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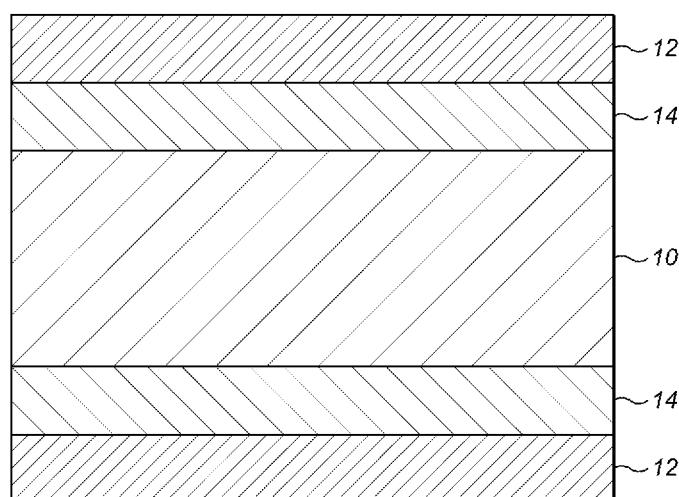


FIG. 1

(57) Abstract: The present disclosure relates to a housing for an electronic device. The housing comprises a magnesium alloy substrate, an electrophoretic deposition layer 5 overlying the substrate, and a sol-gel layer positioned between the substrate and electrophoretic deposition layer.



HOUSINGS FOR ELECTRONIC DEVICES

BACKGROUND

[0001] Electronic devices, such as laptops and mobile phones, include various
5 components located within a housing. The housings may have a metallic finish,
which may be attractive to users.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Figure 1 is a schematic drawing of a cross-section of part of a housing of
10 an electronic device according to an example of the present disclosure.

[0003] Figure 2 is a flowchart showing an example method for producing part of
the housing depicted in Figure 1.

[0004] The figures depict several examples of the present disclosure. It should
be understood that the present disclosure is not limited to the examples depicted
15 in the figures

DETAILED DESCRIPTION

[0005] As used in the present disclosure, the term "about" is used to provide
flexibility to an endpoint of a numerical range. The degree of flexibility of this term
20 can be dictated by the particular variable and is determined based on the
associated description herein.

[0006] Amounts and other numerical data may be expressed or presented in a
range format. It is to be understood that such a range format is used merely for
convenience and brevity and thus should be interpreted flexibly to include not just
25 the numerical values explicitly recited as the limits of the range, but also to include
individual numerical values or sub-ranges encompassed within that range as if
each numerical value and sub-range is explicitly recited.

[0007] As used in the present disclosure, the term "disposed" when used to refer
to the location or position of a layer includes the term "deposited" or "coated".

30 [0008] As used in the present disclosure, the term "comprises" has an open
meaning, which allows other, unspecified features to be present. This term
embraces, but is not limited to, the semi-closed term "consisting essentially of" and

the closed term “consisting of”. Unless the context indicates otherwise, the term “comprises” may be replaced with either “consisting essentially of” or “consists of”.

[0009] It is noted that, as used in this specification and the appended claims, the singular forms “a”, “an” and “the” include plural referents unless the context clearly
5 dictates otherwise.

[0010] The present disclosure relates to a housing for an electronic device. The housing comprises a magnesium alloy substrate, an electrophoretic deposition layer overlying the substrate, and a sol-gel layer positioned between the substrate and electrophoretic deposition layer.

10 [0011] In some examples, the sol-gel layer may comprise a siloxy functional group.

[0012] A magnesium alloy substrate may be used to form at least part of a housing of an electronic device. In some examples, such magnesium alloy substrates may have an appealing metallic appearance. For example, such
15 substrates may have a metallic lustre, which may be attractive to consumers. Magnesium alloy, however, can be susceptible to oxidation. For example, when a magnesium alloy surface is exposed to air, it can oxidize and form a dull surface, which, in some instances, can have an unattractive appearance. By applying a coating to a surface of the substrate, the underlying metallic substrate can be
20 protected.

[0013] Electrophoretic deposition layers can be applied to magnesium alloy substrates as a protective coating. Electrophoretic deposition layers may also provide the substrate with an attractive surface finish. It has been found, however, that, when electrophoretic deposition layers are applied to the magnesium alloy
25 substrate, the resulting structure may still be susceptible to corrosion. For example, the resulting structure may not perform well under the salt fog test (e.g. ASTM B117).

[0014] In the present disclosure, a sol-gel layer may be positioned between the substrate and electrophoretic deposition layer. The sol-gel layer may bind to the
30 underlying magnesium alloy substrate and, in some examples, may improve adhesion between the magnesium alloy substrate and the overlying electrophoretic deposition layer.

[0015] The sol-gel layer may be formed by contacting a magnesium alloy substrate with a sol-gel precursor and gelling the sol-gel precursor to form a sol-gel layer over the magnesium alloy substrate. In some examples, the thickness of the sol gel layer may be controlled, e.g. so that the magnesium alloy substrate bearing the sol-gel layer retains sufficient electrical conductivity to allow an electrophoretic deposition layer to be applied over the sol-gel layer.

[0016] In some examples, the sol-gel layer may have functional groups that bind and/or react with functional groups e.g. hydroxyl groups on the surface of the magnesium alloy substrate. As a result, the sol gel layer may form a good bond with the magnesium alloy substrate. The overlying electrophoretic deposition layer may adhere to the sol-gel coated substrate, for example, as a result of the charge interactions between the electrophoretic deposition layer and the underlying magnesium alloy substrate. Additionally or alternatively, the sol-gel layer may have functional groups that bind and/or react with functional groups in the electrophoretic deposition layer, strengthening the bond between the electrophoretic deposition layer and the magnesium alloy substrate.

[0017] The adhesion between the magnesium alloy substrate, the sol-gel layer and electrophoretic deposition layer may help to reduce the risk of oxidation or corrosion of the overall structure. In some examples, the performance under the salt fog test may be improved (e.g. ASTM B117).

[0018] In some examples, the sol-gel layer comprises a sol gel network, for example, an organosilicon and/or siloxane network. In some examples, the sol-gel layer forms a metal oxide network. The sol gel network may provide a dense barrier against corrosive species that may otherwise react with the magnesium alloy substrate. In some examples, the sol-gel layer may be transparent, such that the visual appeal (e.g. metallic lustre) of the underlying magnesium alloy substrate may be discernible through the overlying electrophoretic deposition layer.

[0019] In some examples, the electrophoretic deposition layer may comprise a polymer selected from epoxy polymers, polyvinylpyrrolidone, polyethyleneimine, and polyacrylic polymers.

[0020] In some examples, the electrophoretic deposition layer has a thickness of about 5 to about 60 μm .

[0021] In some examples, the sol gel layer comprises a siloxy functional group. The sol gel layer may also include a further functional group selected from phosphate, phosphonate, carboxylate and/or sulphonate.

[0022] In some examples, the sol gel layer is derived from a sol gel precursor selected from at least one of 3-(trihydroxysilyl)-1-propanesulfonic acid; 1,1-bis(trimethoxysilylmethyl)ethylene; sodium (3-(trihydroxysilyl)propyl)methyl phosphonate; tetraethoxysilane; tetramethoxysilane, tris(trimethylsilyl) phosphate, 3-(trihydroxysilyl)-1-propanesulfonic acid and N-(trimethoxysilylpropyl)ethylenediaminetriacetate.

5 [0023] In some examples, the sol gel layer has a thickness of about 10 nm to about 3 μ m.

[0024] In some examples, the magnesium alloy substrate has a thickness of about 0.5 to about 1.2 mm.

[0025] In some examples, the electrophoretic deposition layer additionally
15 comprises a pigment.

[0026] In some examples, the pigment is selected from carbon black, titanium dioxide, clay, mica, talc, barium sulfate, calcium carbonate, synthetic pigment, pearl pigment, metallic powder, aluminum oxide, dye, graphene, graphite, and other inorganic powders.

20 [0027] In some examples, the pigment particles are dispersed throughout the electrophoretic deposition layer.

[0028] The present disclosure also relates to a method for manufacturing a housing for an electronic device. The method comprises contacting a magnesium alloy substrate with a sol-gel precursor; gelling the organosilicon sol-gel precursor
25 to form a sol-gel layer over the magnesium alloy substrate; and applying an electrophoretic deposition layer over the sol-gel layer by electrophoresis.

[0029] In some examples, the sol-gel precursor is selected from 3-(trihydroxysilyl)-1-propanesulfonic acid; 1,1-bis(trimethoxysilylmethyl)ethylene; sodium (3-(trihydroxysilyl)propyl)methyl phosphonate; tetraethoxysilane; tetramethoxysilane,
30 tris(trimethylsilyl) phosphate, 3-(trihydroxysilyl)-1-propanesulfonic acid and N-(trimethoxysilylpropyl)ethylenediaminetriacetate.

[0030] In some examples, after the sol-gel layer is applied onto the magnesium alloy substrate but before the electrophoretic deposition layer is applied, the

magnesium alloy substrate bearing the sol-gel layer has a resistivity of about 0.1 to about 10 Ohms.

[0031] In some examples, the magnesium alloy substrate bearing the sol-gel layer is made an electrode of an electrochemical cell having an inert electrode as the counter electrode and an electrolyte comprising an electrophoretic polymer.

[0032] In some examples, a potential difference is applied across the electrodes of the electrochemical cell to deposit the electrophoretic polymer over the sol-gel layer.

10 *Magnesium Alloy Substrate*

[0033] The magnesium alloy substrate may have a thickness of about 0.1 to about 5 mm, for example, about 0.2 to about 4 mm or about 0.3 mm to about 2 mm.

[0034] The magnesium alloy may comprise a content of magnesium of at least about 75 wt.%. For example, the magnesium alloy may comprise at least about 80 wt.% or at least about 90 wt.% of magnesium.

[0035] In some examples, the magnesium alloy may comprise about 85 to about 99 weight % magnesium.

[0036] The magnesium alloy may further comprise aluminum, zinc, manganese, silicon, copper, a rare earth metal or zirconium. The aluminum content may be about 2 wt.% to about 13.0 wt.%. When the magnesium alloy comprises aluminum, then at least one of zinc, manganese, zirconium or silicon is also present.

[0037] Examples of magnesium alloys include AZ31B, AZ61, AZ60, AZ80, AM60, LZ91, LZ14, ALZ and AZ91D alloys, according to the American Society for Testing and Materials standards. In some examples, the magnesium alloy may be AZ31B and/or AZ91D.

[0038] In some examples, the magnesium alloy may comprise about 85 to about 99 weight % magnesium, for example, about 87 to about 97 weight % magnesium. The magnesium alloy may also comprise aluminium, for example, about 2 to about 12 weight %, for instance, about 2.5 to about 10 weight % aluminium. In addition to magnesium and aluminium, the magnesium alloy may also comprise zinc. Zinc may be present in amounts of about 0.2 to about 2 weight %, for example, about 0.3 to about 1 weight %. In addition to magnesium, aluminium and zinc, the

magnesium alloy may also include manganese. Manganese may be present in amounts of about 0.1 to about 1 weight %, for example, about 0.15 to about 0.5 weight %. In addition to magnesium, aluminium, zinc and manganese, at least one of silicon, copper, iron, nickel and/or calcium may be present. The total amount of silicon, copper, iron, nickel and/or calcium may be about 0.001 to about 1 weight %, for example, about 0.005 to about 0.1 weight %.

[0039] In some examples, the magnesium alloy substrate has an oxide layer.

[0040] The oxide layer may be formed on exposure to air. In some examples, the magnesium alloy substrate comprises some surface oxidation. For instance, as a result of the surface oxidation and moisture in the air, hydroxyl groups may be present at the surface of the magnesium alloy substrate.

[0041] In some examples, an oxide layer may be applied, for example, by an electrochemical method. Examples of electrochemical methods include anodising and micro-arc oxidation. To form an oxide layer by anodising, the substrate is made an anode of an electrochemical cell. The cathode may be an inert cathode, for example, stainless steel, while the electrolyte may be an acid solution. When a direct current is passed through the cell, hydrogen is released at the cathode and oxygen at the surface of the anode, which reacts with the metal (e.g. magnesium or aluminium) at the anode's surface to form an oxide layer. The potential applied across the cell may be about 10 to about 200 V, for example, about 30 to about 120 V.

[0042] In microarc oxidation (MAO), higher potentials are applied. For example, potentials of greater than about 200V may be applied, for instance, about 200 to about 500 V. These potentials can exceed the dielectric breakdown potential of the growing oxide film and, as a result, discharges can occur. These discharges can result in localised plasma reactions that modify the growing oxide by, for example, melting, re-solidification, sintering and densification of the growing oxide layer. These modifications can enhance the mechanical properties of the resulting oxide layer. The modifications can result in microcracks and micropores in the surface of the oxide layer.

[0043] Micro-arc oxidation (MAO) may involve creating micro-discharges on a surface of the magnesium alloy immersed in an electrolyte to produce a crystalline oxide coating. The resulting micro-arc oxide layer may also be ductile and have a

relatively high hardness. In comparison to an oxide layer produced by a deposition process, a micro-arc oxide layer may have a higher adhesion to the underlying magnesium alloy.

[0044] The electrolytic solution for MAO may comprise an electrolyte selected from sodium silicate, sodium phosphate, potassium fluoride, potassium hydroxide, sodium hydroxide, fluorozirconate, sodium hexametaphosphate, sodium fluoride, aluminum oxide, silicon dioxide, ferric ammonium oxalate, a salt of phosphoric acid, polyethylene oxide alkylphenolic ether and a combination thereof.

[0045] In one example, the oxide layer may be a micro-arc oxide layer. In one example, the substrate is a magnesium alloy substrate having an oxide layer, for instance, a micro-arc oxide layer.

[0046] Where present, the oxide layer of the magnesium alloy substrate can have a thickness of from about 3 to about 15 μm , for example, from about 5 to about 12 μm . In one example, where the oxide layer is a micro-arc oxide layer, the micro-arc oxide layer may have a thickness of from about 3 to about 15 μm , for example, from about 5 to about 12 μm .

[0047] In some examples, the magnesium alloy substrate has a passivation layer.

[0048] The passivation layer may comprise a salt selected from a molybdate salt, a vanadate salt, a phosphate salt, a chromate salt, a stannate salt and a manganese salt. In one example, the passivation layer comprises a phosphate salt. The passivation layer contains oxidic salts that can provide the first surface with a dark grey appearance.

[0049] The passivation layer may be applied by exposing the surface of the substrate to a solution of the relevant salt. For example, the surface of the metal or metal alloy substrate may be exposed to a solution of a salt selected from a molybdate salt, a vanadate salt, a phosphate salt, a chromate salt, a stannate salt and a manganese salt. In one example, the passivation layer comprises a phosphate salt.

[0050] Where present, the passivation layer can have a thickness of from about 0.5 to about 5 μm , for example, about 1 to about 4 μm .

[0051] In some examples, the magnesium alloy substrate does not include an anodised oxide layer. In some examples, the magnesium alloy substrate does not include a MAO layer. In some examples, the magnesium alloy substrate does not

include a passivation layer. In some examples, the magnesium alloy substrate does not include anodised oxide layer, a MAO layer or a passivation layer.

[0052] In some examples, the magnesium alloy substrate may include some surface oxidation, for example, because of exposure to air. However, the
5 magnesium alloy substrate may be devoid of any electrochemically applied oxide layer.

[0053] In some examples, prior to application of the sol gel layer, the magnesium alloy substrate may be cleaned. Cleaning may help to remove grease, dirt and/or unwanted surface oxidation. In some examples, cleaning may be used to provide
10 the magnesium alloy substrate with the desired level of metallic lustre prior to application of the sol gel layer.

[0054] Any suitable cleaning method may be used. For example, ultrasonic cleaning may be used.

[0055] In other examples, the magnesium alloy substrate may be cleaned with an
15 alkali. Suitable alkalis include alkali metal hydroxide, for example, aqueous sodium hydroxide. In some examples, a sodium hydroxide solution having a concentration of about 0.1 to about 5 weight %, for instance, about 0.5 to about 3 weight % may be used. The substrate may also be washed using a chemical polishing solution. Examples of such solutions include acid solutions. Suitable
20 acids include hydrochloric acid, nitric acid, phosphoric acid and/or sulphuric acid. The acids may be used at concentrations of about 1 to about 20 weight %, for example, about 3 to about 15 weight %.

Sol gel layer

25 [0056] As discussed above, a sol gel layer may be disposed between the magnesium alloy substrate and the electrophoretic deposition layer.

[0057] The sol gel layer may bind to the magnesium alloy substrate to reduce the risk of oxidation or corrosion of the magnesium alloy substrate. In some examples, the sol gel layer may bind to or react with functional groups on the
30 surface of the magnesium alloy substrate to form, for example, covalent bonds. In one example, the sol gel layer may react with e.g. hydroxyl groups on the surface of the magnesium alloy substrate to form, for example, covalent bonds. In one example, the sol gel layer may react with e.g. hydroxyl groups on the surface of

the magnesium alloy substrate to form, for example, a Ti-O, Zr-O, Si-O, P-O, S-O and/or C-O bond. In some examples, the sol gel layer may include a metal oxide bond or a siloxy group. In addition to the metal oxide bonds or siloxy group, the sol gel layer comprises a functional group selected from phosphate, phosphonate, carboxylate and/or sulphonate.

[0058] The sol-gel layer may be formed by a sol-gel process. In such a process, solid particles of a sol-gel precursor are suspended in a liquid, forming a "sol", which is deposited onto the magnesium alloy substrate. The concentration of the sol-gel precursor in the liquid may be about 1 to about 30 weight %, for example, about 5 to about 15 weight %.

[0059] The sol may be deposited onto the magnesium alloy substrate by any suitable method, including dipping and/or coating. The particles in the sol are then gelled, for example, by crosslinking or polymerisation. The gelling process may involve partial evaporation of the liquid solvent and/or the addition of an initiator.

The crosslinking and/or polymerisation may form a network, for example, an organosilicon or siloxane network. This network may present a dense barrier against corrosive species that may otherwise react with the underlying magnesium alloy substrate.

[0060] The gelled layer may then be cured e.g. by heating to form the sol-gel layer. Heating may be performed at any suitable temperature. Examples of suitable temperatures range from about 50 to about 250 degrees C, for example, about 60 to about 220 degrees C.

[0061] The parameters of the sol-gel process may be controlled e.g. to control the thickness of the sol-gel layer. For example, by varying the nature and amounts of the sol-gel precursors and the thickness of the sol-gel layer, it may be possible to control the electrical resistivity of the sol-gel coated substrate for subsequent electrophoretic deposition.

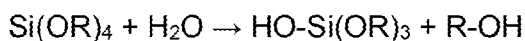
[0062] The sol-gel layer may be formed by applying a precursor of an inorganic oxide, such as a metal alkoxide or an alkylorthosilicate. Examples include aluminum isopropoxide, tetraethylorthosilicate (TEOS), tetramethylorthosilicate (TMOS), titanium isopropoxide and zirconium tert-butoxide.

[0063] In some examples, the sol-gel layer may be derived from a silane. The silane may be any silane that can be crosslinked to form an organosilicon and/or siloxane network.

[0064] Suitable sol-gel precursors include 3-(trihydroxysilyl)-1-propanesulfonic acid, 1,1-bis (trimethoxysilylmethyl)ethylene, sodium (3-trihydroxysilyl)propylmethyl phosphonate, tetraethoxysilane, tetramethoxysilane, tris(trimethylsilyl) phosphate, 3-(trihydroxysilyl)-1-propanesulfonic acid, (3-glycidoxypentyl)-trimethoxysilane and N-(trimethoxysilylpropyl)ethylenediaminetriacetate. In some examples, mixtures of two or more silanes may be employed to form the sol-gel layer (e.g. the organosilicon and/or siloxane network of the sol-gel layer). In one example, (3-glycidoxypentyl)-trimethoxysilane and tris(trimethylsilyl) phosphate may be used in combination to form the sol-gel layer.

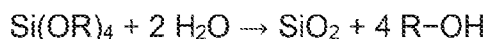
[0065] By way of example, the polymerisation of tetra-alkoxysilane by an example of a sol-gel process will now be described.

[0066] Tetra-alkoxysilane ($\text{Si}(\text{OR})_4$, where R is an alkyl group e.g. C_1 to C_4 alkyl) may undergo hydrolysis under the reaction below:



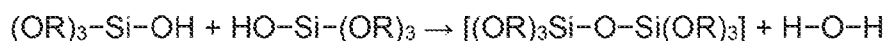
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[0067] Depending on the amount of water present, hydrolysis may continue until silica is formed:

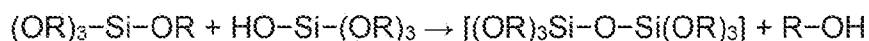


[0068] Complete hydrolysis may require an excess of water and/or the use of a hydrolysis catalyst, for example, acetic acid or hydrochloric acid. Intermediate species including $[(\text{OR})_2\text{-Si-(OH)}_2]$ or $[(\text{OR})_3\text{-Si-(OH)}]$ may result as products of partial hydrolysis reactions. These intermediates may react to form species that are linked by a siloxane bond. For example:

30



or



[0069] Thus, polymerization may be associated with the formation of a 1-, 2-, or 3-dimensional network of siloxane bonds accompanied by the production of H-O-H (water) and R-O-H (alcohol) species.

[0070] In some examples, the condensation of water and/or alcohol can continue to build increasingly large silicon-containing molecules by the process of polymerization. In some examples, polymerization of tetra-alkoxysilane for instance, can lead to complex branching of the polymer. This may be because the fully hydrolysed monomer (Si(OH)₄) is tetra-functional (can branch or bond in 4 different directions). Alternatively, under certain conditions (e.g., low water concentration), fewer than 4 of the OR or OH groups may be capable of condensation. As a result, less branching may occur. The mechanisms of hydrolysis and condensation, and the factors that bias the structure toward linear or branched structures may be controlled in examples of the sol-gel process to tailor the resulting sol-gel layer accordingly.

[0071] In some examples, any e.g. hydroxyl groups on the surface of the magnesium alloy substrate may react with the sol-gel precursor or a sol-gel intermediate. For example, where the sol-gel precursor or sol-gel intermediate may comprise a silyl ether or silyl alcohol functional group, functional groups e.g. hydroxyl groups on the surface of the magnesium alloy substrate may react with the silyl ether or silyl alcohol functional group. As a result, the sol gel precursor or sol gel intermediate may be bonded to the magnesium alloy substrate via a siloxy bond.

[0072] In some examples, the sol gel precursor may comprise a further functional group that may bind or react with any suitable functional group e.g. hydroxyl groups on the surface of the magnesium alloy substrate. As mentioned above, these further functional groups may be selected from phosphate, phosphonate, carboxylate and/or sulphonate.

[0073] As mentioned above, the sol-gel process may be catalysed. Examples of suitable catalysts include water, BiCl₃, ZrCl₄, FeCl₃, AlCl₃ and TiCl₄.

[0074] Once the polymerisation and/or crosslinking reaction is complete, the layer may be cured to form the sol-gel layer. In some examples, curing may be carried

out by heating the layer to an elevated temperature. Examples of suitable temperatures range from about 50 to about 250 degrees C, for example, about 60 to about 220 degrees C.

[0075] The sol-gel layer may be transparent. For example, the metallic appearance of the magnesium alloy substrate may be discernible through the sol-gel layer. In some examples, the metallic lustre of the magnesium alloy substrate may be discernible through the sol-gel layer.

[0076] In some examples, the sol gel layer has a thickness of about 10 nm to about 5 μm , for example, about 0.2 μm to about 4 μm or about 0.5 μm to about 3 μm .

[0077] In some examples, after the sol-gel layer is applied onto the magnesium alloy substrate but before the electrophoretic polymer layer is applied, the magnesium alloy substrate bearing the sol-gel layer has a resistivity of about 0.1 to about 10 Ohms. In some examples, the resistivity may be about 0.2 to about 5 ohms, for example, about 0.3 to about 1.5 Ohms.

[0078] In some examples, the sol-gel layer may be applied to one or more surfaces of the magnesium alloy substrate. For example, the sol-gel layer may be applied to an upper and/or a lower surface of the magnesium alloy substrate.

20 *Electrophoretic deposition layer*

[0079] The electrophoretic deposition layer may be an electrophoretic polymer layer. This layer may be applied by electrophoretic deposition. The electrophoretic deposition layer may protect the magnesium alloy substrate and provide the substrate with a good surface finish.

[0080] In some examples, the magnesium alloy substrate bearing the sol-gel layer is made an electrode of an electrochemical cell having an inert electrode as the counter electrode and an electrolyte comprising the electrophoretic polymer used to form the electrophoretic layer. In some examples, the electrophoretic polymer is in the form of particles. These particles may be suspended in the electrolyte as a colloidal solution.

[0081] When a potential difference is applied across the cell, the particles of electrophoretic polymer may be pulled towards the magnesium alloy substrate

bearing the sol-gel layer by electrophoresis. The polymer may deposit on the substrate to form a coating. In some examples, the polymer coating may be a powder agglomeration that may require further processing (e.g. heating or sintering) to strengthen the bond between the electrophoretic polymer and the underlying substrate. In some examples, the electrophoretic deposition layer may be heated at a temperature of about 100 to about 220 degrees C, for example, about 120 to about 200 degrees C or about 160 to about 180 degrees C.

[0082] Coatings formed by electrophoretic deposition may be uniform. The method can also be used to form coatings on three-dimensional substrates, and the entire exposed surface can be coated, making it possible to coat inner and outer surfaces of objects of a variety of shapes.

[0083] In some examples, the magnesium alloy substrate bearing the sol-gel layer may be cut to shape, for example, by a computer numerical control (CNC) laser cutting process prior to electrophoresis. The sol-gel layer may protect the magnesium alloy substrate from e.g. corrosion or oxidation prior to application of the electrophoretic deposition layer.

[0084] In some examples, the electrophoretic polymers used in electrophoretic deposition may be polarizable or possess the ability to sustain induced dipoles in order for the electrophoresis to take place.

[0085] The electrophoretic deposition layer may comprise a polymer selected from an epoxy polymer, polyvinylpyrrolidone, polyethyleneimine, and a polyacrylic polymer. In one example, the polymer is a polyacrylic polymer.

[0086] In some examples, the electrophoretic deposition layer may comprise a polymer having a molecular weight of about 800 to about 15000, for example, about 1000 to about 12000 or about 1500 to about 8000.

[0087] The electrophoretic deposition layer may be transparent.

[0088] In one example, the electrophoretic deposition layer is colourless. In another example, the electrophoretic deposition layer may be coloured.

[0089] The electrophoretic deposition layer may further comprise a pigment or dye. Pigment and/or dye particles may be dispersed throughout the electrophoretic polymer layer.

[0090] The pigment may be selected from carbon black, titanium dioxide, clay, mica, talc, barium sulfate, calcium carbonate, synthetic pigment, pearl pigment, metallic powder, aluminum oxide, graphene, graphite, and an inorganic powder.

5 [0091] The pigment may also be deposited onto the magnesium alloy substrate bearing the sol-gel layer by electrophoresis, together with the electrophoretic polymer.

[0092] The electrophoretic deposition layer may have a thickness of about 5 to about 60 μm .

10 [0093] The electrophoretic deposition layer may ensure that both the attractive, shiny appearance of the underlying metallic substrate and the metallic lustre are retained.

[0094] The electrophoretic deposition layer may overlie more than one surface of the magnesium alloy substrate. For example, the electrophoretic deposition layer may overlie an upper and/or a lower surface of the magnesium alloy substrate.

15

Electronic device

[0095] The electronic device of the present disclosure may be a computer, a cell phone, a portable networking device, a portable gaming device or a portable GPS. The computer may be portable. When the computer is portable, it may be a laptop
20 or a tablet.

[0096] The electronic device may have an electrical circuit, such as a motherboard or display circuitry. The housing may be external to the electrical circuit.

25 *Figures*

[0097] Various aspects of examples of the present disclosure will now be described, by way of example, with reference to Figures 1 and 2.

[0098] Figure 1 is a schematic drawing of a cross-section of part of a housing of an electronic device according to one example of the present disclosure. The
30 housing comprises a magnesium alloy substrate 10. An electrophoretic deposition layer 12 overlies the upper and lower surfaces of the substrate 10. Sol-gel layers 14 are positioned between the substrate 10 and electrophoretic deposition layers 12. In some examples, the sol-gel layer comprises a siloxy functional group.

[0099] Figure 2 is a flowchart showing an example method for producing part of the housing depicted in Figure 1. The magnesium alloy substrate 10 may be subjected to a surface cleaning 100. Any suitable cleaning method may be used. For example, ultrasonic cleaning may be used. In other examples, the magnesium alloy substrate may be cleaned with an alkali. Suitable alkalis include alkali metal hydroxide, for example, aqueous sodium hydroxide. In some examples, a sodium hydroxide solution having a concentration of about 0.1 to about 5 weight %, for instance, about 0.5 to about 3 weight % may be used. The cleaned substrate may be washed using a chemical polishing solution. Examples of such solutions include acid solutions. Suitable acids include hydrochloric acid, nitric acid, phosphoric acid and/or sulphuric acid. The acids may be used at concentrations of about 1 to about 20 weight %, for example, about 3 to about 15 weight %.

[0100] A sol-gel layer 14 is then applied to the cleaned magnesium alloy substrate 10 in a sol-gel processing method 110. In this procedure, the substrate 10 is dipped into a solution containing a sol-gel precursor. The precursor is then gelled by polymerisation and/or crosslinking to form an adherent sol-gel layer over the substrate 10. In some examples, the gelled sol gel may be heated at about 60 to about 80 degrees for 20 to 40 minutes.

[0101] An electrophoretic deposition layer is then applied over the sol-gel layers 14 in an electrophoretic deposition method 112. Here, the magnesium alloy substrate 10 bearing the sol-gel layers 14 is made an electrode of an electrochemical cell having an inert electrode as the counter electrode and an electrolyte comprising the electrophoretic polymer. In some examples, the electrophoretic polymer is in the form of particles. These particles may be suspended in the electrolyte as a colloidal solution.

[0102] When a potential difference is applied across the cell, the particles of electrophoretic polymer may be pulled towards the magnesium alloy substrate bearing the sol-gel layer by electrophoresis. The polymer may deposit on the substrate to form a coating. In some examples, the polymer coating may be a powder agglomeration that may require further processing (e.g. heating or sintering) to strengthen the bond between the electrophoretic polymer and the underlying substrate. In some examples, the electrophoretic deposition layer may

be heated 114 at a temperature of about 100 to about 220 degrees C, for example, about 120 to about 200 degrees C or about 160 to about 180 degrees C.

CLAIMS

1. A housing for an electronic device comprising:
a magnesium alloy substrate,
5 an electrophoretic deposition layer overlying the substrate, and
a sol-gel layer positioned between the substrate and electrophoretic
deposition layer.
- 10 2. The housing as claimed in claim 1, wherein the electrophoretic
deposition layer is selected from epoxy polymers, polyvinylpyrrolidone,
polyethyleneimine, and polyacrylic polymers.
- 15 3. The housing as claimed in claim 1, wherein the electrophoretic
deposition layer has a thickness of about 5 to about 60 μm .
4. The housing as claimed in claim 1, wherein the sol gel layer comprises
a siloxy functional group and a further functional group selected from
phosphate, phosphonate, carboxylate and/or sulphonate.
- 20 5. The housing as claimed in claim 1, wherein the sol gel layer is derived
from a sol gel precursor selected from at least one of 3-(trihydroxysilyl)-
1-propanesulfonic acid; 1,1-bis(trimethoxysilylmethyl)ethylene; sodium
(3-(trihydroxysilyl)propyl)methyl phosphonate; tetraethoxysilane;
tetramethoxysilane, tris(trimethylsilyl) phosphate, 3-(trihydroxysilyl)-1-
25 propanesulfonic acid and N-
(trimethoxysilylpropyl)ethylenediaminetriacetate.
6. The housing as claimed in claim 1, wherein the sol gel layer has a
thickness of about 10 nm to about 3 μm .
- 30 7. The housing as claimed in claim 1, wherein the magnesium alloy
substrate has a thickness of about 0.5 to about 1.2 mm.

8. The housing as claimed in claim 1, wherein the electrophoretic deposition layer additionally comprises a pigment or dye.
- 5 9. The housing as claimed in claim 8, wherein the pigment is selected from carbon black, titanium dioxide, clay, mica, talc, barium sulfate, calcium carbonate, synthetic pigment, pearl pigment, metallic powder, aluminum oxide, graphene and graphite.
- 10 10. The housing as claimed in claim 8, wherein pigment particles are dispersed throughout the electrophoretic polymer layer.
11. A method for manufacturing a housing for an electronic device, said method comprising:
contacting a magnesium alloy substrate with a sol-gel precursor;
15 gelling the sol-gel precursor to form a sol-gel layer over the magnesium alloy substrate; and
applying an electrophoretic deposition layer over the sol-gel layer by electrophoresis.
- 20 12. The method as claimed in claim 11, wherein the sol-gel precursor is selected from 3-(trihydroxysilyl)-1-propanesulfonic acid; 1,1-bis(trimethoxysilylmethyl)ethylene; sodium (3-(trihydroxysilyl)propyl)methyl phosphonate; tetraethoxysilane; tetramethoxysilane, tris(trimethylsilyl) phosphate, 3-(trihydroxysilyl)-1-
25 propanesulfonic acid and N-(trimethoxysilylpropyl)ethylenediaminetriacetate.
- 30 13. The method as claimed in claim 11, wherein, after the sol-gel layer is applied onto the magnesium alloy substrate but before the electrophoretic deposition layer is applied, the magnesium alloy substrate bearing the sol-gel layer has a resistivity of about 0.1 to about 10 Ohms.

14. The method as claimed in claim 11, wherein the magnesium alloy substrate bearing the sol-gel layer is made an electrode of an electrochemical cell having an inert electrode as the counter electrode and an electrolyte comprising an electrophoretic polymer.

5

15. The method as claimed in claim 14, wherein a potential difference is applied across the electrodes of the electrochemical cell to deposit the electrophoretic polymer over the sol-gel layer.

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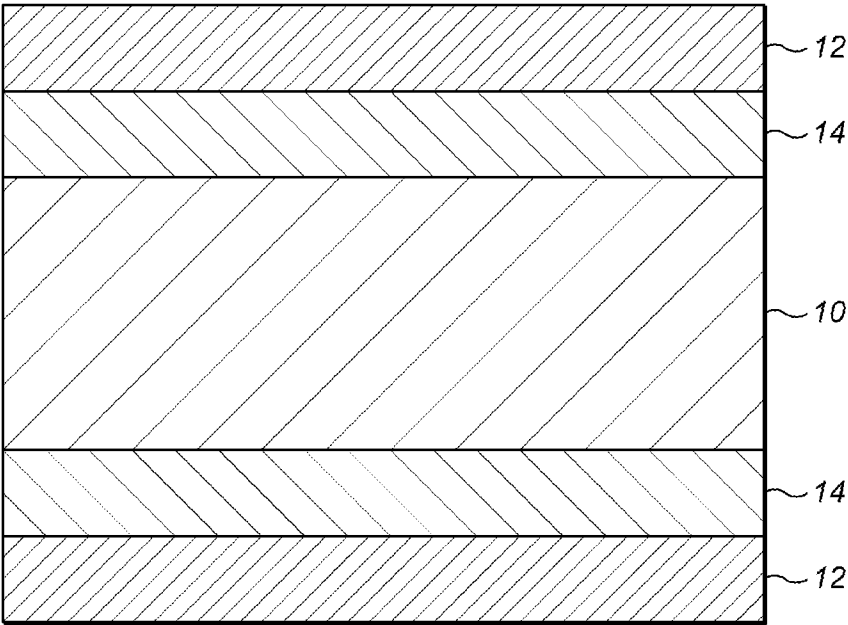


FIG. 1

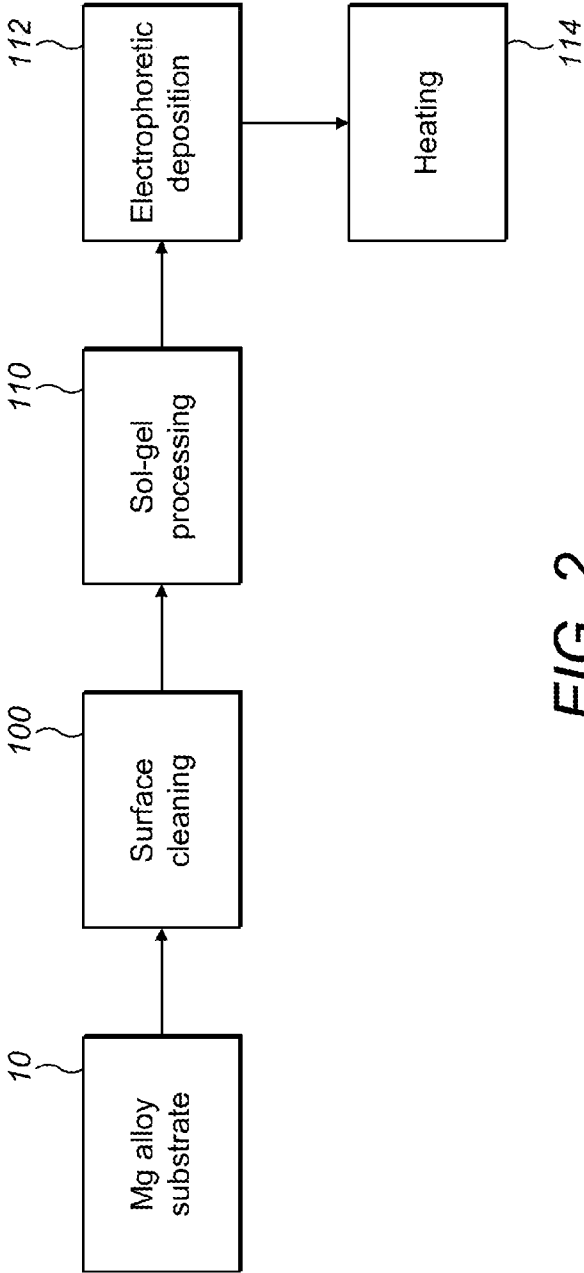


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2019/012806

A. CLASSIFICATION OF SUBJECT MATTER		
<i>G12B 9/02 (2006.01)</i> <i>C23F 17/00 (2006.01)</i> <i>C25D 13/04 (2006.01)</i> <i>C25D 13/20 (2006.01)</i> <i>C09D 5/44 (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, C23F 17/00, C25D 13/00, 13/04, 13/20, C09D 5/00, 5/44		
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, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2018/0305822 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 25.10.2018, [0005], [0009], [0011], [0016]	1-15
Y	US 6284682 B1 (THE UNIVERSITY OF BRITISH COLUMBIA) 04.09.2001, col.6, lines 1-23, 44-65, col. 12, lines 64-67, col. 13, lines 1-13	1-15
Y	US 2014/0272433 A1 (HENKEL AG & CO.KGAA) 18.09.2014, [0030], [0039], [0041], [0043], [0047], [0049], [0052]	4-5, 12
Y	US 2012/0021232 A1 (TECHNISCHE UNIVERSITÄT WIEN) 26.01.2012, [0068]	6
A	US 2018/0155846 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 07.06.2018	1-15
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier document but published on or after the international filing date “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) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “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 “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 “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 “&” document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
20 September 2019 (20.09.2019)		03 October 2019 (03.10.2019)
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. 8 499 240 25 91