the main groups or transition groups of the periodic table, particularly aluminum or titanium. Of course, the metals also include metal alloys containing at least one of the named metals, including lithium, beryllium, scandium, or yttrium, and particularly also steel alloys.

[0014] Due to the inherent electrical conductivity of the metal riblet films, the structured riblet films applied externally to the component assume the function of lightning protection in addition to reducing the airflow resistance. By assuming the function of lightning protection, they obviate the need for metal meshes or “expanded foils” to be laminated into the structure. In addition, a cover paint beneath the riblet film can be dispensed with, such that the weight of the riblet film is compensated for by itself. This means that, by way of example, when an aircraft is equipped with a riblet film the fuel consumption remains constant due to the constant weight of the aircraft, and due to the riblets on the riblet film, the fuel consumption is reduced. The riblet film can reduce airflow resistance up to approx. 10%, which in turn reduces the consumption of fuel.

[0015] All of the metal and metal alloys named above can be used as the material of the metal film, preferably titanium and its alloys, or steel alloys, and particularly aluminum and its alloys. The structuring of the metal film by means of mechanical treatment includes mechanical forming or molding processes such as rolling, grinding, or laser treatment, preferably rolling (including incremental methods such as the so-called “incremental rolling”), or stamping.

[0016] In the process of forming, a structure is transmitted from a roll or roller to the metal film, such that a structure of microscopically small grooves—the riblets—is created on the surface of the metal film. The roll or the roller in this case has the negative shape with respect to the later riblets. The transmission of the structure from the roll or roller to the metal film is realized, by way of example, by rolling down the roll or roller onto the metal film. The rolling method for the production of metallic riblets is described, by way of example, in *Economical and Ecological Benefits of Process-integrated Surface Structuring*, M. Thome, G. Hirt, *Key Engineering Materials Vol. 344*, 2007, pp. 939-946. Reference is hereby made to the same.

[0017] In the process of stamping, the riblet structure is transmitted to the metal film by a stamp or roll. The stamp in this case has the negative shape with respect to the later riblets. The structuring of a metal sheet using a stamp is known, by way of example, from German patent document DE 102008032618 A1, to which reference is hereby made.

[0018] The structuring of the metal film by means of grinding or laser treatment is described, by way of example, in *Exploratory Experiments on Machined Riblets for 2-D compressor blades*, Oehlert et. al, *Proceedings of IMECE2007, 2007 ASME International Mechanical Engineering Congress and Exposition*, Nov. 11-15, 2007, Seattle, Wash., USA, to which reference is hereby made.

[0019] In contrast to plastic films, the structuring of the metal film also has the additional advantage that, as a result of the mechanical treatment, the metal is strengthened, and thereby the resistance thereof to mechanical loads (e.g. erosion, rain, hail, etc.) is increased.

[0020] The riblet film can also take on the function of a heat conductor, such that, by way of example, it is possible to

prevent the formation of ice. As a result of heating of the metallic riblet film, no ice is able to form, which is particularly advantageous in the case of aircraft or helicopters, because no stalling can occur as a result of the formation of ice.

[0021] The surface treatment advantageously includes an anodizing. In the anodizing process, at least one surface of the riblet film is dipped into an electrolyte, and an oxide layer is formed on the surface of the riblet film once an electric voltage is applied. The thickness of the oxide layer is preferably 0.1 to 20 μm . This results in an increase in hardness and improvement of the erosion resistance of the riblet film.

[0022] The OOL preferably has a porous structure. This topography ensures an inner interlock structure, for example of an adhesive, adhesive primer, or resin, with the riblet film made of metal, and ensures improved adhesion and long-term durability of the riblet film.

[0023] An adhesive primer is advantageously applied to at least the surface of the riblet film which is opposite the riblets. The adhesive primer can improve the adhesive strength of the riblet film on the component, such that the riblet film does not separate from the component during operation of the component. As a result, durable, long-term adhesion between the riblet film and the component is ensured.

[0024] The application of an adhesive primer protects the oxide layer from damage or alteration, for example as a result of scratching during the application of the riblet film to the component. The applied adhesive primer also enables storage or packing of the film between the production and the application thereof to the component.

[0025] The surface treatment of the surface of the riblet film having the riblets advantageously includes an impregnation with a water-repelling or dirt-repelling liquid. This prevents contamination with dirt, the accumulation of ice, or similar deposits. The oxide layer is preferably impregnated on the surface having the riblets. This functionalization can have a temporary or long-term effect.

[0026] Particularly in the case of a temporary surface treatment, the pore structure of the oxide layer is impregnated with the water-repelling or dirt-repelling liquid. The diffusion of the liquid from the pores results in a water-repelling or dirt-repelling effect. After the liquid stored in the pores is used up, the efficacy of the surface of the riblet film can be regenerated by means of a subsequent impregnation.

[0027] A surface treatment with a long-term effect on the surface having the riblets includes an embedding of water-repelling or dirt-repelling solids into the pore structure. In addition, a coating with a thickness of several nanometers has a long-term effect, wherein the coating can be plasma-supported.

[0028] Fluorinated or partially fluorinated polymers, or modified silanes, are advantageously used in the impregnation, embedding, or coating process.

[0029] It is advantageous for the production of the riblet film if the riblet structures have trapezoidal, semi-circular, or sawtooth-shaped structures. These, substantially oriented parallel to the flow, reduce the airflow resistance and therefore increase the uplift, for example of an aircraft, a turbine blade, a helicopter rotor, or another body. The angle between the direction of flow and the riblet is advantageously less than 5° , and preferably approximately 0° .

[0030] The riblet structures have a range of sizes, with a riblet width of approximately 20 μm to 130 μm , preferably 30 μm to 80 μm , and particularly 50 μm to 60 μm . The riblet

height is in the range of 50-100% of the riblet width. The riblet height can be the same as the riblet width, or can be a combination of one of the given size ranges. A maximum reduction of the skin friction of the air flow can be achieved if the height of at least one riblet is half as large as the distance to a neighboring riblet, wherein the riblet structure can be designed in such a manner that the individual riblets directly border each other—that is, they are flush with each other—or there can be a distance between the individual riblets. A maximum reduction in the airflow resistance can be achieved if the riblets are oriented local to the direction of airflow.

[0031] If the riblet film is used to reduce the airflow resistance of a component, wherein the riblet film is produced by means of one of the methods described above, the airflow resistance is reduced when the riblet film is applied to the component.

[0032] The application of the riblet film to the component is carried out, by way of example, by adhering the riblet film to the component, or—if the component is entirely or partially manufactured from a fiber composite component—by curing (co-curing) the riblet film with the material of the fiber composite component. The riblet film advantageously has an improved adhesion to the component as a result of the inner interlock structure between the adhesive, the adhesive primer, or the resin with the riblet film on the one hand, and the component on the other, by means of the porous oxide layer.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0033] The invention is described below in an exemplary manner with reference to the embodiments illustrated in the figures. To simplify the presentation, no accurate scale has been used in the representation.

[0034] FIG. 1 shows a perspective view of a riblet film;

[0035] FIG. 1a shows a cross-section of a riblet film with sawtooth-shaped riblets;

[0036] FIG. 1b shows a cross-section of a riblet film with semi-circular riblets;

[0037] FIG. 1c shows a cross-section of a riblet film with trapezoidal riblets;

[0038] FIG. 2 shows a riblet film with an upper and a lower oxide layer;

[0039] FIG. 3a shows a cutaway view of an oxide layer in FIG. 2;

[0040] FIG. 3b shows a top view of an oxide layer in FIG. 2;

[0041] FIG. 4a shows an enlargement of detail A in FIG. 2 prior to the impregnation;

[0042] FIG. 4b shows an enlargement of detail A in FIG. 2 after the impregnation;

[0043] FIG. 5 shows an enlargement of detail B in FIG. 2 after the application of the riblet film on a component;

[0044] FIG. 6 shows an enlargement of detail B in FIG. 2 after the application of the riblet film on a fiber composite component;

[0045] FIG. 7 shows a riblet film on the wing of an aircraft;

[0046] FIG. 8 shows the production of a riblet film.

DETAILED DESCRIPTION

[0047] FIG. 1 shows a perspective, sketched view of a riblet film 10. Following a mechanical treatment (for example as described below in connection with FIG. 8), a metal film made of aluminum, which was originally without structure,

has a structured surface on one side thereof with riblets. The riblets are microscopic, small grooves on the surface of the aluminum film. In this embodiment, trapezoidal riblets 13 have been molded on the one side of the aluminum film, such that, following the mechanical treatment, a structured surface with trapezoidal riblets 13 is formed on a base 14 of the original aluminum film. The thickness of the base 14 is 200 μm . The trapezoidal riblets 13 extend in parallel over the riblet film 10.

[0048] Of course, the riblets can also have another shape, for example as described in FIG. 1a-c.

[0049] FIG. 1a illustrates a cross-section of a riblet film 10 having sawtooth-shaped riblets 11, which achieve a reduction in the airflow resistance between 5 and 6% when a fluid flows over the same. The height of the riblets 11, measured starting from the base 14, is 50 μm . The distance between two tips of the riblets 11 is 100 μm . The radius of the tips is 5% of the width of the riblets 11, but can also be up to 10%.

[0050] FIG. 1b illustrates a cross-section of another riblet film 10 having sawtooth-shaped riblets 12, which achieve a reduction in the airflow resistance between 7 and 8% when a fluid flows over the same. The height of the riblets, measured starting from the base 14, is 30 μm . The distance between two tips of the riblets 12 is 60 μm . The radius of the tips is 2% of the width of the riblets 12.

[0051] FIG. 1c illustrates a cross-section of a riblet film 10 having trapezoidal riblets 13, which achieve a reduction in the airflow resistance of a fluid which flows over the same between 7 and 8%. The height of the riblets 13, measured starting from the base 14, is 25 μm . The distance between two tips of the riblets 13 is 50 μm .

[0052] The maximum reduction of the airflow resistance is achieved when the riblets (11, 12, 13) are arranged in such a manner that they are arranged local to the flow. The angle between the riblets (11, 12, 13) and the direction of flow in this case is ideally V

[0053] In addition to riblet films 10 made of aluminum, comparable results have been obtained using riblet films made of aluminum alloys, titanium/aluminum alloys, or steel alloys. Because the density of aluminum and its alloys is rather low, this material is particularly suitable for applications of the riblet film 10 in aircraft, helicopters, or other flying bodies.

[0054] FIG. 2 shows a riblet film 10 having an upper oxide layer 15 and a lower oxide layer 16. The oxide layers 15, 16 are the result of a surface treatment. In this embodiment, an oxide layer 15, 16—and more precisely an aluminum oxide layer—is produced on both sides of the riblet film 10 by means of a phosphoric acid/sulfuric acid anodizing. The oxide layer 15, 16 increases the hardness of the riblet film 10. This improves the erosion resistance, by way of example.

[0055] The upper oxide layer 15 has a structure as is shown in FIG. 3a, b, and is additionally impregnated—see FIG. 4a, b. As a result of the impregnation, the configuration prevents contamination with dirt or the accumulation of ice. A riblet film 10 with long-term durability results, which can be used for practically the entire lifetime of an aircraft.

[0056] The lower oxide layer 16 also has a structure as is shown in FIG. 3a, b, following the anodizing, and additionally has an adhesive primer 19—see FIG. 5. Instead of the adhesive primer, an adhesive can also be used. As a result of the inner interlock structure of the adhesive primer 19 with the riblet film 10, it is possible to ensure a very good adhesion between a component and the riblet film 10 applied thereto.

[0057] The single-side application of the adhesive primer **19** on the side of the riblet film **10** facing the component protects the lower oxide layer **16** from damage. In addition, the riblet film **10** can be more easily stored between its production and the application thereof to the component—for example a turbine blade or a wing of an aircraft, and can be adapted to the component.

[0058] FIG. **3a** shows a cutaway view of an oxide layer in FIG. **2**. The oxide layer formed by the anodizing is clearly visible. The topography of the layer shows a pore structure with pores **17** of different sizes and depths. The pore opening is between 10-30 nm, with a pore depth of up to 300 nm.

[0059] FIG. **3b** shows a top view of an oxide layer in FIG. **2**.

[0060] FIG. **4a** shows an enlargement of the detail A in FIG. **2** prior to the impregnation. An oxide layer **15** has formed on the aluminum material of the riblet film **10** as a result of anodizing. The oxide layer **15** has a pore structure. The pores **17** are such as those described in the context of FIG. **3a, b**. For reasons of simplicity, the pores **17** in FIG. **4a** are shown with a consistent structure.

[0061] FIG. **4b** shows an enlargement of the detail A in FIG. **2** following the impregnation. During the impregnation, the oxide layer **15** is filled with a liquid. The liquid diffuses out of the pores **17** and thereby establishes the water-repelling or dirt-repelling effect. The liquid is retained in the pores **17**. As soon as the liquid in the pores **17** is used up, the function of the oxide layer can be re-established by means of a subsequent impregnation.

[0062] Instead of or in addition to the impregnation, water-repelling or dirt-repelling solids can be embedded in the pores **17**; or a plasma-supported coating, with a size of approx. 50-100 nm, can be used. The embedding or coating provides the advantage of giving the repelling function long life or long-term durability.

[0063] Fluorinated polymers or modified silanes are suitable as the liquid, coating material, or solid material.

[0064] FIG. **5** shows an enlargement of the detail B in FIG. **2** following the application of the riblet film **10** to the component **20**. The component **20** is a wing of an aircraft, by way of example.

[0065] Following the anodizing, a lower oxide layer **16** is formed on the side of the riblet film **10** facing the component. The oxide layer **16** has a pore structure such as that described in the context of FIG. **3a, b**. The adhesive primer **19** diffuses into the pores **17** and covers the surface of the oxide layer **16**. When the riblet film **10** is applied to the component **20**, the adhesive **28** adheres the riblet film **10** to the component on the adhesive primer **19**. An inner interlock structure (positive- and force-fitting connection) is created between the component **20** and the riblet film **10** over the adhesive primer in the pores **17** in the oxide layer **16**.

[0066] The interlock structure between a fiber composite component **21** and a riblet film is shown in FIG. **6** as an enlargement of the detail B in FIG. **2**. The riblet film **10** having a lower oxide layer **16** on the side thereof facing the component is applied to the fiber composite component **21** prior to the curing (“co-curing”) of the same. In the production of the composite of the riblet film **10** and the fiber composite component **21**, liquid resin **22** penetrates the pores of the oxide layer **16**. Upon curing, the resin remains in the pores and becomes solid. After the curing, a positive- and force-fitting connection is created between the riblet film **10** and the fiber composite component **21**.

[0067] FIG. **7** shows a riblet film **10** from one of the previous embodiments, on the wing of an aircraft **23**. For reasons of simplicity, an illustration has been chosen which is not to scale. The riblet film **10** is applied to the wing of the aircraft **23** in such a manner that the direction of flow is substantially parallel to the riblets **13**. In a view which is not shown here, the riblets **13** extend from the leading edge to the trailing edge, over the upper and lower sides of the wing. In the illustration shown, the riblet film **10** is only applied on the upper side of the wing. It is equally possible for the riblet film **10** to be applied to the fuselage of the wing or to other parts for which a reduction in the airflow resistance thereof is desired.

[0068] FIG. **8** shows the production of a riblet film **10** in a side view. A metal film **24**, for example made of aluminum or an alloy thereof, titanium or an alloy thereof, or a steel alloy, is provided on a roll **27**, rolled around the same. The metal film **24** is not structured. The length of the metal film **24** can be any arbitrary length. The width of the metal film **24** can also be any arbitrary width, and in this embodiment depends on the width of the roll **27**.

[0069] A riblet structure as shown in FIG. **1a-c** is applied to the metal film **24** by means of a stamp **25**. During the stamping, the force *F* applied by the stamp **25** is received by a counter holder **26**. The stamp **25** has a negative shape with respect to the riblet structure being generated.

[0070] The finished riblet film **10** is rolled onto another roll **27**.

[0071] The foregoing disclosure has been set forth merely to illustrate the invention and is not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.

LIST OF REFERENCE NUMBERS

- [0072] **10** riblet film
 - [0073] **11** sawtooth-shaped riblets
 - [0074] **12** semi-circular riblets
 - [0075] **13** trapezoidal riblets
 - [0076] **14** base
 - [0077] **15** upper oxide layer
 - [0078] **16** lower oxide layer
 - [0079] **17** pore
 - [0080] **18** impregnated layer
 - [0081] **19** adhesive primer
 - [0082] **20** component
 - [0083] **21** fiber composite component
 - [0084] **22** resin
 - [0085] **23** aircraft
 - [0086] **24** metal film
 - [0087] **25** stamp
 - [0088] **26** counter support
 - [0089] **27** roll
 - [0090] **28** adhesive
- 1-15. (canceled)
- 16.** A method for the production of a riblet film, comprising:
- providing a metal film;
 - structuring the metal film by mechanical treatment to form a riblet film having riblets on at least one surface, wherein the riblets are arranged in such a manner that the riblets reduce airflow resistance when a fluid flows over the riblets;
 - surface treating at least one surface of the riblet film.

17. The method according to claim **16**, wherein the surface treatment includes anodizing, which forms an oxide layer.

18. The method according to claim **17**, further comprising: applying an adhesive primer to at least, the oxide layer, which is situated opposite theriblets.

19. The method according to claim **17**, further comprising: impregnating the oxide layer with a water-repelling or dirt-repelling liquid at least on the surface comprising the riblets.

20. The method according to claim **17**, further comprising: embedding water-repelling or dirt-repelling solids into the oxide layer at least on the surface which comprising the riblets.

21. The method according to claim **17**, further comprising: coating the oxide layer with a plasma-supported coating at least on the surface comprising the riblets.

22. The method according claim **17**, wherein the oxide layer has fluorinated polymers or modified silanes at least on the surface comprising the riblets.

23. The method according to claim **16**, wherein the riblet film has trapezoidal, semi-circular, streamline-shaped, or sawtooth-shaped riblets.

24. The method according to claim **16**, wherein the riblets have a riblet width between 20 μm to 130 μm .

25. The method according to claim **24**, wherein the riblet width is between 30 μm to 80 μm .

26. The method according to claim **25**, wherein the riblet width is between 50 μm to 60 μm .

27. The method according to claim **26**, wherein the riblet width is 60 μm .

28. The method according to claim **16**, wherein a height of a riblet is half of a distance to a neighboring riblet.

29. A riblet film, comprising:
a metal film having a plurality of riblets; and
an anodized surface treatment on at least one surface of the metal film, wherein the riblet film reduces airflow resistance.

30. A component, comprising:
a riblet film applied to at least one surface of the component, wherein the riblet film comprises
a metal film having a plurality of riblets; and
an anodized surface treatment on at least one surface of the metal film,

wherein the riblet film reduces airflow resistance.
wherein the component is a component of an aircraft, helicopter, or flying body.

31. The component according to claim **30**, wherein the component is composed of a fiber composite material.

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