



(51) International Patent Classification:

G12B 9/06 (2006.01) C09K 3/00 (2006.01)
C25D 11/02 (2006.01)

(21) International Application Number:

PCT/US2018/061315

(22) International Filing Date:

15 November 2018 (15.11.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.** [US/US]; 10300 Energy Drive, Spring, Texas 77389 (US).

(72) Inventors: **CHUANG, Yacheng**; 1F-6F, 2727 Jinke Road, Block A, Jinke Building, Zhangjiang, Pudong, Shanghai, Pudong 201203 (CN). **XU, Yong Yong**; 1F-6F, 2727 Jinke Road, Block A, Jinke Building, Zhangjiang, Pudong, Shanghai, Pudong 201203 (CN). **LI, Yong-Jun**; 1F-6F, 2727 Jinke Road, Block A, Jinke Building, Zhangjiang, Pudong, Shanghai, Pudong 201203 (CN). **LIU,**

Hai Tao; 1F-6F, 2727 Jinke Road, Block A, Jinke Building, Zhangjiang, Pudong, Shanghai, Pudong 201203 (CN).

(74) Agent: **COSTALES, Shruti** et al.; HP Inc., Intellectual Property, 3390 E. Harmony Road, Mail Stop 35, Fort Collins, Colorado 80528 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: HOUSINGS FOR ELECTRONIC DEVICES

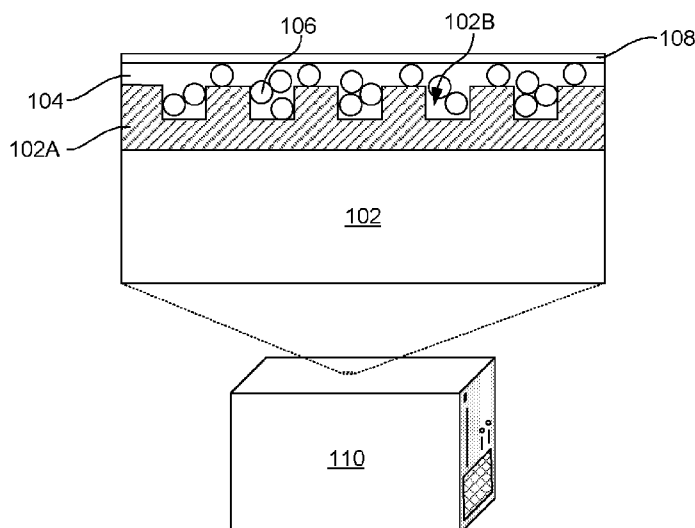


FIG. 1

(57) Abstract: A housing for an electronic device including a metal substrate, a pearlized layer, and a sealant layer. The metal substrate can have an exterior surface with a porous oxide layer including pores with an average size from about 2 nm to about 75 nm. The pearlized layer can be on the porous oxide layer, and can include a plurality of pearl particles positioned within pores of the porous oxide layer. The sealant layer can be on the pearlized layer.

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *with international search report (Art. 21(3))*

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HOUSINGS FOR ELECTRONIC DEVICES

BACKGROUND

[0001] The use of electronic devices of all types continues to increase. Cellular
10 phones, including smartphones, tablet computers, desktop computers, and laptop
computers are used by many for personal, entertainment, and/or business purposes.
Electronic devices have become a staple product in individual's lives. All electronic
devices include a housing. As the use of electronic devices continues to rise, so does
the demand for new housings for electronic devices.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 graphically illustrates an example electronic device housing in
accordance with the present disclosure;

20 [0003] FIG. 2 graphically illustrates an example electronic device housing in
accordance with the present disclosure; and

[0004] FIG. 3 is a flow diagram illustrating an example method of manufacturing
an electronic device in accordance with the present disclosure.

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DETAILED DESCRIPTION

[0005] Electronic devices incorporate housings to encase and protect the
electronic components of the electronic device. These housings can be manufactured
from various materials and can include decorative finishes to increase aesthetic appeal.
30 Decorative finishes available for use on housings manufactured from metals can be
somewhat limited. In some examples, an after-market decorative finish, such as paint,
can be applied over an exterior surface of the metal; however, application of after-

market finishes can be difficult to apply evenly or neatly in some instances because the device is already assembled and may need to be masked or otherwise prepared for a typically more complicated finishing process. In addition, after-market finishes can have limited durability and can be susceptible to scratching in some instances.

5 [0006] An example of a decorative and protective finish that can be applied to a metal housing can include finishes applied to porous oxide layers on the metal housing, which can be applied for example by anodizing the metal housing, e.g., prior to encasing the electrical components or at some other convenient time prior shipping. In general, anodizing involves treating a surface of a metal by an electrolytic process
10 which can increase a thickness of a protective oxide layer formed on the surface of the metal housing. Anodizing can also increase corrosion resistance. Anodized metals can be dyed with pure colors, e.g. blue, pink, red, grey, silver, or gold; however, dyed anodized metals can exhibit lackluster and have an overall flat, dull appearance.

[0007] In accordance with examples of the present disclosure, a housing for an
15 electronic device can include a metal substrate having an exterior surface with a porous oxide layer including pores with an average size from about 2 nm to about 75 nm; a pearlized layer on the porous oxide layer including a plurality of pearl particles positioned within pores of the porous oxide layer; and a sealant layer on the pearlized layer. In one example, the metal substrate can include aluminum, magnesium, titanium,
20 zinc, or an alloy thereof. In another example, an average thickness of the porous oxide layer can be from about 5 μm to about 20 μm . In yet another example, the pearl particles can have a D50 particle size distribution value from about 1 nm to about 50 nm. In a further example, the sealant layer can include nickel (II) acetate, sodium acetate, alkali silicate, or a combination thereof. In a further example, the sealant layer
25 can have a pencil hardness value from about 5H to about 9H. In one example, the housing can be a laptop housing, a desktop computer housing, a smartphone housing, a tablet housing, a printer housing, a monitor housing, a keyboard housing, a headphones housing, a television housing, a speaker housing, a docking station housing, a webcam housing, a smart watch housing, or a calculator housing.

30 [0008] In another example, an electronic device can include a housing. The housing can include a metal substrate that can have an interior surface and an exterior surface, and the exterior surface can include a porous oxide layer including pores with

an average size from about 2 nm to about 75 nm. A pearlized layer can be on the porous oxide layer and can include a plurality of pearl particles positioned within pores of the porous oxide layer. The electronic device can further include an electronic component adjacent to the interior surface of the metal substrate. In further detail, the metal can further include a sealant layer on the pearlized layer.

[0009] In another example, a method of manufacturing a housing for an electronic device can include treating a metal substrate in an acid bath; anodizing the metal substrate in an anodizing acid bath by passing a current there through to form a porous oxide layer on an exterior surface of the metal substrate; applying pearl particles dispersed in a polymer, solvent, or a combination of polymer and solvent over an exterior surface of the porous oxide layer to form a pearlized layer; and applying a sealant over the pearlized layer to form a sealant layer. In one example, the acid bath can be warmed to from about 50 °C to about 100 °C for treating the metal substrate. In another example, the current passed there through can range from about 10V to about 20V. In yet another example, applying the pearl particles to the porous oxide layer can include preparing a pearlized coating composition that can include the pearl particles in an amount of about 1 wt% to about 20 wt% dispersed in the polymer in an amount of about 0.5 wt% to about 10 wt%, based on a total weight of the pearlized coating composition; and applying the pearlized coating composition to the porous oxide layer by dipping, ejecting, electrical plating, hydro-printing, or thermal printing. In one example, the applying of the sealant can include contacting the pearlized layer with a sealant solution, and baking the metal substrate after contacting at a temperature from about 60 °C to about 110 °C for a period of time ranging from about 2 minutes to about 20 minutes. In another example, the method can further include baking the metal substrate after applying the sealant at a temperature from about 60 °C to about 110 °C for a period of time ranging from about 2 minutes to about 20 minutes.

[0010] It is noted that when discussing the housing for an electronic device, the electronic device, and/or the method of manufacturing a housing for an electronic device herein, these discussions can be considered applicable to one another whether or not they are explicitly discussed in the context of that example. Thus, for example, when discussing a metal substrate related to a housing for an electronic device, such

disclosure is also relevant to and directly supported in the context of the electronic device, the method of manufacturing a housing for an electronic device, and *vice versa*.

[0011] It is also understood that terms used herein will take on the ordinary meaning in the relevant technical field unless specified otherwise. In some instances, there are terms defined more specifically throughout the specification or included at the end of the present specification, and thus, these terms can have a meaning as described herein.

[0012] *Housings for Electronic Devices*

[0013] Housings for electronic devices, also referred to herein as “housing(s),” can have a variety of configurations which can be determined in part by the electronic device and the electric component that may be associated with the housing. For example, the housing can be a laptop housing, a desktop computer housing, a smartphone housing, a tablet housing, a printer housing, a monitor housing, a keyboard housing, a headphones housing, a television housing, a speaker housing, a docking station housing, a webcam housing, a smart watch housing, or a calculator housing, and can thus be shaped accordingly to efficiently (in some instances) provide a protective cover to the underlying electronics. In examples herein, the housings can include a metal that can be anodized and include a pearlized layer. An example housing for an electronic device 110 is shown in FIG. 1. The housing for the electronic device, by way of example, can include a metal substrate 102 having an exterior surface with a porous oxide layer 102A that can have pores 102B having an average size from about 2 nm to about 75 nm. A pearlized layer 104 can be on the porous oxide layer and can include a plurality of pearl particles 106 that can be positioned within pores of the porous oxide layer. In some examples, there can be some pearl particles that are not embedded in the pores, but some of the particles are within or partially within the pores. In further detail, a sealant layer 108 can be on the pearlized layer.

[0014] In further detail, as mentioned, the housing can include a metal substrate 102. The metal substrate can be shaped in the form of a housing for an electronic device. In one example, a material of the housing can include a metal. The metal can include aluminum, magnesium, titanium, zinc, or an alloy thereof. In one example, the metal substrate can include aluminum. In another example, the metal substrate can

include an aluminum alloy. The metal substrate can have a thickness prior to anodizing that can range from about 9 μm to about 18 μm . In another example, the metal substrate can have a thickness prior to anodizing that can range from about 12 μm to about 16 μm , or from about 9 μm to about 14 μm .

5 [0015] Anodizing the metal substrate can result in a metal substrate that can include a porous oxide layer 102A on a surface thereof. A thickness of the porous oxide layer can range from about 5 μm to about 20 μm , from about 9 μm to about 15 μm , or from about 10 μm to about 20 μm . The porous oxide layer can include pores that can range from about 2 nm to about 75 nm, for example. In other examples, the pores 102B
10 of the porous oxide layer can range from about 25 nm to about 50 nm, from about 5 nm to about 65 nm, from about 30 nm to about 75 nm, from about 10 nm to about 30 nm, or from about 10 nm to about 50 nm.

[0016] A pearlized layer 104 can be over the porous oxide layer 102A of the metal substrate 102. The pearlized layer can include pearl particles 106 that can be
15 positioned in the pores of the porous oxide layer. The pearl particles can be natural crushed pearl, synthetic pearls (e.g. crushed mollusk shell crushed pearl oyster shell, a core material coated with powdered mother of pearl), or a combination thereof. The pearl particles can have a D50 particle size distribution value that can range from about 1 nm to about 50 nm. In yet other examples, a D50 particle size distribution of the pearl
20 particles can range from about 5 nm to about 25 nm, from about 2 nm to about 30 nm, from about 15 nm to about 45 nm. Individual particle sizes can be outside of these ranges, as "D50 particle size" is defined as the particle size at which half of the particles are larger than the D50 particle size and about half of the other particles are smaller than the D50 particle size (by weight based on the metal particle content of the
25 particulate build material).

[0017] As used herein, particle size can refer to a value of the diameter of spherical particles or in particles that are not spherical can refer to a longest dimension of that particle. The particle size can be presented as a Gaussian distribution or a Gaussian-like distribution (or normal or normal-like distribution). Gaussian-like
30 distributions are distribution curves that can appear Gaussian in distribution curve shape, but which can be slightly skewed in one direction or the other (toward the smaller end or toward the larger end of the particle size distribution range). That being

stated, an example Gaussian-like distribution or other distribution profile of the pearl particles can be characterized generally using "D10," "D50," and "D90" particle size distribution values, where D10 refers to the particle size at the 10th percentile, D50 refers to the particle size at the 50th percentile, and D90 refers to the particle size at the 90th percentile. For example, a D50 value of 25 μm means that 50% of the particles (by number) have a particle size greater than 25 μm and 50% of the particles have a particle size less than 25 μm . In one example of the present disclosure, the pearl particles can have a Gaussian distribution, or more typically a Gaussian-like distribution with offset peaks at about D50. The shape of the pearl particles can be spherical, discoidal, cylindrical, tabular, ellipsoidal, equant, irregular, etc. The pearlized layer can include the pearl particles dispersed in a carrier matrix including polymer, solvent, or a combination of polymer and solvent, for example, such as styrene-acrylic, polyurethane, isopropanolamine, or the like.

[0018] In further detail, a sealant layer 108 can be on the pearlized layer. The sealant layer can have a thickness that can range from about 10 nm to about 30 nm, from about 15 nm to about 25 nm, or from about 20 nm to about 30 nm. In one example, the sealant layer can include a metal acetate such as nickel (II) acetate or sodium acetate; an inorganic metal salt such as, alkali silicate; or a combination thereof. The sealant layer is typically transparent, but can be translucent, as the sealant coating can be applied to allow for the pearlized layer 104 to provide luster to the appearance of the housing. Thus, housing for electronic devices 100 as described above, can have a lustrous appearance. The pearl particles can catch and reflect light, creating aesthetic interest. The housing can be durable and resistant to scratches. In some examples, the housing at a location of the sealant layer can have a pencil hardness value from about 5H to about 9H. Pencil hardness is one way to quantify a hardness of the housing and can refer to the ability of a surface to resist scratching.

[0019] Pencil hardness can be tested using ASTM D 3363, Standard Test Method for Film Hardness. The standard test method includes the following details: Pencil type: 6B-5B-4B-2B-B-HB-F-H-2H-3H-4H-5H-6H-7H-8H-9H (brand: Mitsubishi) with 6B being softest and 9H being hardest; Test Protocol: Force loading at 750g; drawing lead sharpened; substrate placed on a level, firm, horizontal surface; starting with the hardest lead, hold the pencil or lead in holder firmly with the lead against the

substrate layer at a 45° angle (point away from the operator) and push away from the operator; allow the load weight to apply uniform pressure downward and forward as the pencil is moved to either cut or scratch the substrate or to crumble the edge of the lead (length of stroke to be 1/4 inch (6.5 mm); repeat process down the hardness scale until
5 a pencil is found that will not scratch or gouge the substrate; the hardest pencil that does not scratch or gouge the substrate is then considered the pencil hardness of the substrate.

[0020] *Electronic Devices*

10 [0021] The housing above can encase an electronic component of an electronic device. The electronic device 200 as shown in FIG. 2 can include a housing 210 and an electronic component 220. The housing can include a metal substrate 202 that can have an interior surface 212 and an exterior surface 214. The exterior surface can be of a pearlized layer 204, as shown in FIG. 2, or can include a sealant layer thereon (not
15 shown in this example, but shown in FIG. 1). The metal substrate can also include porous oxide layer 202A that can have pores with an average size from about 2 nm to about 75 nm between the pearlized layer and a non-anodized portion of the metal substrate. The pearlized layer can include plurality of pearl particles 206 that can be positioned (partially or fully) within pores of the porous oxide layer, with some particles
20 not positioned with the pores in some examples (not shown, but shown by example in FIG. 1). The interior surface of the metal substrate can be adjacent to the electronic component. The housing, metal substrate, porous oxide layer, and pearlized layer, and sealant layer, if present, can be as described above.

[0022] The electronic component can include any electric component of any
25 electrical device. In some examples, the electronic component can include electronic components for a laptop, a desktop, a smartphone, a table, a printer, a monitor, a keyboard, headphones, a television, a speaker, a docking station, a webcam, a smart watch, a calculator, or the like. In some examples, the electronic device can be a laptop, a desktop, a smartphone, a tablet, a printer, a monitor, a keyboard, headphones, a
30 television, a speaker, a docking station, a webcam, a smart watch, or a calculator. Thus, the housing can be a laptop housing, a desktop computer housing, a smartphone housing, a tablet housing, a printer housing, a monitor housing, a keyboard housing, a

headphones housing, a television housing, a speaker housing, a docking station housing, a webcam housing, a smart watch housing, or a calculator housing, for example.

5 [0023] *Methods of Manufacturing Housing for Electronic Devices*

[0024] A flow diagram of an example method 300 of manufacturing a housing for an electronic device is shown in FIG. 3. The method can include treating 302 a metal substrate in an acid bath; anodizing 304 the metal substrate in an anodizing acid bath by passing a current there through to form a porous oxide layer on an exterior surface of the metal substrate; applying 306 pearl particles dispersed in a polymer, solvent, or a combination of polymer and solvent over an exterior surface of the porous oxide layer to form a pearlized layer; and applying 308 a sealant over the pearlized layer to form a sealant layer. In one example, the method can further include cleaning the metal substrate prior to treating the metal substrate. In another example, the method can include dying the metal substrate after anodizing. In yet another example, the method can further include baking the metal substrate after applying the sealant.

[0025] *Cleaning Metal Substrate*

[0026] In further detail, cleaning the metal substrate can include dipping the metal substrate in a cleaning solution, rinsing the metal substrate, and neutralizing the metal substrate after rinsing. The cleaning solution can include an acid and a surfactant. The acid can be present at from about 180 g/L to about 220 g/L or from about 190 g/L to about 210 g/L. In one example, the acid can include sulfuric acid, hydrosulfuric acid, hydrochloric acid, phosphoric acid, citric acid, combinations thereof and the like. In one example, the acid can include sulfuric acid. The surfactant can be present at from about 180 g/L to about 220 g/L or from about 190 g/L to about 210 g/L. The surfactant can include alcohol ethoxylates, alkyl polyglucosides, octylphenol ethoxylates, nonylphenol ethoxylates, alcohol alkoxylate, alkylamine ethoxylates, phosphate esters, alkyl diphenyl oxide disulfonates, dioctyl sulfosuccinates, N-acyl sarcosines, and the like.

Commercially available surfactant examples can include TERGITOL® 15-S series, TERGITOL® TMN series, TERGITOL® MDS-42, TERGITOL® NP series, TRITON™ CF, TRITON™ DF, TRITON™ BG-10, TRITON™ CG-110, TRITON™ X series, TRITON™

RW series, TRITON™ H-55, TRITON™ H-66, TRITON™ QS-44, TRITON™ GR series, DOWFAX®, and HAMPOSYL™, all available from The DOW Chemical Company, Missouri.

[0027] The cleaning solution can be warmed to a temperature ranging from about 45 °C to about 75 °C. In other examples, the cleaning solution can be warmed to a temperature ranging from about 50 °C to about 70 °C, from about 55 °C to about 65 °C, from about 45 °C to about 65 °C, or from about 55 °C to about 75 °C. The metal substrate can be dipped in the cleaning solution for a period of time ranging from about 10 seconds to about 120 seconds, from about 30 seconds to about 60 seconds, or from about 20 seconds to about 80 seconds. Following dipping, the metal substrate can be rinsed with deionized water to remove the cleaning solution. In some examples, the dipping and/or rinsing can be repeated.

[0028] The metal substrate can then be neutralized using a neutralizing solution. The neutralizing solution can include nitric acid, water, or a combination thereof. In one example, the neutralizing solution can include nitric acid. The nitric acid can be present at from about 250 g/L to about 350 g/L, from about 270 g/L to about 330 g/L, or from about 285 g/L to about 315 g/L, with water to balance. The neutralizing solution can be warmed to a temperature ranging from about 5 °C to about 25 °C, or from about 10 °C to about 20 °C. The metal substrate can be dipped in the neutralizing solution for a period of time ranging from about 10 seconds to about 120 seconds, from about 30 seconds to about 60 seconds, or from about 20 seconds to about 80 seconds. Following dipping, the metal substrate can be rinsed with water to remove the neutralizing solution. In one example, the water can be deionized.

[0029] *Treating Metal Substrates in Acid Bath*

[0030] Treating the metal substrate in an acid bath can include dipping the metal substrate in an acid bath. The acid bath can include phosphoric acid, sulfuric acid, water, or a combination thereof. In one example, the acid bath can include a combination of phosphoric acid and sulfuric acid. In one example, the phosphoric acid can be present at from about 1,100 g/L to about 1,300 g/L and the sulfuric acid can be present at from about 150 g/L to about 250 g/L. The acid bath can be warmed to a temperature ranging from about 50 °C to about 100 °C, from about 75 °C to about 85

°C, or from about 60 °C to about 90 °C. The metal substrate can be dipped in the acid bath for a period of time ranging from about 10 seconds to about 120 seconds, from about 30 seconds to about 60 seconds, or from about 20 seconds to about 80 seconds. Following dipping, the metal substrate can be rinsed with water to remove the acid bath.

5 In one example, the water can be deionized. Treating the metal substrate in the acid bath can adjust the surface texture (roughness) and surface gloss.

[0031] *Anodizing Metal Substrates*

[0032] Anodizing the metal substrate in an anodizing bath can include placing the
10 metal substrate in an anodizing solution and passing a current there through. The anodizing solution can include sulfuric acid, chromic acid, malic acid, water, or a combination thereof. The acid can be present in the anodizing solution at from 80 wt% to about 99 wt%, from about 85 wt% to about 95 wt%, or from about 90 wt% to about 99 wt% with water to balance. In one example, the anodizing solution can include sulfuric
15 acid and water. In one example, the sulfuric acid can be present at from about 90 wt% to about 99 wt%. In another example, the sulfuric acid can be present at from about 175 g/L to about 195 g/L with water to balance. In some examples, a dye can be added to the anodizing solution to add a color to the metal substrate. The dye can include commercially available dyes.

20 [0033] The metal substrate can be placed in the anodizing bath for a period of time ranging from about 25 minutes to about 45 minutes, from about 30 minutes to about 40 minutes, or from about 33 minutes to about 37 minutes. The current passed there through can range from about 10V to about 20V, from about 12V to about 18V, or from about 14V to about 16V. The anodizing can be coil, sheet, or piece anodizing.

25 [0034] Anodizing the metal substrate can alter a surface structure of the metal substrate and can create texture on the surface. In addition, anodizing can create a porous oxide layer on the surface of the metal substrate. The longer the period of time and the greater the current, the thicker the porous oxide layer will be on the surface. The porous oxide layer can be as described above.

[0035] *Applying Pearl Particles as Pearlized Layer*

[0036] Following anodizing, a pearlized coating composition can be applied over the porous oxide layer. The pearlized coating composition can include pearl particles dispersed in a polymer, a solvent, or a combination of a polymer and a solvent. The
5 pearlized coating composition can be prepared by dispersing from about 1 wt% to about 20 wt% or from about 5 wt% to about 25 wt% pearl particles in a polymer, a solvent, or a combination thereof. The pearl particles can be as described above. The polymer can include acrylic acid, ethylene vinyl acetate, polyurethane, polyurethane resin, copolymers, or co-mixtures thereof and can be present at from about 0.05 wt% to about
10 20 wt%, from about 0.5 wt% to about 20 wt%, from about 5 wt% to about 15 wt%, from about 2 wt% to about 10 wt%, from about 2 wt% to about 8 wt%, or from about 0.05 wt% to about 10 wt%. The solvent can include phenolic aldehyde, organosilicone, butyl acetate, butoxyethyl acetate, isobutyl acetate, amyl acetate, acetone, methyl ethyl ketone, toluene, ether, ethylbenzene, xylene, methanol, propanol, 2-methyl-1-propanol,
15 1 methoxy-2-proanol acetate, 2-butoxyethanol, isoamyl acetate, vinylidene chloride, or combinations thereof and can be present at from about 5 wt% to about 60 wt%, from about 5 wt% to about 35 wt%, from about 10 wt% to about 45 wt%, or from about 20 wt% to about 60 wt%. In one example, the pearlized coating composition can include pearl particles in an amount of about 1 wt% to about 20 wt% and the pearl particles can
20 be dispersed in the polymer in an amount of about 0.5 wt% to about 10 wt% based on a total weight of the pearlized coating composition.

[0037] A pH of the pearlized coating can be adjusted to result in a pearlized coating that can have a pH ranging from about 5.5 to about 6.5. In one example, a pH of the pearlized coating can be adjusted using a pH modifier selected from ammonia,
25 glacial acetic acid, or a combination thereof.

[0038] Prior to application, the pearlized coating composition can be warmed to a temperature ranging from about 20 °C to about 50 °C, from about 25 °C to about 45 °C, or from about 30 °C to about 40 °C. The pearlized coating composition can be applied
30 over the porous oxide layer, for example, by dipping, ejecting, electrical deposition, or thermal printing. Dipping can include submerging the metal substrate in the pearlized coating composition for a period of time ranging from about 120 seconds to about 350 seconds, from about 120 seconds to about 240 seconds, from about 150 seconds, to

about 210 seconds. Ejecting can involve blowing droplets of the pearlized coating composition from a fluid ejector on a surface of the metal substrate. The fluid ejector can have a flow rate that can range from about 10 gpm to about 30 gpm and can have a pressure ranging from about 5 psi to about 15 psi. Following application of the pearlized coating solution the solvent and/or polymer can vaporize leaving the pearl particles behind.

[0039] *Applying a Sealant Layer*

[0040] A sealant solution can then be applied over the pearlized layer to form a sealant layer. The sealant solution, in one example, can include a metal acetate, an inorganic salt, water, or a combination. In one example, the sealant solution can include nickel (II) acetate, sodium acetate, alkali silicate, or a combination thereof. In one example, the sealant solution can include from about 55 wt% to about 85 wt% nickel (II) acetate, from about 1 wt% to about 10 wt% sodium acetate, and a balance of water. In another example, the sealant solution can include from about 60 wt% to about 90 wt% nickel (II) acetate, sodium acetate, or a combination thereof. The metal substrate can be dipped in the sealant solution for a period of time ranging from about 10 seconds to about 120 seconds, from about 30 seconds to about 60 seconds, or from about 20 seconds to about 80 seconds.

[0041] *Heat Curing the Metal Substrates*

[0042] Lastly, the metal substrate can be heat cured. "Heat curing" can be defined as applying elevated temperatures (above ambient, e.g., 25 °C) to remove fluids from a surface. Heat curing can involve baking the metal substrate in a heating tank or an oven, for example, and can occur at a temperature that can range from about from about 60 °C to about 110 °C, from about 70 °C to about 110 °C, or from about 80 °C to about 90 °C. These temperatures are not high enough to effect a chemical structure of the metal substrate; however, they can be high enough to remove fluids from the pearlized layer and/or the sealant layer. The baking can occur for a period of time that can range from about 2 minutes to about 20 minutes, from about 5 minutes to about 15 minutes, from about 10 minutes to about 20 minutes, or from about 8 minutes to about 17 minutes.

[0043] The housing for an electronic device manufactured using the method described above, can have a lustrous appearance. The pearl particles that can be positioned within the pores of the porous oxide layer can catch and reflect light, thereby creating aesthetic interest. Furthermore, the housings for an electronic device can exhibit an increase in pencil hardness values from a pencil hardness value for the same metal not treated using the method above. For example, an aluminum housing can exhibit a pencil hardness value of about 5H prior to the method described above and can exhibit a pencil hardness value of 6H following the method.

[0044] *Definitions*

[0045] As used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise.

[0046] The term "about" as used herein, when referring to a numerical value or range, allows for a degree of variability in the value or range, for example, within 10%, or, in one aspect within 5%, of a stated value or of a stated limit of a range. The term "about" when modifying a numerical range includes as one numerical subrange a range defined by the exact numerical value indicated, e.g., the range of about 1 wt% to about 5 wt% includes 1 wt% to 5 wt% as an explicitly supported sub-range.

[0047] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though the individual member of the list is also identified as a separate and unique member. Thus, no individual member of such list should be construed as a *de facto* equivalent of any other member of the same list based on presentation in a common group without indications to the contrary.

[0048] Concentrations, dimensions, amounts, and other numerical data may be presented herein in a range format. A range format is used merely for convenience and brevity and should be interpreted flexibly to include the numerical values explicitly recited as the limits of the range, as well as to include all the individual numerical values or sub-ranges encompassed within that range as the individual numerical value and/or sub-range is explicitly recited. For example, a weight ratio range of about 1 wt% to about 20 wt% should be interpreted to include the explicitly recited limits of 1 wt% and

20 wt% and to include individual weights such as about 2 wt%, about 11 wt%, about 14 wt%, and sub-ranges such as about 10 wt% to about 20 wt%, about 5 wt% to about 15 wt%, etc.

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EXAMPLE

[0049] The following examples illustrate the technology of the present disclosure. However, it is to be understood that the following is merely illustrative of the housings, electronic devices, and methods herein. Numerous modifications and alternative
10 methods and systems may be devised without departing from the present disclosure. Thus, while the technology has been described above with particularity, the following provides further detail in connection with what are presently deemed to be the acceptable examples. Additional housing, device, and/or method step elements illustrated in the examples are provide by way of example only, and can be practiced
15 with or without these additional elements.

Example 1 – Electronic Device Housing

[0050] An example electronic device housing is prepared as follows:

- 20 1) A 13 μm thick aluminum substrate having a pencil hardness value of 5H and in the shape of a housing for an electronic device is cleaned by dipping the aluminum once in an about 170 g/L sulfuric acid and water solution that is heated to about 60 °C.
- 25 2) The aluminum is rinsed with deionized water and neutralized by dipping the aluminum in about 300 g/L nitric acid and water solution.
- 3) The aluminum is then pre-treated by dipping the aluminum for about 30 seconds to about 60 seconds in an about 200 g/L phosphoric acid and about 200 g/L sulfuric acid solution that is heated to a temperature of about 80 °C.
- 30 4) The pre-treated aluminum is then submerged in an about 98 wt% sulfuric acid solution and about 20V of current passed there through for a period of time ranging from about 30 minutes to about 40 minutes. This creates a porous oxide layer on a surface of the aluminum having a thickness ranging from

about 9 μm to about 15 μm and pores with an average pore size ranging from about 10 nm to about 30 nm.

5) Pearl particles having a D50 particle size distribution value ranging from about 5 nm to about 25 nm dispersed in a solvent and/or a polymer and are applied to the oxide layer. The solvent can include phenolic aldehyde, organosilicone, butyl acetate, butoxyethyl acetate, isobutyl acetate, amyl acetate, acetone, methyl ethyl ketone, toluene, ether, ethylbenzene, xylene, methanol, propanol, 2-methyl-1-propanol, 1 methoxy-2-proanol acetate, 2-butoxyethanol, isoamyl acetate, vinylidene chloride, or combinations thereof. The polymer can include polymer can include acrylic acid, ethylene vinyl acetate, polyurethane, polyurethane resin, copolymers, or co-mixtures thereof. The pearl particles deposit in the pores of the porous oxide layer.

6) The aluminum is dipped in a sealant solution including about 75 wt% nickel (II) acetate, about 5 wt% sodium acetate, and water to balance.

7) The aluminum is baked in a heating tank having a temperature ranging from about 70 $^{\circ}\text{C}$ to about 100 $^{\circ}\text{C}$ for about 10 minutes to about 20 minutes.

[0051] The aluminum of the electronic device housing is anodized and has a pearl appearance. A treated surface of the electronic device housing has a pencil hardness value of 6H.

Example 2 – Assembly of an Electronic Device

[0052] An electronic device housing as described in above in example 1, is placed over an electronic component for a desktop unit. The housing is placed such that a metal surface containing the porous oxide layer, pearlized layer, and sealant layer is exterior to the electronic component. The electronic device has an aesthetically pleasing, lustrous appearance, and exhibits scratch resistance.

CLAIMS

What is Claimed Is:

- 5 1. A housing for an electronic device comprising:
a metal substrate having an exterior surface with a porous oxide layer including
pores with an average size from about 2 nm to about 75 nm;
a pearlized layer on the porous oxide layer, the pearlized layer including plurality
of pearl particles positioned within pores of the porous oxide layer; and
10 a sealant layer on the pearlized layer.
2. The housing of claim 1, wherein the metal substrate includes aluminum,
magnesium, titanium, zinc, or an alloy thereof.
- 15 3. The housing of claim 1, wherein an average thickness of the porous oxide
layer is from about 5 μm to about 20 μm .
4. The housing of claim 1, wherein the pearl particles have a D50 particle
size distribution value from about 1 nm to about 50 nm.
- 20 5. The housing of claim 1, wherein the sealant layer includes nickel (II)
acetate, sodium acetate, alkali silicate, or a combination thereof.
6. The housing of claim 1, wherein the sealant layer has a pencil hardness
25 value from about 5H to about 9H.
7. The housing of claim 1, wherein the housing is a laptop housing, a
desktop computer housing, a smartphone housing, a tablet housing, a printer housing, a
monitor housing, a keyboard housing, a headphones housing, a television housing, a
30 speaker housing, a docking station housing, a webcam housing, a smart watch housing,
or a calculator housing.

8. An electronic device comprising:

a housing, the housing including:

a metal substrate having an interior surface and an exterior surface, the exterior surface comprising a porous oxide layer including pores with an average size from about 2 nm to about 75 nm, and

a pearlized layer on the porous oxide layer, the pearlized layer including a plurality of pearl particles positioned within pores of the porous oxide layer; and

an electronic component adjacent to the interior surface of the metal substrate.

9. The electronic device of claim 8, wherein the metal substrate further includes a sealant layer on the pearlized layer.

10. A method of manufacturing housing for an electronic device comprising:

treating a metal substrate in an acid bath;
anodizing the metal substrate in an anodizing acid bath by passing a current therethrough to form a porous oxide layer on an exterior surface of the metal substrate;

applying pearl particles dispersed in a polymer, solvent, or a combination of a polymer and a solvent over an exterior surface of the porous oxide layer to form a pearlized layer; and

applying a sealant layer over the pearlized layer.

11. The method of claim 10, wherein the acid bath is warmed to from about 50 °C to about 100 °C for treating the metal substrate.

12. The method of claim 10, wherein the current passed there through ranges from about 10V to about 20V.

13. The method of claim 10, wherein applying the pearl particles to the porous oxide layer includes:

preparing a pearlized coating composition that includes the pearl particles in an amount of about 1 wt% to about 20 wt% dispersed in the polymer in an amount of about

0.5 wt% to about 10 wt%, based on a total weight of the pearlized coating composition; and

applying the pearlized coating composition to the porous oxide layer by dipping, ejecting, electrical deposition, or thermal printing.

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14. The method of claim 10, wherein the applying of the sealant layer comprises contacting the pearlized layer with a sealant solution, and baking the metal substrate after contacting at a temperature from about 60 °C to about 110 °C for a period of time ranging from about 2 minutes to about 20 minutes.

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15. The method of claim 10, where the sealant layer includes nickel (II) acetate, sodium acetate, alkali silicate, or a combination thereof.

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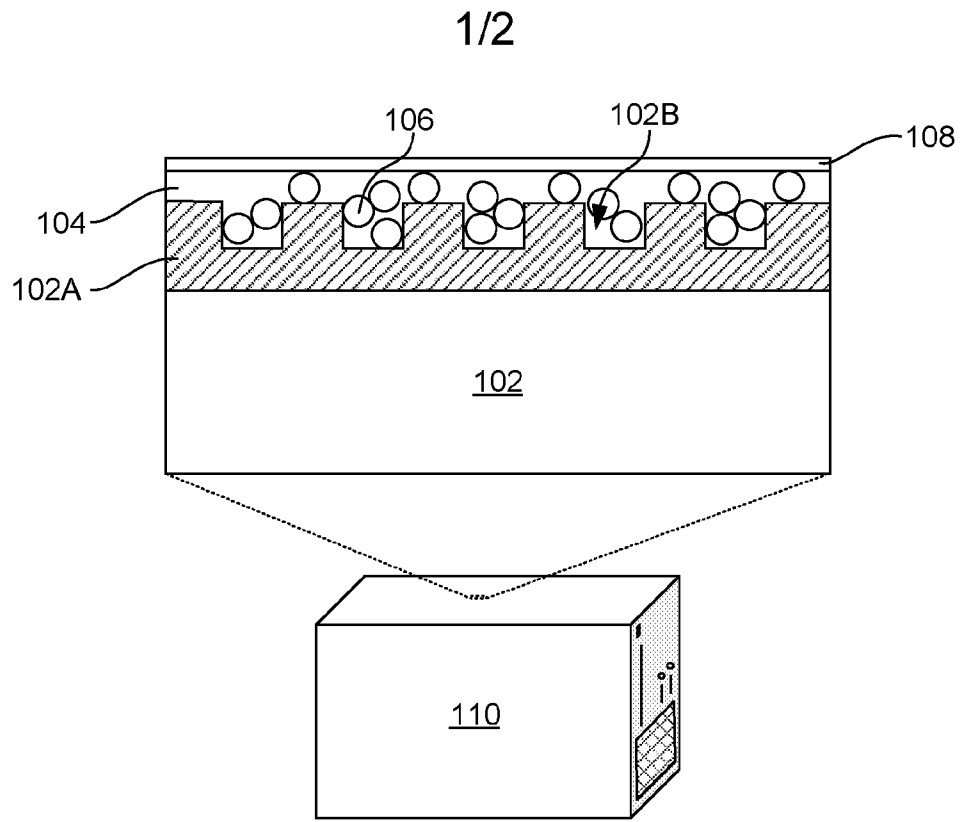


FIG. 1

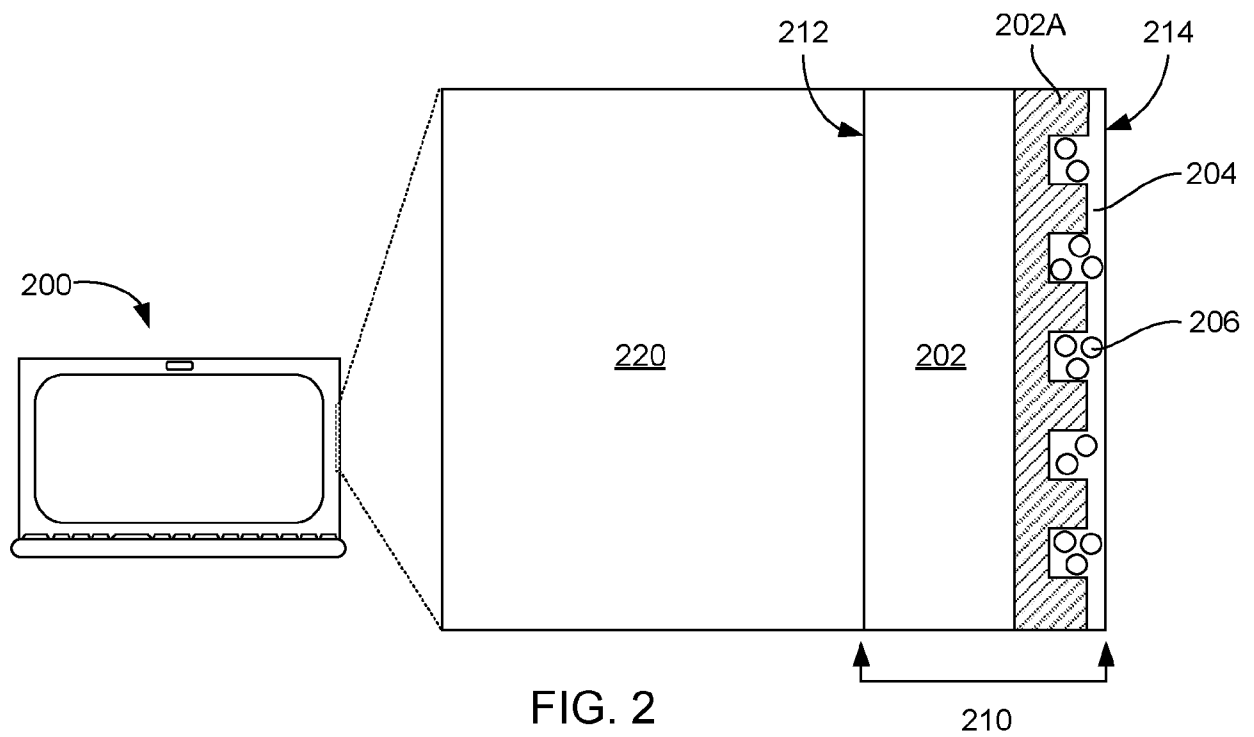


FIG. 2

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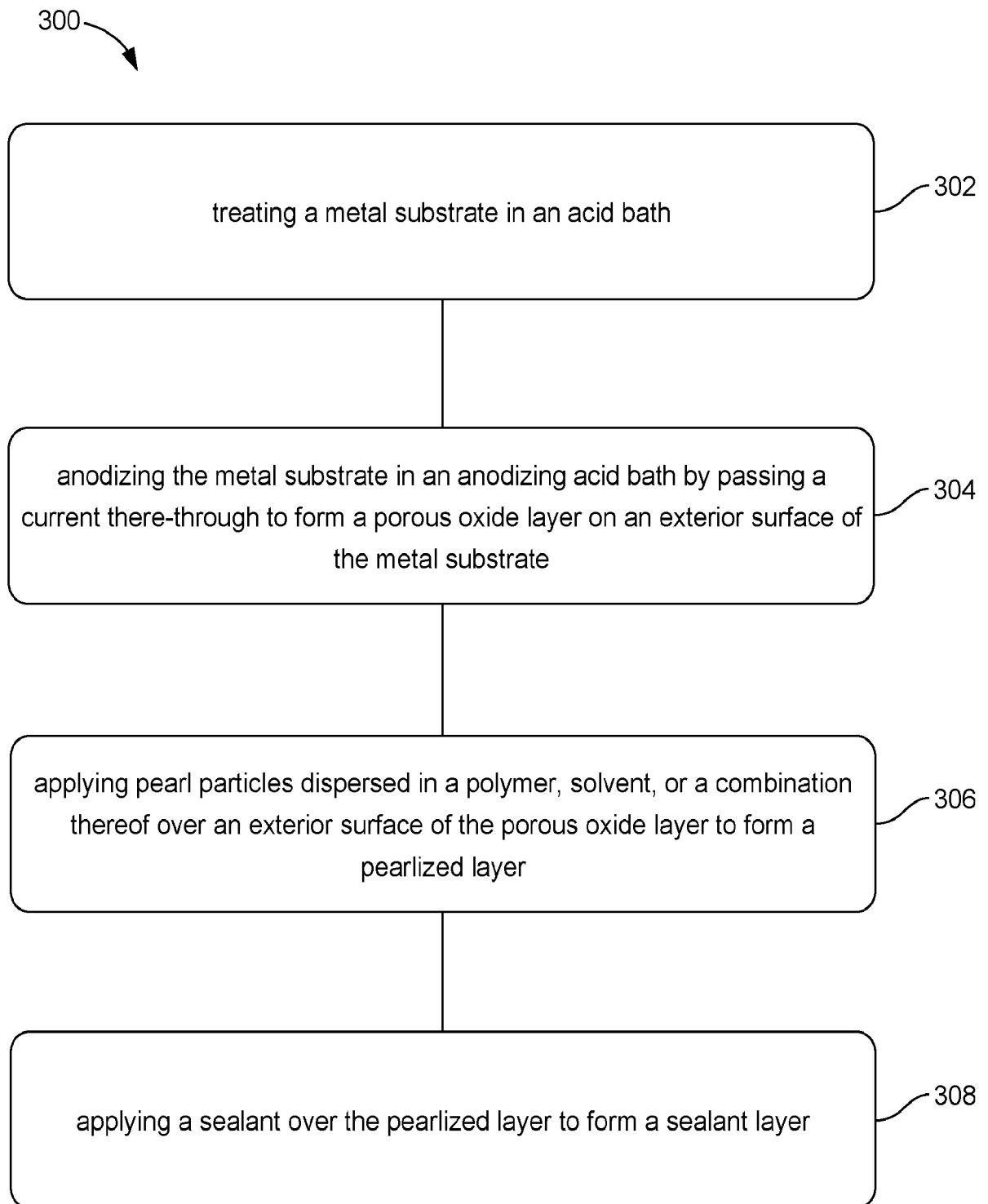


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/061315

A. CLASSIFICATION OF SUBJECT MATTER																						
<i>G12B 9/06 (2006.01)</i> <i>C25D 11/02 (2006.01)</i> <i>C09K 3/00 (2006.01)</i>																						
According to International Patent Classification (IPC) or to both national classification and IPC																						
B. FIELDS SEARCHED																						
Minimum documentation searched (classification system followed by classification symbols)																						
G12B 9/00, 9/02, 9/06, C25D 11/00, 11/02, 11/16, C09K 3/00, C09C 1/00																						
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																						
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)																						
PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS																						
C. DOCUMENTS CONSIDERED TO BE RELEVANT																						
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																				
Y	US 2015/0122660 A1 (ALCOA INC.) 07.05.2015, p. 1, paragraph [0005], p. 5, paragraph [0111], p. 8, paragraph [0123], p. 23, paragraph [0256], p. 24, paragraph [0258], p. 25, paragraphs [0273], [0274], p. 26, paragraphs [0275], [0276], [0278], [0281], p. 27, paragraphs [0281] - [0283], [0284], [0288], [0289], p. 28, paragraph [0299]	1-15																				
Y	US 2017/0013735 A1 (SAMSUNG ELECTRONICS CO., LTD.) 12.01.2017, p. 1, paragraphs [0007], [0011], p. 4, paragraphs [0055], [0056], [0058], [0059], [0064]	1-15																				
A	US 2016/0137846 A1 (MERCK PATENT GMBH) 19.05.2016	1-15																				
A	WO 2018/194639 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 25.10.2018	1-15																				
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.																						
* Special categories of cited documents: <table border="0"> <tr> <td>“A”</td> <td>document defining the general state of the art which is not considered to be of particular relevance</td> <td>“T”</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>“E”</td> <td>earlier document but published on or after the international filing date</td> <td>“X”</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>“L”</td> <td>document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>“Y”</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>“O”</td> <td>document referring to an oral disclosure, use, exhibition or other means</td> <td>“&”</td> <td>document member of the same patent family</td> </tr> <tr> <td>“P”</td> <td>document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			“A”	document defining the general state of the art which is not considered to be of particular relevance	“T”	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	“E”	earlier document but published on or after the international filing date	“X”	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	“L”	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	“Y”	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	“O”	document referring to an oral disclosure, use, exhibition or other means	“&”	document member of the same patent family	“P”	document published prior to the international filing date but later than the priority date claimed		
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“P”	document published prior to the international filing date but later than the priority date claimed																					
Date of the actual completion of the international search		Date of mailing of the international search report																				
09 July 2019 (09.07.2019)		15 August 2019 (15.08.2019)																				
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37		Authorized officer O. Gudkova Telephone No. 8(495) 531-64-81																				