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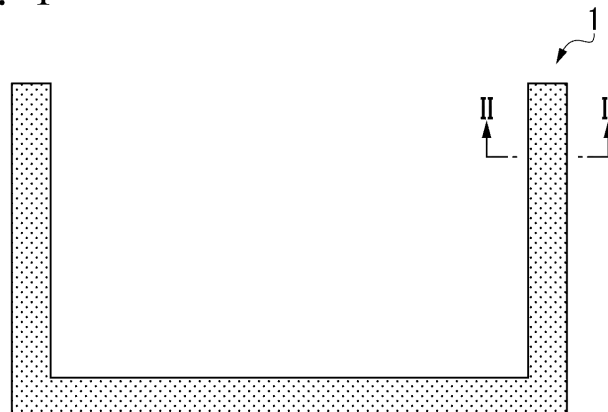
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(54) **INSULATING FILM-EQUIPPED DIE-CUT PRODUCT AND METHOD FOR PRODUCING SAME**

(57) This punched-workpiece with the insulating film includes a punched-workpiece having a cut surface, a plating layer formed on at least the cut surface of the

punched-workpiece, and an insulating film formed on the surface of the plating layer.

FIG. 1



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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to an insulating film-attached punched workpiece and a method for producing the same.

[0002] Priority is claimed on Japanese Patent Application No. 2020-048868, filed March 19, 2020, the content of which is incorporated herein by reference.

10 BACKGROUND ART

[0003] Punched-workpieces are produced by punching a metal sheet in a predetermined shape. The punched-workpieces are used as, for example, electronic components such as terminal members of bus bars or wire harnesses and motor components such as coils. Punched-workpieces that are used in these electronic components or motor components are coated with an insulating film in some cases. As a method for coating an insulating film-attached punched workpiece, a method in which a resin material is applied to a punched-workpiece and ultraviolet ray, heat, or the like is applied to the obtained coating film to cure the resin material is known (for example, Patent Documents 1 and 2).

[Citation List]

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[Patent Documents]

[0004]

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[Patent Document 1]

Japanese Unexamined Patent Application, First Publication No. 2011-113816

[Patent Document 2]

Japanese Unexamined Patent Application, First Publication No. 2018-200848

30 SUMMARY OF INVENTION

Technical Problem

35 **[0005]** Punched-workpieces have an advantage of being easily processed into a variety of shapes compared with rolled products. However, in an insulating film-attached punched workpieces obtained by coating the punched-workpieces with the insulating films, there is a tendency that, in a cut surface that is formed during punching, the generation of a pinhole attributed to the partial peeling of the insulating film or a decrease in breakdown voltage is likely to occur.

[0006] The present invention has been made in view of the above-described circumstances, and an object of the present invention is to provide an insulating film-attached punched workpiece having a high breakdown voltage in which the generation of a pinholes attributed to the partial peeling of the insulating film is suppressed and a method for producing the same.

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Solution to Problem

45 **[0007]** As a result of repeating studies to solve the above-described problem, the present inventors found that an insulating film is likely to peel off at the interface between a shear surface and a fracture surface or the unevenness of the fracture surface, which is formed on a cut surface by punching. In addition, the present inventors confirmed that an insulating film-attached punched workpiece having a high breakdown voltage can be obtained by forming a plating layer on the cut surface of the punched-workpiece to make the surface state of the cut surface uniform and then coating the surface with an insulating film and completed the present invention.

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[0008] In order to solve the above-described problem, an insulating film-attached punched workpiece of the present invention includes a punched-workpiece having a cut surface, a plating layer formed on at least the cut surface of the punched-workpiece, and an insulating film formed on a surface of the punched-workpiece having the plating layer.

55 **[0009]** According to the insulating film-attached punched workpiece of the present invention, in the punched-workpiece, the plating layer is formed on the cut surface, and the surface state of the cut surface of the punched-workpiece becomes uniform, and thus adhesion between the cut surface of the punched-workpiece and the insulating film improves. Therefore, the insulating film-attached punched workpiece of the present invention is capable of suppressing the generation of a pinholes attributed to the partial peeling of the insulating film and increasing the breakdown voltage.

[0010] Here, in the insulating film-attached punched workpiece of the present invention, it is preferable that the insulating film is an electrodeposition film.

[0011] In this case, the insulating film can be formed by the electrodeposition method, and thus it is possible to form the insulating film on the surface of the punched-workpiece in a uniform film thickness regardless of the shape of the punched-workpiece.

[0012] In addition, in the insulating film-attached punched workpiece of the present invention, it is preferable that the punched-workpiece contains a copper-based metal material and the plating layer contains a copper-based metal material.

[0013] In this case, the punched-workpiece itself has high conductivity and is thus useful as an electronic component such as a terminal member of a bus bar or a wire harness or a motor component such as a coil. In addition, since the punched-workpiece and the plating layer contain a copper-based metal material, adhesion between the punched-workpiece and the plating layer improves. This further enhances adhesion between the punched-workpiece, the plating layer, and the insulating film, and thus the generation of a pinhole attributed to the partial peeling of the insulating film can be suppressed more reliably, and the breakdown voltage of the insulating film-attached punched workpiece becomes higher.

[0014] In addition, in the insulating film-attached punched workpiece of the present invention, it is preferable that a thickness of the plating layer is in a range of 1 μm or more and 100 μm or less.

[0015] In this case, since the thickness of the plating layer is 1 μm or more, the uniformity of the surface state of the punched-workpiece is more reliably enhanced. On the other hand, since the thickness of the plating layer is 100 μm or less, the variation in the thickness of the plating layer is small and has a small influence on the dimensions of the punched-workpiece. Therefore, it becomes difficult for the variation in the thickness of the plating layer to affect the function when the insulating film-attached punched workpiece is used in, for example, a terminal member of a bus bar or a wire harness, a coil, or the like.

[0016] A method for producing an insulating film-attached punched workpiece of the present invention includes a plating step of forming a plating layer on at least a cut surface of a punched-workpiece having the cut surface and a film-forming step of forming an insulating film on a surface of the punched-workpiece having the plating layer.

[0017] According to the method for producing an insulating film-attached punched workpiece of the present invention, since the plating step is performed before the film-forming step, it is possible to form the insulating film in a state where the surface of the punched-workpiece is uniform. Therefore, in an insulating film-attached punched workpiece obtained by the production method of the present invention, adhesion between the punched-workpiece and the insulating film improves, the generation of a pinholes attributed to the partial peeling of the insulating film can be suppressed, and the breakdown voltage becomes high.

[0018] Here, in the method for producing an insulating film-attached punched workpiece of the present invention, it is preferable that the film-forming step includes the following steps.

[0019] A step of immersing the punched-workpiece having the plating layer and an electrode in an electrodeposition liquid containing charged insulating resin particles to apply a DC (direct-current) voltage between the punched-workpiece and the electrode, thereby electrodepositing the insulating resin particles on a surface of the punched-workpiece having the plating layer.

[0020] A step of heating the punched-workpiece to which the insulating resin particles have been electrodeposited to bake the insulating resin particles to the punched-workpiece.

[0021] In this case, since the insulating resin particles are electrodeposited, it is possible to form the insulating film on the surface of the punched-workpiece in a uniform film thickness regardless of the shape of the punched-workpiece.

Advantageous Effects of Invention

[0022] According to the present invention, it becomes possible to provide an insulating film-attached punched workpiece having a high breakdown voltage in which the generation of a pinholes attributed to the partial peeling of the insulating film is suppressed and a method for producing the same.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

Fig. 1 is a plan view of an insulating film-attached punched workpiece according to an embodiment of the present invention.

Fig. 2 is a cross-sectional view taken along a line II-II in Fig. 1.

Fig. 3 is a plan view of a copper substrate that is used in Present Invention Example 1.

Fig. 4 is a photograph of a cut surface of a punched copper sheet obtained in Present Invention Example 1.

DESCRIPTION OF EMBODIMENTS

[0024] Hereinafter, an insulating film-attached punched workpiece, which is an embodiment of the present invention, and a method for producing the same will be described with reference to the attached drawings.

[0025] Fig. 1 is a plan view of an insulating film-attached punched workpiece according to an embodiment of the present invention. Fig. 2 is a cross-sectional view taken along a line II-II in Fig. 1.

[0026] As shown in Fig. 1, an insulating film-attached punched workpiece 1 has a U-like shape in a plan view. As shown in Fig. 2, the insulating film-attached punched workpiece 1 includes a punched-workpiece 2, a plating layer 3 formed on the surfaces of the punched-workpiece 2, and an insulating film 4 formed on the surfaces of the plating layer 3.

[0027] The punched-workpiece 2 is produced by punching a metal sheet in a U-like shape. Therefore, in the punched-workpiece 2, a set of surfaces facing each other are regarded as cut surfaces 2a. In the cut surface 2a, a shear surface and a fracture surface are formed. The material of the punched-workpiece 2 is not particularly limited. The punched-workpiece 2 preferably contains a copper-based metal material, and the copper-based metal material is particularly preferably copper or a copper alloy.

[0028] The plating layer 3 has an action of uniforming the surface states of the surfaces of the punched-workpiece 2, particularly, the cut surfaces 2a. The material of the plating layer 3 is not particularly limited. Similar to the punched-workpiece 2, the plating layer 3 also preferably contains a copper-based metal material, and the plating layer 3 is particularly preferably made of a copper-based metal material. The copper-based metal material is copper or a copper alloy. Examples of the copper alloy are the same as those in the case of the punched-workpiece 2. The thickness of the plating layer 3 is preferably in a range of 1 μm or more and 100 μm or less and particularly preferably in a range of 3 μm or more and 21 μm or less.

[0029] As the material of the insulating film 4, it is possible to use materials that are generally used as materials for insulating films such as a polyamide-imide resin, a polyimide resin, a polyamide resin, a fluororesin, a polyester imide resin, a formalized polyvinyl alcohol resin, a polyvinyl alcohol resin, a polyester resin, and a polyurethane resin. The insulating film 4 preferably contains a polyamide-imide resin, a polyimide resin, a polyamide resin, or a fluororesin and is particularly preferably made of a polyamide-imide resin, a polyimide resin, a polyamide resin, a fluororesin, or a mixture thereof.

[0030] The thickness of the insulating film 4 is preferably in a range of 10 μm or more and 200 μm or less and preferably in a range of 30 μm or more and 100 μm or less.

[0031] The insulating film 4 is preferably an electrodeposition film. The electrodeposition film is a film formed by the electrodeposition method. The electrodeposition method will be described below.

[0032] Next, a method for producing the insulating film-attached punched workpiece 1 of the present embodiment will be described.

[0033] The method for producing the insulating film-attached punched workpiece 1 of the present embodiment can be produced by, for example, a method including the following steps.

(1) A plating step of forming the plating layer 3 on the surfaces of the punched-workpiece 2.

(2) A film-forming step of forming the insulating film 4 on the surfaces of the plating layer 3 of the punched-workpiece 2 on which the plating layer 3 has been formed.

[0034] The plating step is a step of forming the plating layer 3 on the surfaces of the punched-workpiece 2. In the present embodiment, the plating layer 3 is formed on all of the surfaces including the cut surfaces 2a of the punched-workpiece 2. A method for forming the plating layer 3 is not particularly limited, and any method of an electrolytic plating method or an electroless plating method can be used. For example, in the case of forming a copper plating layer, it is possible to use an electrolytic plating method in which a copper sulfate bath is used.

[0035] Before performing the plating step, it is preferable to remove an oil component and an oxide adhering to the surfaces of the punched-workpiece 2 by a surface treatment. For example, the oil component adhering to the surfaces of the punched-workpiece 2 can be removed by an immersion degreasing treatment and an electrolytic degreasing treatment. An oxide film adhering to the surfaces of the punched-workpiece 2 can be removed by an etching treatment with an acid.

[0036] The film-forming step is a step of forming the insulating film 4 on the surfaces of the plating layer 3 of the plating layer 3-attached punched-workpiece 2 manufactured in the plating step. The insulating film 4 is preferably formed by the electrodeposition method. The insulating film 4 is preferably formed by a method including the following steps. (3) A electrodeposition step of immersing the plating layer 3-attached punched-workpiece 2 and an electrode in an electrodeposition liquid containing charged insulating resin particles to apply a DC voltage between the punched-workpiece 2 and the electrode, thereby electrodepositing the insulating resin particles on the plating layer 3 of the punched-workpiece 2.

[0037] (4) A baking step of heating the punched-workpiece 2 to which the insulating resin particles have been elec-

trodeposited to bake the insulating resin particles to the punched-workpiece 2.

[0038] The electrodeposition liquid that is used in the electrodeposition step preferably contains charged insulating resin particles, an organic solvent, water, and a hydrophobic base. As the insulating resin particles, for example, polyamide-imide particles can be used. The particle diameters of the polyamide-imide particles are not particularly limited; however, for example, the median diameter is in a range of 50 nm or more and 500 nm or less. The content of the polyamide-imide particles in the electrodeposition liquid is not particularly limited, but is, for example, in a range of 1 mass% or more and 10 mass% or less and preferably in a range of 1.5 mass% or more and 5 mass% or less. The electrodeposition liquid may further contain fluororesin particles as the insulating resin particles. Examples of the fluororesin particles include polytetrafluoroethylene (PTFE), perfluoroalkoxy fluororesin (PFA) particles, and tetrafluoroethylene-hexafluoropropylene copolymer (FEP) particles. The content of the fluororesin particles in the electrodeposition liquid is not particularly limited, but is, for example, in a range of 0.5 mass% or more and 5 mass% or less with respect to the electrodeposition liquid and in a range of 20 mass% or more and 50 mass% or less with respect to the polyamide-imide particles.

[0039] As the organic solvent in the electrodeposition liquid, it is possible to use polar solvents such as N-methyl-2-pyrrolidone (NMP), N,N-dimethylformamide (DMF), N,N-dimethylacetamide (DMAc), 1,3 dimethylimidazolidinone, dimethyl sulfoxide (DMSO), and γ -butyrolactone (γ -BL). These solvents may be used singly or two or more solvents may be used in combination. In addition, the hydrophobic base preferably has an affinity to the organic solvent. Examples of the hydrophobic base include tri-n-propylamine, tri-n-butylamine, dibenzylamine, decylamine, octylamine, hexylamine, diethylamine, dihexylamine, dioctylamine triamylamine, trihexylamine, trioctylamine, tribenzylamine, aniline, and the like. These hydrophobic bases may be used singly or two or more hydrophobic bases may be used in combination. The content of the organic solvent with respect to the total amount of the organic solvent and water is, for example, in a range of 70 mass% or more and 87 mass% or less. The content of the hydrophobic base is, for example, in a range of 0.02 mass% or more and 0.1 mass% or less with respect to the electrodeposition liquid.

[0040] The electrodeposition liquid containing polyamide-imide particles can be obtained by, for example, adding water, which is a poor solvent of a polyamide-imide solution, to the polyamide-imide solution prepared by mixing a polyamide-imide, an organic solvent capable of dissolving the polyamide-imide, and a hydrophobic base. The polyamide-imide particles obtained as described above generally have negative charges.

[0041] In the electrodeposition step, a DC voltage is applied between the plating layer 3-attached punched-workpiece 2 and an electrode in a state where the plating layer 3-attached punched-workpiece 2 and the electrode are immersed in the electrodeposition liquid, thereby electrodepositing the insulating resin particles on the plating layer 3-attached punched-workpiece 2. The DC voltage that is applied is preferably in a range of 1 V or higher and 600 V or lower.

[0042] In the baking step, the punched-workpiece 2 on which the insulating resin particles have been electrodeposited is heated to bake the insulating resin particles to the punched-workpiece 2, thereby forming an electrodeposition film (insulating film 4). The heating temperature and time at the time of baking the insulating resin particles to the punched-workpiece 2 are not particularly limited as long as the insulating resin particles are cured to form the electrodeposition film. The heating temperature is, for example, in a range of 200°C or higher and 450°C or lower. The heating time is, for example, in a range of 5 minutes or longer and 60 minutes or shorter.

[0043] Before the baking step, it is preferable to remove the electrodeposition liquid adhering to the punched-workpiece 2. As a method for removing the electrodeposition liquid, it is possible to use a method in which a compressed air is blown to the punched-workpiece 2 to blow off the electrodeposition liquid and a method in which the punched-workpiece 2 is heated at a temperature lower than a temperature at which the electrodeposition film is formed to volatilize the electrodeposition liquid.

[0044] According to the insulating film-attached punched workpiece 1 of the present embodiment configured as described above, the punched-workpiece 2 has the plating layer 3 formed on the surfaces including the cut surfaces 2a, and the surface state of the punched-workpiece 2 becomes uniform, and thus the adhesion between the punched-workpiece 2 and the insulating film 4 improves. Therefore, the insulating film-attached punched workpiece 1 of the present embodiment is capable of suppressing the generation of a pinholes attributed to the partial peeling of the insulating film 4 and increasing the breakdown voltage.

[0045] In addition, in the insulating film-attached punched workpiece 1 of the present embodiment, in a case where the insulating film 4 is an electrodeposition film, the insulating film can be formed by the electrodeposition method, and thus it is possible to form the insulating film on the surfaces of the punched-workpiece in a uniform film thickness regardless of the shape of the punched-workpiece.

[0046] In addition, in the insulating film-attached punched workpiece 1 of the present embodiment, in a case where the punched-workpiece 2 contains a copper-based metal material and the plating layer 3 contains a copper-based metal material, the punched-workpiece 2 itself has high conductivity and is thus useful as an electronic component such as a terminal member of a bus bar or a wire harness or a motor component such as a coil. In addition, since the punched-workpiece 2 and the plating layer 3 contain a copper-based metal material, adhesion between the punched-workpiece 2 and the plating layer 3 improves. This further enhances adhesion between the punched-workpiece 2, the plating layer

3, and the insulating film 4, and thus the generation of a pinhole attributed to the partial peeling of the insulating film 4 can be suppressed more reliably, and the breakdown voltage of the insulating film-attached punched workpiece 1 becomes higher.

[0047] In addition, in the insulating film-attached punched workpiece 1 of the present embodiment, in a case where the thickness of the plating layer 3 is 1 μm or more, the uniformity of the surface state of the punched-workpiece 2 is more reliably enhanced. On the other hand, in a case where the thickness of the plating layer 3 is 100 μm or less, the variation in the thickness of the plating layer 3 is small and has a small influence on the dimensions of the punched-workpiece. Therefore, it becomes difficult for the variation in the thickness of the plating layer to affect the function when the insulating film-attached punched workpiece 1 is used in, for example, a terminal member of a bus bar or a wire harness, a coil, or the like.

[0048] According to the method for producing an insulating film-attached punched workpiece of the present embodiment, since the plating step is performed before the film-forming step, it is possible to form the insulating film in a state where the surfaces of the punched-workpiece are uniform. Therefore, in an insulating film-attached punched workpiece obtained by the production method of the present embodiment, adhesion between the punched-workpiece and the insulating film improves, the generation of a pinholes attributed to the partial peeling of the insulating film 4 can be suppressed, and the breakdown voltage becomes high.

[0049] In addition, in the method for producing an insulating film-attached punched workpiece of the present embodiment, in a case where the film-forming step is performed by the electrodeposition method, the insulating resin particles are electrodeposited, and thus it is possible to stably coat the insulating film-attached punched workpiece regardless of the shape of the punched-workpiece.

[0050] Hitherto, the embodiment of the present invention has been described, but the present invention is not limited thereto and can be appropriately modified within the scope of the technical concept of the invention.

[0051] For example, in the present embodiment, the plating layer 3 is formed on all of the surfaces of the punched-workpiece 2, but the place where the plating layer 3 is formed is not limited thereto. The plating layer 3 needs to be formed at least on the cut surfaces 2a of the punched-workpiece 2.

[0052] In addition, in the present embodiment, the electrodeposition method is used as the method for forming the insulating film, but the method for forming the insulating film is not limited thereto. As the method for forming the insulating film, for example, a coating method may also be used. The coating method is a method in which a coating liquid in which an insulating resin material has been dissolved is applied to a plating layer-attached punched-workpiece to form a coating film, next, the coating film is dried, and then the obtained dried film is heated to be baked to the punched-workpiece, thereby forming an insulating film. As a method for applying the coating liquid to the plating layer-attached punched-workpiece, a spin coating method, a bar coating method, a knife coating method, a roll coating method, a blade coating method, a die coating method, a gravure coating method, a dip coating method, or the like can be used.

[Examples]

[Present Invention Example 1]

(1) Manufacturing step of punched copper sheet

[0053] Fig. 3 is a plan view of a copper substrate that was used in Present Invention Example 1. A copper substrate 10 is a pure copper sheet having a thickness of 2 mm and a purity of 99.90 mass%. This copper substrate 10 was punched in a U-like shape to obtain a punched copper sheet 11. A photograph of a cross section of a recessed portion 12 of the obtained punched copper sheet 11 is shown in Fig. 4. From the photograph of Fig. 4, it is found that, in the cut surface of the punched copper sheet 11, a shear surface and a fracture surface were formed and the fracture surface had unevenness.

(2) Degreasing treatment step of punched copper sheet

[0054] A degreasing treatment by which an oil component adhering to the surfaces of the punched copper sheet was removed by the following immersion degreasing treatment and electrolytic degreasing treatment was performed.

[0055] In the immersion degreasing treatment, the obtained punched copper sheet was immersed in a degreasing agent adjusted to a liquid temperature of 30°C for 1 minute and then washed with water.

[0056] In the electrolytic degreasing treatment, an electrolytic degreasing agent (MAXCLEEN BG-3200, Kizai Corporation) was injected into an electrolytic cell including an electrode, the liquid temperature of the electrolytic degreasing agent was adjusted to 50°C, and then the punched copper sheet was immersed in the electrolytic degreasing agent. Next, a current was passed between the electrode (anode) of the electrolytic cell and the punched copper sheet (cathode) at a current density of 6 A/dm² for 1 minute to degrease the punched copper sheet, and then the punched copper sheet

was washed with water.

(3) Copper plating pretreatment step of punched copper sheet

[0057] The punched copper sheet was immersed in a sulfuric acid aqueous solution having a concentration of 50 g/L for 10 seconds and then washed with water.

[0058] Next, the punched copper sheet was immersed in an acid etching liquid (hydrogen peroxide concentration: 10 g/L, sulfuric acid concentration: 100 g/L) for 30 seconds and then immersed in a sulfuric acid aqueous solution having a concentration of 50 g/L for 10 seconds. After that, the punched copper sheet was washed with water. A pretreatment of the punched copper sheet was performed as described above.

(4) Manufacturing step of copper plating layer-attached punched copper sheet

[0059] A plating liquid was injected into an electrolytic plating tank, the liquid temperature was adjusted to 45°C, and then the punched copper sheet on which the pretreatment of the (3) had been performed was immersed in the plating liquid. As the plating liquid, an aqueous solution having a copper sulfate pentahydrate concentration of 250 g/L and a sulfuric acid concentration of 55 g/L was used. Next, an electrolytic copper plating treatment was performed for 5 minutes under a condition of a current density of 5 A/dm². After that, the punched copper sheet was washed with water to obtain a copper plating layer-attached punched copper sheet. The thickness of the copper plating layer of the obtained copper plating layer-attached punched copper sheet was measured using a micrometer and found to be 4 μm.

(5) Preparation step of electrodeposition liquid

[0060] Polyimide-amide (PAI) was dissolved in N-methyl-2-pyrrolidone (NMP) to prepare PAI varnish (PALNMP = 20 mass%:80 mass%). NMP, tri-n-propylamine, and water were added to the obtained PAI varnish to precipitate PAI particles, thereby preparing a PAI particle dispersion containing 0.5 mass% of the PAI particles, 76.0 mass% of NMP, 18.8 mass% of water and 0.2 mass% of tri-n-propylamine in terms of proportions.

[0061] In addition, a commercially available polytetrafluoroethylene resin (PTFE) dispersion was diluted with water, then, stirred and mixed to obtain a PTFE particle dispersion containing 30 mass% of PTFE particles.

[0062] The PAI particle dispersion, the PTFE particle dispersion, NMP, water, and tri-n-propylamine were mixed to prepare an electrodeposition liquid containing 4.3 mass% of the PAI particles, 4.3 mass% of PTFE particles, 65 mass% of NMP, 26.2 mass% of water, and 0.2 mass% of tri-n-propylamine in terms of proportions.

(6) Film-forming step of electrodeposition film (insulating film)

[0063] The electrodeposition liquid prepared in the (5) was injected into an electrodeposition tank, and the copper plating layer-attached punched copper sheet manufactured in the (4) and an electrode were immersed in the electrodeposition liquid. The copper plating layer-attached punched copper sheet was immersed in an oxide film-removing agent for 1 minute in advance to remove an oxide film on the copper plating layer and then washed with water.

[0064] Next, a DC voltage of 500 V was applied for 40 seconds using the copper plating layer-attached punched copper sheet as a positive electrode and the electrode as a negative electrode to electrodeposit the insulating resin particles (the PAI particles and the PTFE particles) to the surface of the copper plating layer-attached punched copper sheet.

[0065] Next, the punched copper sheet to which the insulating resin particles had been electrodeposited was taken out from the electrodeposition liquid, heated at 300°C for 5 minutes, and dried. After that, the dried punched copper sheet was heated at 330°C for 7 minutes, and the insulating resin particles were baked to the punched copper sheet to form an electrodeposition film (insulating film). The thickness of the insulating film of the obtained insulating film-attached punched copper sheet was measured using the micrometer and found to be 78 μm.

[Present Invention Example 2]

[0066] An insulating film-attached punched copper sheet was manufactured in the same manner as in Present Invention Example 1 except that, in the manufacturing step of the copper plating layer-attached punched copper sheet (4) in Present Invention Example 1, the time of the electrolytic copper plating treatment was set to 15 minutes and the thickness of the copper plating layer was set to 11 μm. The thickness of the insulating film of the obtained insulating film-attached punched copper sheet was 76 μm.

[Comparative Example 1]

[0067] An insulating film-attached punched copper sheet was manufactured in the same manner as in Present Invention Example 1 except that, in the degreasing treatment step of the punched copper sheet (2) in Present Invention Example 1, the oil component adhering to the surface was removed by the immersion degreasing treatment and the electrolytic degreasing treatment, and then the film-forming step of the electrodeposition film (6) was performed without performing the steps (3) and (4). The thickness of the insulating film of the obtained insulating film-attached punched copper sheet was 81 μm .

[Comparative Examples 2 to 4]

[0068] Insulating film-attached punched copper sheets were manufactured in the same manner as in Present Invention Example 1 except that the film-forming step of the electrodeposition film (6) was performed without performing the steps (2) to (4) in Present Invention Example 1. The thicknesses of the insulating films of the obtained insulating film-attached punched copper sheets were 79 μm (Comparative Example 2), 81 μm (Comparative Example 3), and 82 μm (Comparative Example 4).

[Evaluation]

[0069] The insulating film-attached punched copper sheets obtained in Present Invention Examples 1 and 2 and Comparative Examples 1 to 4 were immersed in a glycerin solution, and the breakdown voltages were measured using a breakdown tester (YHT-20K-05KMR, manufactured by YAMABISHI Corporation). The results are shown in Table 1 below.

[Table 1]

	Surface treatment	Thickness of insulating film (μm)	Breakdown voltage (KV)
Present Invention Example 1	Copper plating (thickness of plating layer: 4 μm)	78	5.00
Present Invention Example 2	Copper plating (thickness of plating layer: 11 μm)	76	4.62
Comparative Example 1	Immersion degreasing treatment + electrolytic degreasing treatment	81	3.08
Comparative Example 2	None	79	0.28
Comparative Example 3	None	81	0.84
Comparative Example 4	None	82	0.92

[0070] It is found that, in the insulating film-attached punched copper sheets of Present Invention Examples 1 and 2 in which the copper plating treatment was performed on the surface of the punched copper sheet, the breakdown voltages were significantly high values compared with those of the insulating film-attached punched copper sheets of Comparative Examples 1 to 4 in which no plating layer was formed on the surface of the punched copper sheet. This is because the plating layer formed on the surface of the punched copper sheet made the surface state of the punched copper sheet uniform and improved the adhesion between the punched copper sheet and the insulating film.

Reference Signs List

[0071]

- 1: Punched-workpiece with the insulating film
- 2: Punched-workpiece
- 2a: Cut surface
- 3: Plating layer
- 4: Insulating film
- 10: Copper substrate

11: Punched copper sheet

12: Recessed portion

5 **Claims**

1. An insulating film-attached punched workpiece comprising:

10 a punched-workpiece having a cut surface;
a plating layer formed on at least the cut surface of the punched-workpiece; and
an insulating film formed on a surface of the punched-workpiece having the plating layer.

15 2. The insulating film-attached punched workpiece according to Claim 1,
wherein the insulating film is an electrodeposition film.

3. The insulating film-attached punched workpiece according to Claim 1 or 2,
wherein the punched-workpiece contains a copper-based metal material, and the plating layer contains a copper-
based metal material.

20 4. The insulating film-attached punched workpiece according to any one of Claims 1 to 3,
wherein a thickness of the plating layer is in a range of 1 μm or more and 100 μm or less.

5. A method for producing an insulating film-attached punched workpiece, comprising:

25 a plating step of forming a plating layer on at least a cut surface of a punched-workpiece having the cut surface;
and
a film-forming step of forming an insulating film on a surface of the plating layer of the punched-workpiece on
which the plating layer is formed.

30 6. The method for producing an insulating film-attached punched workpiece according to Claim 5:

35 wherein the film-forming step includes a step of immersing the punched-workpiece having the plating layer and
an electrode in an electrodeposition liquid containing charged insulating resin particles to apply a DC voltage
between the punched-workpiece and the electrode, thereby electrodepositing the insulating resin particles on
a surface of the punched-workpiece having the plating layer, and
a step of heating the punched-workpiece to which the insulating resin particles have been electrodeposited to
bake the insulating resin particles to the punched-workpiece.

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FIG. 1

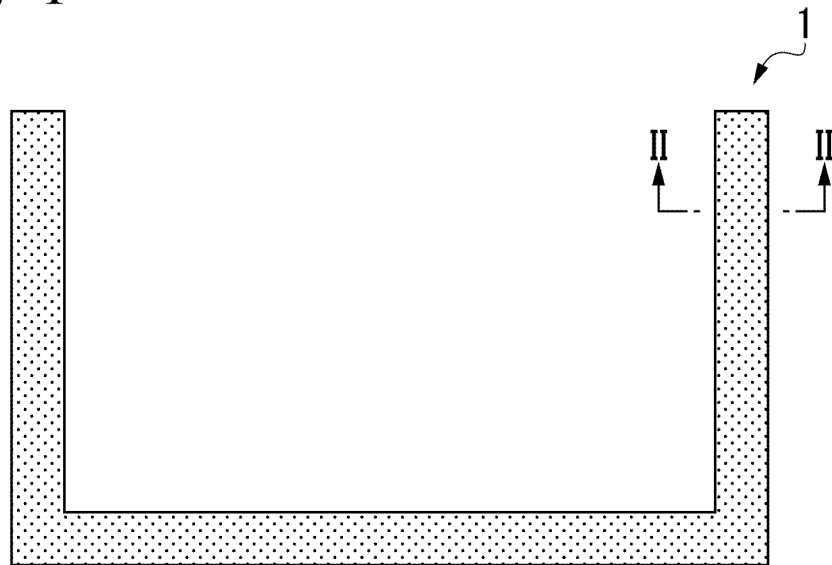


FIG. 2

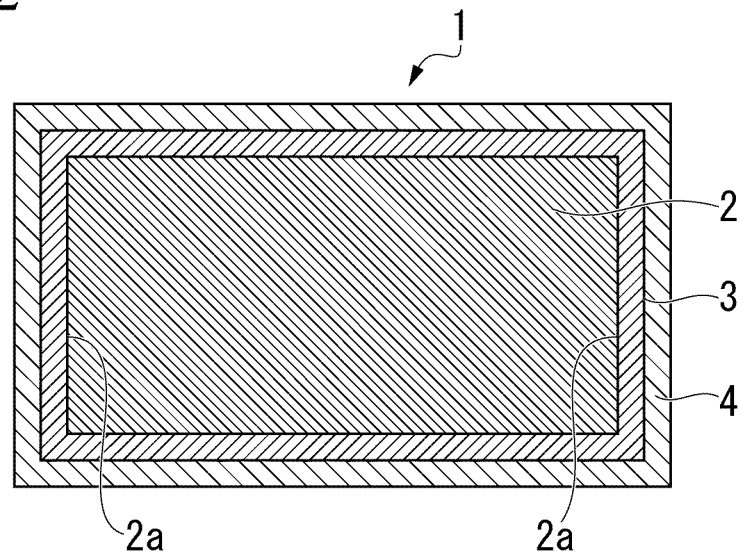


FIG. 3

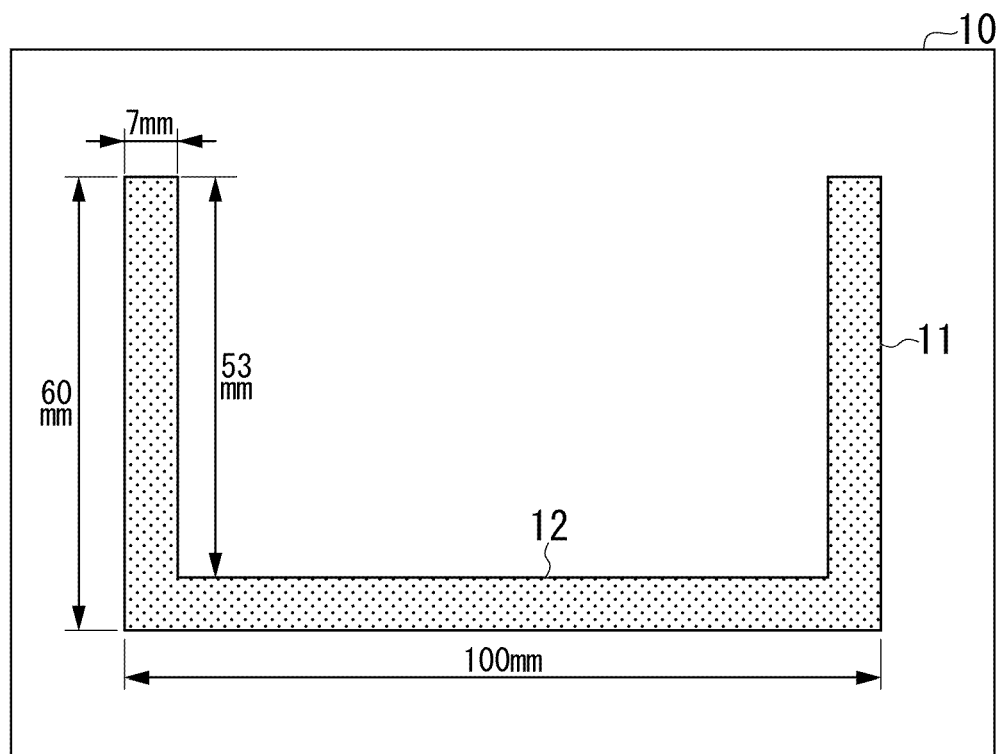
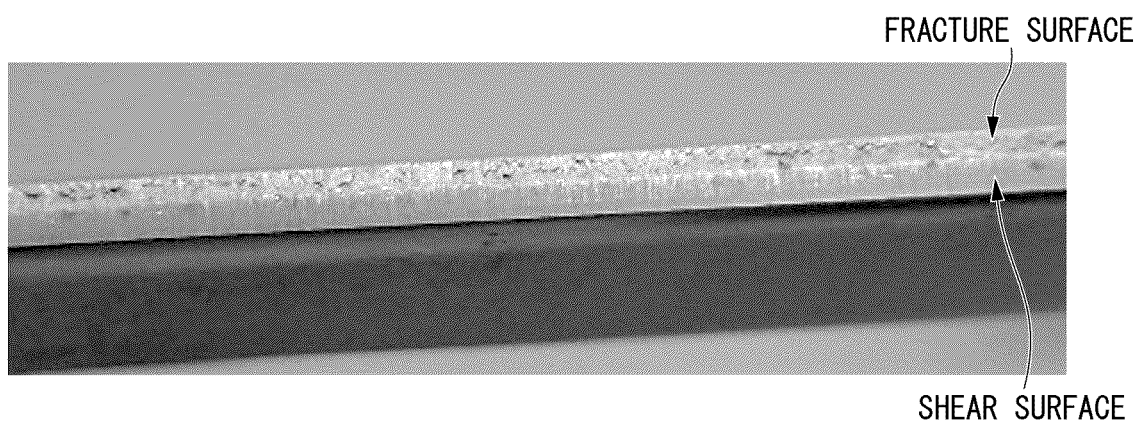


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/006755

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. C25D13/00 (2006.01) i, C25D13/04 (2006.01) i, C25D13/12 (2006.01) i

FI: C25D13/04, C25D13/00 307D, C25D13/12 A

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)

Int. Cl. C25D13/00, C25D13/04, C25D13/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2021

Registered utility model specifications of Japan 1996-2021

Published registered utility model applications of Japan 1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/157457 A1 (THE FURUKAWA ELECTRIC CO., LTD.) 30 December 2009, example 4, paragraphs [0010], [0011], [0023], [0027]-[0029]	1, 3-4
Y		2
A		5-6
Y	JP 2014-173110 A (MITSUBISHI MATERIALS CORP.) 22 September 2014, paragraphs [0005], [0006]	2
A	JP 2002-280685 A (CANON INC.) 27 September 2002, entire text	1-6
A	JP 2010-62406 A (PANASONIC CORP.) 18 March 2010, entire text	1-6



Further documents are listed in the continuation of Box C.



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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

21.04.2021

Date of mailing of the international search report

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Name and mailing address of the ISA/

Japan Patent Office

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Tokyo 100-8915, Japan

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Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/006755

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
WO 2009/157457 A1	30.12.2009	US 2011/0091739 A1 example 4, paragraphs [0009]-[0014], [0039], [0046]-[0048] EP 2302105 A1 KR 10-2011-0028362 A CN 102076889 A TW 201005125 A	
JP 2014-173110 A	22.09.2014	(Family: none)	
JP 2002-280685 A	27.09.2002	(Family: none)	
JP 2010-62406 A	18.03.2010	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2020048868 A [0002]
- JP 2011113816 A [0004]
- JP 2018200848 A [0004]