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(54) **SURFACE PROCESSING OF AN ALUMINUM ARTICLE**

(57) Method for the surface processing of an aluminum article which visually simulates the external effect of marble or granite.

The method comprises a step of engraving an aluminum article (1), in order to make a plurality of grooves (20) thereon defining a grooved surface (2'), which is

obtained by means of vibratory finishing; a subsequent step of anode oxidation of the grooved surface (2') of said aluminum article (1), generating a colorable aluminum oxide layer (22); a subsequent step of dyeing said colorable aluminum oxide layer (22).

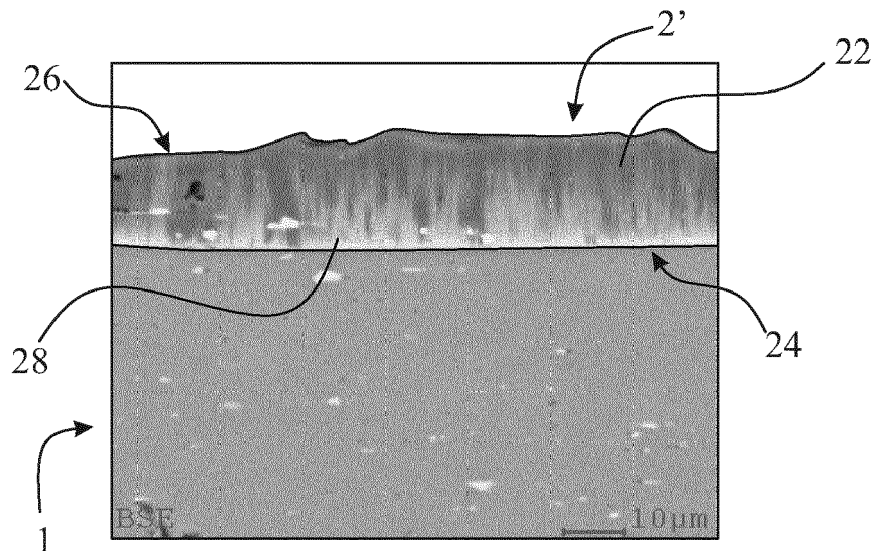


Fig. 5

Description

Field of application

[0001] The present invention regards a method for the surface processing of an aluminum article, according to the preamble of the main independent claim.

[0002] The present method is advantageously aimed to obtain an aluminum article provided with at least one surface which visually simulates the external effect of a stone, such as marble or granite, in particular reproducing the veins and colors thereof.

[0003] The present method is intended to be employed in the metallurgy field of production of aluminum articles, and in particular in the field of building construction and furniture/interior design.

State of the art

[0004] As is known, aluminum articles - whether they are rolled, extruded or produced via molding - are generally subjected to surface treatments for improving the external characteristics thereof and for improving their characteristics of resistance both to environmental factors and to chemical or physical stresses to which the article itself is subjected in accordance with the different possibilities of application.

[0005] Surface treatment processing is well known, hereinbelow generally also termed prefinishing operations, which for example comprise operations of anode oxidation, chemical sanitizing, chemical polishing, organic dyeing, electro-coloring, brushing, cleaning, grinding, micro-shot peening, vibratory finishing, vibratory polishing or still other processing activities.

[0006] In particular, the vibratory finishing surface treatment (also known with the term tumbling) is aimed to obtain a final surface that is as uniform as possible, eliminating possible defects present after the step of production of a semifinished aluminum article.

[0007] More in detail, vibratory finishing surface treatments of known type generally provide for placing the article to be treated in a bath of abrasive bodies made of plastic or urea, which execute a uniform smoothing thereon.

[0008] After the vibratory finishing, it is known to subject the article to a process of anode oxidation in order to confer a greater resistance to wear thereto.

[0009] A further prefinish processing of known type is painting. This can be provided with the object of isolating the external surface of the article from the surrounding environment, for example in order to prevent corrosion effects, i.e. also with the object of conferring the desired external finish to the article.

[0010] In order to render the articles more attractive on the market, there is the known need to carry out painting operations aimed to confer particular and appreciable aesthetic effects and in particular advantageously aimed to simulate the aesthetic effect of stones such as marble

or granite.

[0011] For such purpose, such painting processing for conferring an aesthetic effect to the article that simulates stone and in particular the veins of marble (hereinbelow for the sake of simplicity reference will only be made to marble) is generally followed by means of a process of ink sublimation.

[0012] More in detail, ink sublimation processes of known type provide for depositing a dye, generally powder, on the surface of the article to be painted and subsequently subjecting the painted article to a thermal treatment in which the dye sublimates and is bonded to the article itself and confers a desired aesthetic finish thereto.

[0013] Such painting processing with the object of reproducing marble finish on the surface of the article has in practice shown that it does not lack drawbacks.

[0014] An important drawback of such painting processing operations lies in the incapacity of obtaining a surface finish of the article that simulates the marble finish in a sufficiently realistic manner.

[0015] A further drawback of the aforesaid painting processing operations lies in the incapacity of obtaining a paint surface layer which is provided with good resistance to environmental factors and to the chemical or physical stresses to which the article itself is subjected.

[0016] In particular, the painting processing operations of known type are unable to obtain a paint surface layer capable of resisting for an extended time period and consequently require being repeated over time, and hence they involve a continuous expense for the maintenance of the article.

Presentation of the invention

[0017] In this situation, the problem underlying the present invention is therefore that of overcoming the drawbacks shown by the prefinishing processing of known type, by providing a method for the surface processing of an aluminum article which allows making aluminum articles which realistically simulate the surface effect of a stone, in particular marble or granite, and which is simultaneously less expensive than the latter.

[0018] A further object of the present invention is to provide a method for the surface processing of an aluminum article which allows making aluminum articles provided with good resistance to corrosion and wear.

[0019] A further object of the present invention is to provide a method for the surface processing of an aluminum article which allows obtaining aluminum articles that are durable over time.

[0020] A further object of the present invention is to provide a method for the surface processing of an aluminum article which does not require maintenance processing over time.

Brief description of the drawings

[0021] The technical characteristics of the invention,

according to the aforesaid objects, can be clearly seen in the contents of the below-reported claims and the advantages thereof will be more event in the following detailed description, made with reference to the enclosed drawings, which represent a merely exemplifying and non-limiting embodiment, in which:

- Figure 1 shows an aluminum article obtained by means of the method of the present invention;
- Figure 2 shows a schematic view of an engraving step of the present method;
- Figures 3a, 3b and 3c show three micrographs attained by means of an optical microscope in which it is possible to appreciate the extension of the grooves present on the surface of the article of figure 1, in particular, such micrographs were attained at three distinct areas of investigation of a section of the aforesaid aluminum article made along the trace III-III of figure 1;
- Figures 4a and 4b show two images attained by means of an optical photomicroscope of the surfaces of two aluminum articles treated with the present method, in which the grooves are represented white and the non-grooved surface is represented gray;
- Figure 5 shows an image attained by means of a scanning electron microscope of a further area of investigation of the section of the aluminum article made along the trace III-III of figure 1, in which it is possible to appreciate the aluminum oxide layer of the article of figure 1, dyed with the present method.

Detailed description of a preferred embodiment

[0022] With reference to the enclosed drawings, reference number 1 overall indicates an aluminum article obtained with the surface processing method, object of the present invention.

[0023] Advantageously, the present method is aimed to obtain an aluminum article 1 provided with at least one surface 2 provided with a surface finish that simulates the aesthetic effect of stones such as marble or granite.

[0024] Advantageously, the aluminum article 1 is intended to be employed in the construction field in substitution of the aforesaid stone materials, allowing a significant reduction of the costs with respect to the latter.

[0025] In accordance with the enclosed Figure 1, the aluminum article 1 is in sheet form, and of course it is intended that the aluminum article 1 can be of any one form and can be made by means of any one aluminum processing operation of known type, such as rolling, extrusion or molding.

[0026] Advantageously, in the present patent, the term "aluminum" will indicate aluminum at various commercial purities, or aluminum alloys.

[0027] According to the idea underlying the present invention, the present method comprises an engraving step, an anode oxidation step and a dyeing step.

[0028] In particular, the method according to the inven-

tion comprises a step of engraving at least one surface 2 of the aluminum article 1 and advantageously of the entire aluminum article 1, with the formation of at least one grooved surface 2' provided with a plurality of grooves.

[0029] In particular, the aforesaid engraving step is obtained by means of vibratory finishing, in which a plurality of impacting bodies 30 hits at least one surface 2 of the aluminum article 1, making a plurality of grooves 20, advantageously defining the aforesaid grooved surface 2', thus as schematized in the enclosed Figure 2.

[0030] Advantageously, with the term "grooves", it must be intended any type of surface incision, scratch, slit or cavity of any shape and size. For example, the grooves can comprise incisions of elongated shape and/or circular or point-like cavities.

[0031] Advantageously, the aforesaid vibratory finishing is made by means of a shaker in order to shake and/or vibrate the impacting bodies 30.

[0032] Advantageously, the aforesaid shaker which produces the aforesaid vibratory finishing is a tumbler, of known type in the field, loaded with impacting bodies 30 of hardness, size and quantity selected for imparting the above-indicated grooves 20 on the surface 2. Even if structurally the employed tumbler can be similar to those of known type, the impacting bodies in the case of the present invention will not interact with the aluminum article 1 with forces adapted to smooth the surface, i.e. uniform its appearance, as in the normal prior art tumblers - rather, on the contrary, they will attain the aforesaid grooves 20.

[0033] In particular, the tumbler for executing the aforesaid vibratory finishing is advantageously provided with a tank for containing the impacting bodies 30, such tank mechanically associated with vibrating means adapted to shake and/or vibrate the impacting bodies 30 themselves, transmitting the vibrations imparted to the tank thereto.

[0034] In operation, therefore, in the aforesaid vibratory finishing, the aluminum article 1 is inserted in the containment tank with the impacting bodies 30 shaken and/or vibrated in order to hit the surface 2.

[0035] Advantageously, in the aforesaid vibratory finishing, the impacting bodies 30 are provided with an impact force against the surface 2 such to abrade and/or deform and/or scratch the surface 2 itself, forming the grooves 20.

[0036] Advantageously, the impacting bodies 30 employed in the aforesaid vibratory finishing are constituted by stones and/or cast iron and/or ceramic material and/or other bodies preferably having hardness greater than the hardness of the aluminum article 1.

[0037] Advantageously, moreover, the impacting bodies 30 are provided with an extension comprised between 0.5 and 7 cm and preferably are provided with at least one pointed portion for scratching the surface 2.

[0038] In accordance with one embodiment of the present invention, the engraving step provides that the

aluminum article 1 is immersed for a time comprised between 20 and 60 seconds in a mass of impacting bodies 30 moved within a tumbler and made of stone, e.g. crushed river stones with dimensions comprised between 0.5 and 4 cm, and preferably between 0.5 and 1 cm, and with hardness greater than 20 HB (measured with a 10 mm ball with 500 kg load applied for 30 seconds), and preferably greater than 100 HB. The impacting bodies 30 are present in a quantity such to completely cover the aluminum article 1 in the containment tank. Advantageously, moreover, a lubricant liquid, e.g. water, is added together with the impacting bodies 30 in the containment tank of the tumbler. The entire step is repeated multiple times and advantageously twice.

[0039] Of course, it is possible to use impacting bodies 30 of different hardness, size and quantity so as to obtain grooves 20 with different characteristics, without departing from the protective scope of the present invention. For example, also artificial impacting bodies 30 made of ceramic can be used on their own or in combination with the impacting bodies 30 made of stone.

[0040] Advantageously, the use of impacting bodies 30 of smaller dimensions and provided with at least one pointed portion causes grooves 20 defined by a plurality of point-like cavities that are substantially aligned. In addition, the use of impacting bodies 30 of greater quantity or weight causes grooves 20 of greater depth, since the weight of the impacting bodies 30 increases as well as consequently the forces imparted on the surface 2 of the aluminum article 1.

[0041] Advantageously, the aluminum article can be subjected multiple times to the engraving step in order to increase the quantity of grooves 20.

[0042] In accordance with a preferred embodiment, the grooves 20 obtained by means of the vibratory finishing are extended in an irregular manner along the grooved surface 2', and in particular they are extended along non-rectilinear trajectories in order to simulate the veins and spots that characterize the aesthetic effect of stones such as marble and granite.

[0043] Preferably the grooves 20 are extended along the surface 2 for a length preferably comprised between 0.1 and 5 cm and in addition the impacting bodies 30, driven for example by the tumbler, act on the surface with forces adapted to make the grooves 20 with depth starting from the surface 2 comprised between 1 and 30 μm , and more preferably between 1 and 15 μm .

[0044] Advantageously, the aforesaid depth values were selected starting from a large number of experimental measurements executed on various aluminum articles 1 treated with the present method. In particular, Figures 3a, 3b and 3c report several experimental images made by means of a metallographic optical microscope Leica DMI5000, which depict three areas of investigation obtained starting from a section of the aluminum article 1, in which the local depths H of the grooves 20 are indicated starting from the surface 2.

[0045] Several values of the local depths detected in

the aforesaid images are shown in the following Table 1.

Table 1: Measurements of local depths of grooves 20

5	20	
	Depth	Measurement (μm)
	H1	7.34
	H2	12.3
10	H3	13.9
	H4	9.74

[0046] Preferably, moreover, the aforesaid vibratory finishing is extended for a time such to make the grooves 20 for an area comprised between 10 and 20 % of the surface 2.

[0047] Advantageously, in fact, the aforesaid values of the area affected by the grooves 20 were selected starting from a large number of experimental measurements executed on various aluminum articles 1 treated with the present method, extended for different vibratory finishing times and selecting the aluminum articles 1 which simulate the aesthetic effect of stones such as marble and granite in the most realistic manner.

[0048] In particular, the enclosed Figures 4a and 4b show two experimental images of two grooved surfaces 2' obtained by means of an optical photomicroscope WILD M420, and such grooved surfaces 2' respectively have an area affected by the grooves 20 equal to the 10.47 % of the entire surface 2, and an area affected by the grooves 20 equal to 19.61 % of the entire surface 2.

[0049] As indicated above, the present method comprises, after the engraving step, a step of anode oxidation of the grooved surface 2' of the aluminum article 1.

[0050] In operation, the anode oxidation step is aimed to generate a colorable aluminum oxide layer 22, advantageously distributed along the entire grooved surface 2'.

[0051] Advantageously, moreover, the present method provides, before the anode oxidation step, and preferably after the engraving step, a step of cleaning the aluminum article 1. In operation, such cleaning step is aimed to eliminate possible traces of impurities from the grooved surface 2', such as organic substances, oils, fats or pastes generally coming from various handling that the aluminum article 1 previously sustains.

[0052] In particular, the aforesaid cleaning step comprises one or more operations of degreasing, rinsing and/or deoxidizing of the surface 2 (all the aforesaid operations are of conventional type, known to the man skilled in the art and therefore not described hereinbelow).

[0053] Preferably, the anode oxidation step provides for positioning the aluminum article 1 in a tank containing an electrolytic bath preferably constituted by sulfuric acid in aqueous solution.

[0054] In particular, within the electrolytic bath, also an electrode is positioned adapted to act as a cathode, with

the aluminum article 1 that acts as anode.

[0055] Advantageously, moreover, the anode oxidation step provides for connecting the aluminum article 1 to the positive pole of a voltage and/or current generator, and provides for connecting the electrode to the negative pole of the same generator so as to anodically polarize the aluminum article 1 itself by means of a passage of current between the anode and cathode.

[0056] Advantageously, the aforesaid anode oxidation step is extended over time up to obtaining a desired average thickness of the aluminum oxide layer 22. In operation, in fact, the greater the duration of the anode oxidation step, the greater the average thickness of the aluminum oxide layer 22.

[0057] Advantageously, the anode oxidation step does not modify the morphology of the grooves 20, and more precisely it does not modify the depth or the length of the grooves 20 themselves, as can be appreciated in the enclosed Figures 3a, 3b and 3c. Indeed, the aluminum oxide layer 22 does not increase from the grooved surface 2' towards the environment outside the aluminum article 1, but rather it increases towards the interior of the article, without filling the grooves 20.

[0058] According to the invention, the aluminum oxide layer 22 is provided with a first thickness T1 of aluminum oxide 22 at the grooves 20, and with a second thickness T2 of aluminum oxide 22 at the remaining regions of the surface 2 free of grooves 20.

[0059] In particular, the first thickness T1 attained with the present method is smaller than the second thickness T2, as can be appreciated by the enclosed Figures 3a, 3b and 3c.

[0060] Advantageously, the second thickness T2 of aluminum oxide is comprised between 5 and 30 μm , e.g. from Figures 3a, 3b and 3c a second average thickness T2 of aluminum oxide 22 was measured of about 20 μm . As indicated above, such thickness can be suitably varied by varying the time extension of the aforesaid anode oxidation step.

[0061] In particular, the aluminum oxide layer 22 is extended between a first face 24 and a second face 26, regarding which the first face 24 is placed in contact with the non-oxidized aluminum forming the aluminum article 1, and the second face 26 is directed in the opposite direction with respect to the first face 24 and in particular is placed in contact with the environment surrounding the aluminum article 1.

[0062] Advantageously, moreover, as can be appreciated from the enclosed figures, the first face 24 is substantially planar and in particular it is arranged at a greater depth than the depth of the grooves 20.

[0063] Advantageously, moreover, the aluminum oxide layer 22 is provided with a porous structure, i.e. with a plurality of pores which are extended to at least partially traverse the aluminum oxide layer 22.

[0064] The aforesaid pores are extended starting from the second face 26 of the aluminum oxide layer 22 for an oxidation depth, in particular up to a bottom wall (not

illustrated) which is placed in proximity to the first face 24 of the aluminum oxide layer 22 itself, and after such bottom wall the pores are negligible or absent.

[0065] Advantageously, the bottom wall of each pore separates the non-oxidized aluminum forming the aluminum article 1 from the outside environment, preventing a further oxidation thereof.

[0066] Advantageously, the aforesaid pores are provided with substantially cylindrical form and in particular are provided with a nanometric diameter.

[0067] Advantageously, the first thickness T1 of aluminum oxide 22 is provided with first pores and the second thickness T2 is provided with second pores, which are generally provided with different dimensions with respect to the aforesaid first pores and in particular, the first pores are provided with a smaller size than the second pores. More in detail, the first pores are characterized by an extension, and advantageously also by a diameter, smaller than the second pores.

[0068] As indicated above, following the anode oxidation step, the present method also comprises a step for dyeing the colorable aluminum oxide layer 22 along the first and the second thickness T1, T2.

[0069] Advantageously, in the dyeing step, the aluminum article 1 is immersed in a bath containing dye substances 28, such as pigmented substances or metals, which are adapted to penetrate into the aluminum oxide layer 22 of the treated aluminum article 1.

[0070] In particular, in the aforesaid dyeing step, the first thickness T1 of the aluminum oxide layer 22 is dyed with a corresponding first coloring depth while the second thickness T2 of the aluminum oxide layer 22 is dyed with a corresponding second coloring depth greater than the first depth.

[0071] Advantageously, in fact, the present method allows dyeing in a different manner, and hence underlining the grooves 20 with respect to the remaining surface 2 lacking the grooves 20 themselves. In particular, such underlining allows advantageously simulating the aesthetic effect of veins present in stones such as marble and granite in a realistic manner.

[0072] More in detail, in the aforesaid dyeing step, the dye substances 28 penetrate into the pores of the aluminum oxide layer 22 which are filled with different coloring depths at the aforesaid first and second thickness T1, T2.

[0073] As indicated above, in fact, the first pores of the first thickness T1 of the aluminum oxide layer 22 are advantageously provided with a size (i.e. a volume) smaller than the second pores and hence they are susceptible of being filled with a smaller quantity (i.e. with a lower coloring depth) of dye substance 28 with respect to the second pores, thus determining the different coloring of the grooves 20 with respect to the surface 2 lacking the latter.

[0074] Advantageously, moreover, also the different orientation of the grooves 20 with respect to the remaining surface 2 involves light reflection differences, regarding the light incident on the grooved surface 2'. This trans-

lates into a different perception of the color of the grooved surface 2' itself and more greatly enhances the grooves 20.

[0075] One example of the colored oxide layer 22 is shown in the section of figure 5, which was obtained by means of a scanning optical microscope (SEM), by means of analysis of the backscattered electrons (BSE). In particular, in such figure, it is possible to appreciate the presence of the dye substance 28 (indicated with a lighter coloring), which is more greatly concentrated in proximity to the first face 24 of the aluminum oxide layer 22.

[0076] In a first embodiment variant of the present dyeing step, the aluminum oxide layer 22 is dyed via electro-coloring.

[0077] More in detail, in such electro-coloring, the anodized aluminum article 1 is immersed in an acidic solution containing the dye substance 28, in particular composed of metallic salts, and subsequently is subjected to an alternating current.

[0078] Consequently, metallic deposits are formed within the pores of the aluminum oxide layer 22, which dye the layer itself with the characteristic color of the used metallic salt. For example, tin metallic salts confer a dark surface coloring.

[0079] In a second embodiment variant of the present dyeing step, the aluminum oxide layer 22 is dyed via absorption of organic pigments, i.e. via immersion of the aluminum article 1 in a bath containing a solution of organic pigments.

[0080] In operation, such organic pigments are absorbed from the aluminum oxide layer 22 and are deposited within the pores, being bonded to the aluminum oxide layer 22 itself through chemical bonds (generally of covalent or Van Der Waals type). Advantageously, in such second embodiment variant of the dyeing step, watersoluble organic dyes are used, having high solidity under light.

[0081] Advantageously, the dyeing step of the aluminum article 1 can also occur through other coloring methods of known type (e.g. coloring via inorganic absorption), without departing from the protective scope of the present patent.

[0082] Advantageously, the present method also comprises, following the dyeing step, a step of fixing the oxide layer 22 and in particular the dye substance 28 present in its pores. Advantageously, such fixing step allows sealing the pores of the aluminum oxide layer 22, increasing the resistance of the aluminum article 1 against corrosive attacks.

[0083] In a first embodiment variant of the fixing step, the latter is made under cold conditions by immersing the aluminum article 1 in a nickel fluoride based solution, which is susceptible of obstructing the pores of the aluminum oxide layer 22. In operation, in fact, in the aforesaid first embodiment of the fixing step, the nickel fluoride precipitates within the pores of the aluminum oxide 22 and chemically reacts with the aluminum oxide 22 itself,

determining the formation of aluminum hydroxy fluorides which obstruct the pores.

[0084] In a second embodiment variant of the fixing step, the latter is made under hot conditions, in which the aluminum oxide 22 is placed in contact with a high-temperature aqueous solution (in particular at temperature higher than 85°C) which determines the transformation of the aluminum oxide 22 itself into a compound termed "pseudo-boehmite", which possesses a specific volume greater than the aluminum oxide 22. Consequently, the pseudo-boehmite tends to be expanded, sealing the pores.

[0085] Advantageously, the present method can also comprise a step of polishing the surface 2 of the aluminum article 1, which provides for removing a surface part of the aluminum oxide thickness 22, e.g. provided with a thickness of 1 or 2 µm.

[0086] Advantageously such polishing step is subsequent to the anode oxidation step, more preferably it follows the dyeing step and still more preferably it follows the fixing step.

[0087] The invention thus conceived therefore allows obtaining the pre-established objects.

Claims

1. Method for the surface processing of an aluminum article, which is **characterized in that** it comprises:

- a step of engraving an aluminum article (1) by means of vibratory finishing, wherein a plurality of impacting bodies (30) hits at least one surface (2) of said aluminum article (1), forming a grooved surface (2') provided with a plurality of grooves (20);

- a subsequent step of anode oxidation of the grooved surface (2') of said aluminum article (1), generating a colorable aluminum oxide layer (22) having:

- a first thickness (T1) of aluminum oxide (22) at said grooves (20), and
- a second thickness (T2) of aluminum oxide (22) at the remaining regions of said surface (2) free of said grooves (20); said first thickness (T1) being smaller than said second thickness (T2);

- a subsequent step of dyeing said colorable aluminum oxide layer (22) along said first and second thickness (T1, T2) in order to color the first thickness (T1) of said aluminum oxide layer (22) with a corresponding first coloring depth and to color the second thickness (T2) of said aluminum oxide layer (22) with a corresponding second coloring depth greater than the first depth.

2. Method according to claim 1, **characterized in that** said impacting bodies (30) employed in said vibratory finishing are provided with an extension comprised between 0.5 and 7 cm. 5
3. Method according to any one of the preceding claims, **characterized in that** said vibratory finishing is extended in order to make said grooves (20) for an area comprised between 10 and 20% of said surface (2). 10
4. Method according to any one of the preceding claims, **characterized in that** said impacting bodies (30) employed in said vibratory finishing are provided with a hardness greater than the hardness of said aluminum article (1). 15
5. Method according to any one of the preceding claims, **characterized in that** said grooves (20) made in said vibratory finishing are extended starting from said surface (2) for a depth comprised between 1 and 30 μm . 20
6. Method according to any one of the preceding claims, **characterized in that** said aluminum oxide layer (22) made in said anode oxidation step is provided with a porous structure. 25
7. Method according to any one of the preceding claims, **characterized in that** said dyeing step provides for an electro-coloring. 30
8. Method according to any one of the preceding claims 1 to 6, **characterized in that** said dyeing step provides for dyeing said aluminum oxide layer (22) via absorption of organic dyes. 35
9. Method according to claim 6, 7 or 8, **characterized in that** it comprises, subsequent to said dyeing step, a step of fixing said aluminum oxide layer (22), in which the pores of said porous structure are sealed. 40
10. Method according to any one of the preceding claims, **characterized in that** it comprises a step of polishing the surface (2) of said aluminum article (1) subsequent to said anode oxidation step. 45

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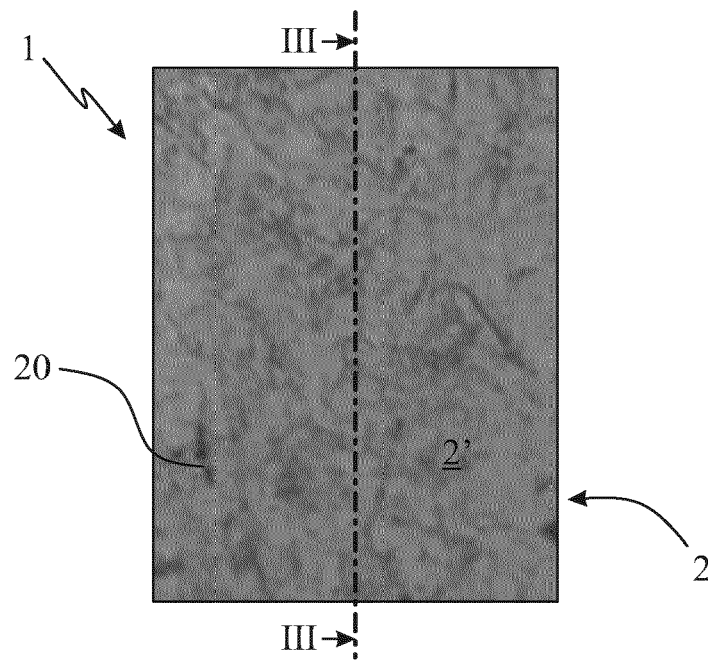


Fig. 1

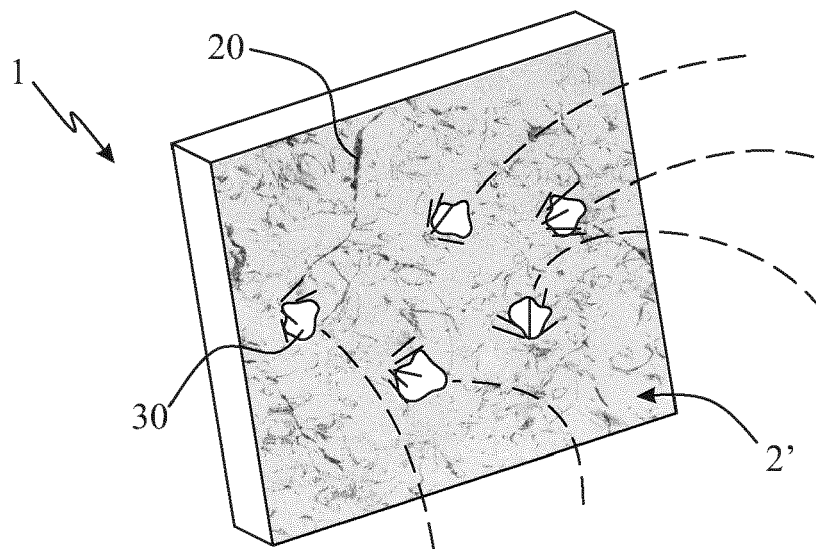


Fig. 2

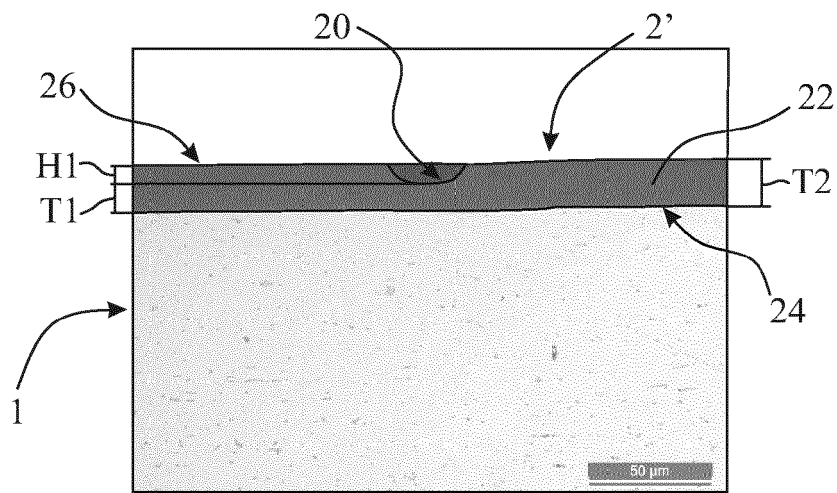


Fig. 3a

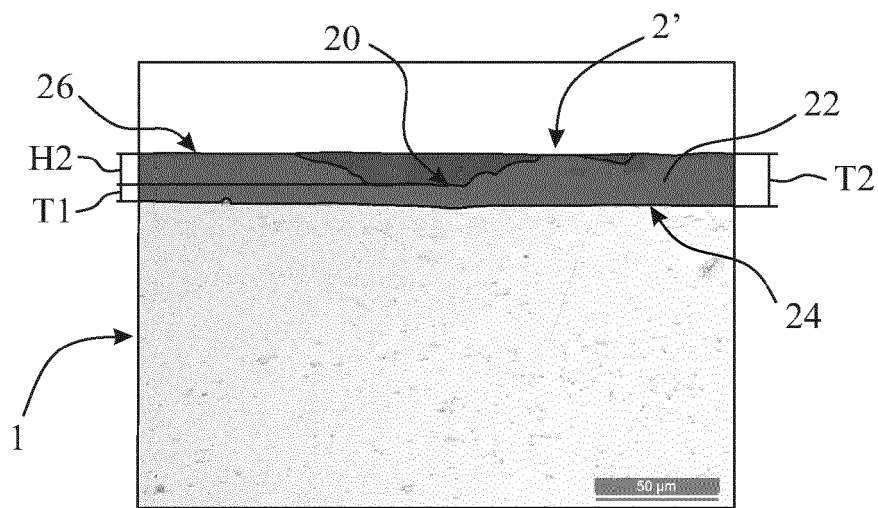


Fig. 3b

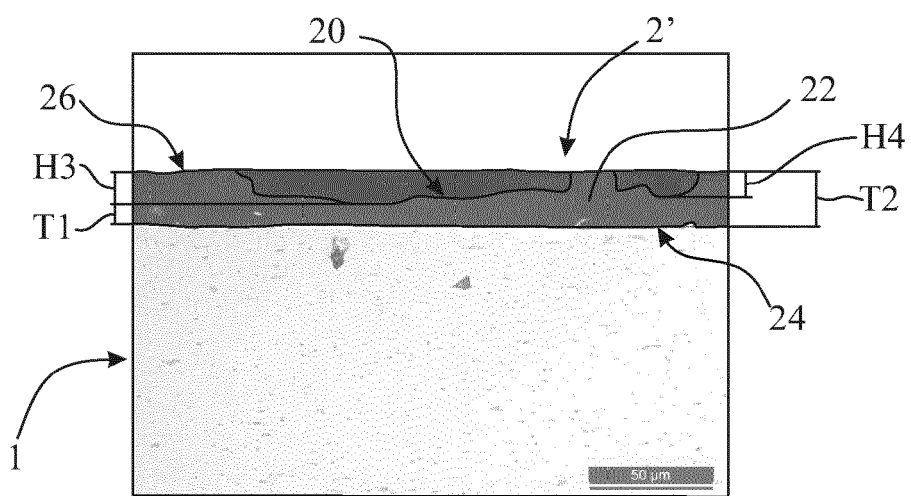


Fig. 3c

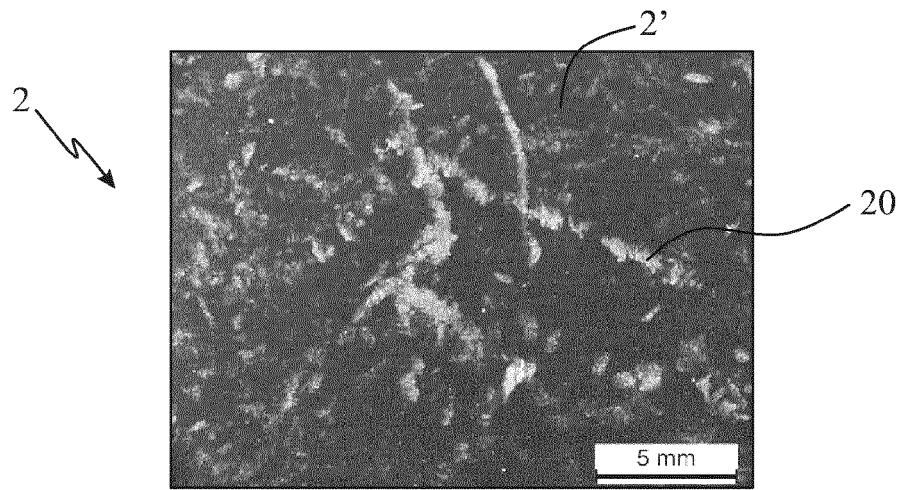


Fig. 4a

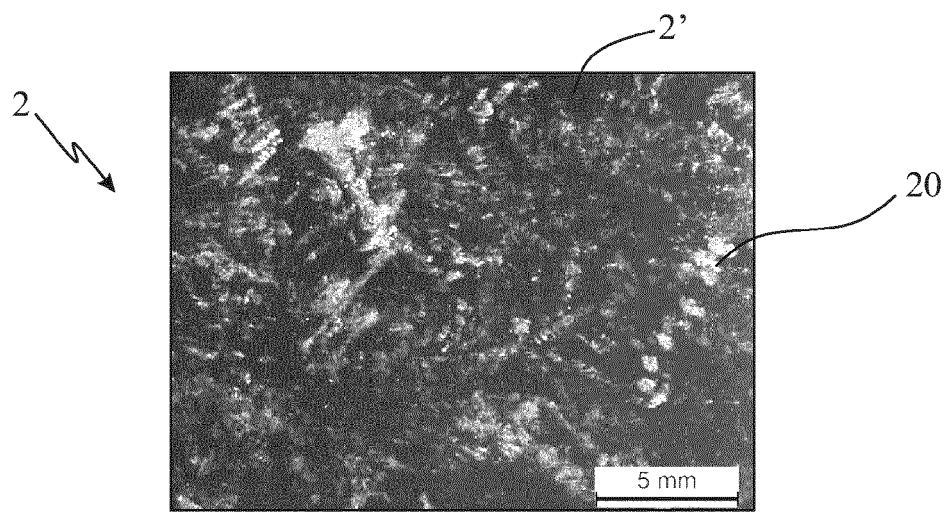


Fig. 4b

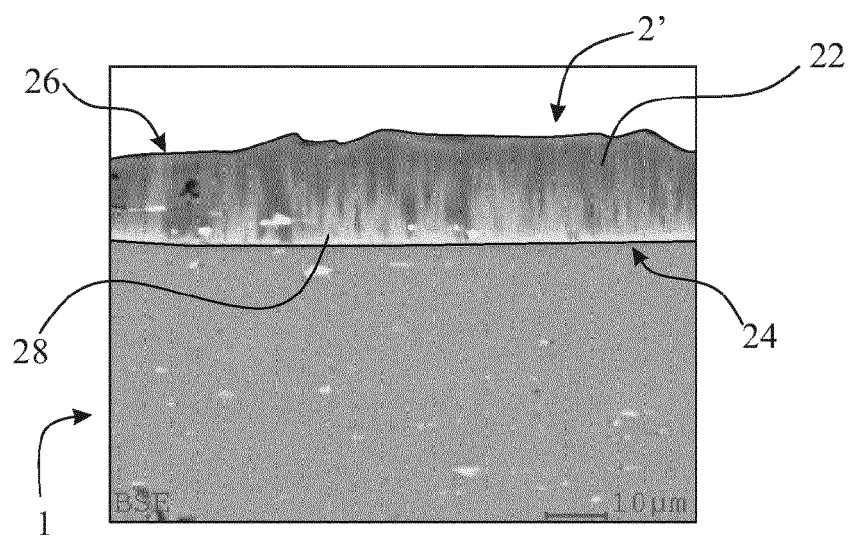


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 20 15 0976

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2013/049081 A2 (APPLE INC [US]) 4 April 2013 (2013-04-04) * paragraph [0040] - paragraph [0041]; claims 1-21; figures 1-13 *	1-10	INV. C22F1/04 B24B1/00 C25D11/22
A	WO 2013/095739 A1 (APPLE INC [US]) 27 June 2013 (2013-06-27) * claims 1-20; figures 1-8 *	1-10	
A	US 2013/153427 A1 (TATEBE MASASHIGE [JP]) 20 June 2013 (2013-06-20) * claims 1-25; figures 1-10 *	1-10	
A	EP 0 535 457 A2 (YOSHIDA KOGYO KK [JP]) 7 April 1993 (1993-04-07) * claims 1-12 *	1-10	
A	US 2 947 124 A (MADIGAN GERALD C ET AL) 2 August 1960 (1960-08-02) * column 6, line 35 - line 37 *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			C22F C25D B24D B24B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 15 April 2020	Examiner Liu, Yonghe
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