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The document is designated as:

- #98029_2._Choi_(WO2015102323A1)

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August 5, 2024

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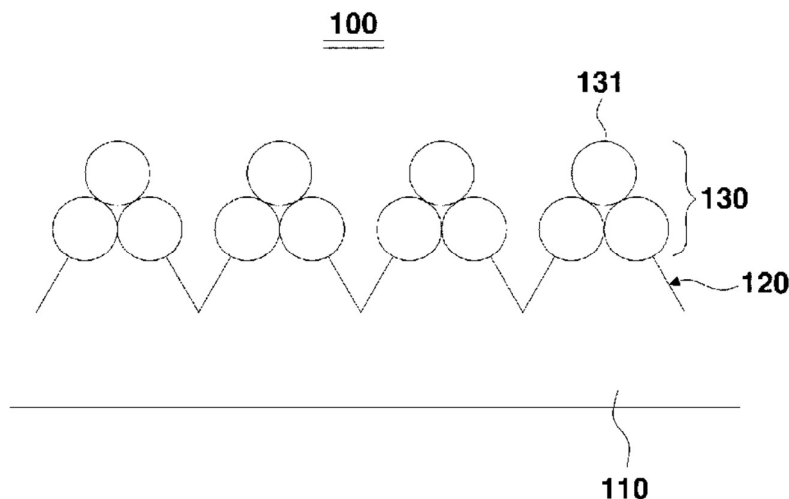
(43) Date of International
Disclosure
July 9, 2015 (09.07.2015)

(10) International Disclosure No.
WO 2015/102323 A1

- (51) **International Patent Classification:**
H05K 1/03 (January 2006) *H05K 1/09 (January 2006)*
- (21) **International Application No.:** PCT/KR2014/012942
- (22) **International Application Date:** December 26, 2014 (12.26.2014)
- (25) **Application Language:** Korean
- (26) **Disclosed Language:** Korean
- (30) **Priority Information:**
10-2013-0166916 December 30, 2013 (30.12.2013) KR
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- (81) **Designated States** (for the protection of all possible domestic rights, unless otherwise indicated): 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, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, 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 the protection of all possible intra-regional rights): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasia (AM, AZ, BY, KG, KZ, RU, TJ, TM), Europe (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).
- Disclosure:**
- Together with the international search report (Article 21(3) of the Treaty)
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(54) **Title:** COPPER FOIL, AND ELECTRICAL COMPONENT AND BATTERY INCLUDING SAME

(54) **Name of Invention:** Copper foil, and electrical components and batteries including the same



(57) **Abstract:** Provided is copper foil having low roughness and excellent adhesive strength. The provided copper foil is a copper foil having an uneven portion formed on at least one surface thereof and a fine particle layer formed on the surface thereof, wherein the number of upper fine particles located above a mean line according to the mean height of the surface is greater than the number of lower fine particles located below the mean line.

(57) **Summary:** A copper foil having low roughness and excellent adhesive strength is proposed. The proposed copper foil is a copper foil having irregularities formed on at least one surface and a layer of fine particles formed on the surface, wherein the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.

Specification

Name of Invention: Copper foil, and electrical components and batteries including the same

Technology Field

- [1] The present invention relates to copper foil, electrical components and batteries containing copper foil, and more specifically, to copper foil with low roughness and excellent adhesive strength.

Background Technology

- [2] Laminated plates for printed circuit boards used in the electronics industry are manufactured by impregnating glass cloth, kraft paper, fiberglass non-woven cloth, etc. with thermosetting resins such as phenolic resins and epoxy resins, preparing prepregs by semi-curing the resins, and laminating copper foil on one or both sides of the prepregs. In addition, multilayer printed circuit boards are manufactured by forming circuits on both sides of a copper-clad laminate to form an inner layer material, and then laminating copper foil on both sides of the inner layer material using prepregs.
- [3] When laminating copper foil on one or both sides of a prepreg, the adhesion rate may be insufficient due to differences in the materials, causing the copper foil to separate from the prepreg during subsequent processing, resulting in a defective product. Therefore, a surface treatment is performed on the copper foil to increase its adhesion to resins such as prepregs.
- [4] The copper foil used in the manufacture of printed circuit boards is roughened to form irregularities by attaching fine copper particles to one surface. When bonding with a resin such as prepreg, the irregularities of the roughened copper foil are embedded in the base resin to provide an anchoring effect, thereby improving the adhesion of the copper foil to the base resin.
- [5] In recent years, due to the influence of lightweight miniaturization and high functionalization of electronic devices embedded in printed circuit boards, the requirement for wiring density of printed circuit boards has been increasing year by year. Improvement of product quality has been required, so the shape of the circuit formed by etching has also become more advanced, and a circuit etching factor at a level that can completely perform impedance control has become required.
- [6] When the surface treatment of the copper foil is performed as described above, the surface roughness of the copper foil increases and the adhesion between the copper foil and the base resin improves, but the etching property for fine circuits may be lowered. Therefore, there is a need to develop a technology that can improve adhesion while maintaining the surface roughness of copper foil in consideration of etching properties.

Detailed Description of the Invention

Technical Tasks

- [7] The present invention was devised to solve the above problems, and the purpose of the present invention is to provide copper foil with low roughness and excellent adhesive strength.

Means to Resolve Task

- [8] The copper foil according to one aspect of the present invention to achieve the above object is a copper foil having an irregularity formed on at least one surface and a layer of fine particles formed on the surface, wherein the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.
- [9] The ratio of the number of upper fine particles and the number of lower fine particles may be 80:20 to 100:0.
- [10] The upper fine particles may form a triangle by connecting the center points.
- [11] The diameter of the fine particles may be 1 to 3 μm .
- [12] The fine particles may be metal particles or copper alloy particles containing at least one metal from copper (Cu), iron (Fe), molybdenum (Mo), and cobalt (Co).
- [13] The peel strength of the copper foil may be 1.28 to 1.33 kgf/cm, the surface roughness R_z may be 5.2 to 6.5 μm , and the surface roughness R_{max} may be 6.5 to 7.7 μm .
- [14] According to another aspect of the present invention, an insulating substrate; and an electrical component including the above copper foil attached to one surface of an insulating substrate is proposed.
- [15] According to another aspect of the present invention, a battery including the above copper foil is provided.
- [16] According to another aspect of the present invention, a surface treatment method of copper foil is provided, including preparing a copper foil with irregularities formed on at least one surface; and forming a fine particle layer on the surface where the irregularities are formed so that the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.
- [17] The step of forming a fine particle layer is performed by immersing the copper foil in a surface treatment solution comprising copper sulfate; sulfuric acid; and metals including iron (Fe), molybdenum (Mo), and cobalt (Co); and electrolyzing to form a fine particle layer on the irregular surface.
- [18] The iron content may be 10 to 30 g, the molybdenum content may be 0.5 to 10 g, and the cobalt content may be 1 to 15 g. The electroplating process to form a fine particle layer may be performed at 20 to 60 A/dm² for 1 to 5 seconds.

Effectiveness of Invention

- [19] The copper foil according to the present invention has low roughness and excellent adhesive strength. Therefore, while etching properties for forming fine circuit boards are guaranteed, adhesive strength is excellent and adhesion to resin, etc. is improved, which has the effect of improving product reliability when manufacturing products using copper foil.

Brief Description of the Figures

- [20] FIG. 1 is a diagram showing the surface of copper foil according to one embodiment of the present invention.
- [21] FIG. 2 is a diagram showing the surface of the copper foil in FIG. 1 excluding fine particles.
- [22] FIG. 3 is a diagram showing a portion of the copper foil surface in FIG. 1.
- [23] FIG. 4 is a scanning electron microscopy (SEM) image of the surface of the copper foil surface-treated in Example 1.

- [24] FIG. 5 is an SEM image of the surface of the copper foil of Example 2.
- [25] FIG. 6 is an SEM image of the surface of the copper foil of Example 3.
- [26] FIG. 7 is an SEM image of the surface of the copper foil of Example 4.
- [27] FIG. 8 is an SEM image of the surface of the copper foil of Comparative Example 1.
- [28] FIG. 9 is an SEM image of the surface of the copper foil of Comparative Example 2.
- [29] FIG. 10 is an SEM image of the surface of the copper foil of Comparative Example 3.

Best Forms for the Implementation of the Invention

- [30] The copper foil according to one aspect of the present invention is a copper foil having irregularities formed on at least one surface and a layer of fine particles formed on the surface, wherein the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.

Forms for Embodiment of the Invention

- [31] The following will describe in more detail copper foil, electrical components and cells comprising copper foil, and methods of surface treatment of copper foil, in accordance with the preferred embodiments.
- [32] FIG. 1 is a diagram showing the surface of the copper foil according to one embodiment of the present invention, FIG. 2 is a diagram showing the surface of the copper foil excluding fine particles in FIG. 1, and FIG. 3 is a diagram showing a part of the copper foil surface in FIG. 1. The copper foil according to this embodiment is a copper foil having irregularities formed on at least one surface and a layer of fine particles formed on the surface, wherein the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.
- [33] The copper foil according to the present invention has irregularities formed on its surface. The process of manufacturing copper foil is generally divided into a foil manufacturing process, that is, a process of manufacturing the copper foil itself, and a process of treating the surface of the manufactured copper foil. Copper foil manufactured according to the foil manufacturing process has a surface roughness of different values depending on the process. In other words, at high illumination, the surface contains large irregularities, and at low illumination, the surface contains small irregularities.
- [34] The surface containing these irregularities is subjected to various surface treatments as needed to give it the properties required for subsequent processes. For example, when used in FPCB or as a negative electrode current collector for secondary batteries, in order to increase adhesion to resins or active materials, the roughness can be increased by roughening the surface, or it can be treated as a barrier to prevent diffusion of copper particles to other layers, and surface treatment to strengthen adhesion can be performed through rust prevention treatment to prevent surface oxidation, or surface treatment using a silane coupling agent on the outermost surface.
- [35] Among these, in order to increase the adhesion between the copper foil and the resin or active material, roughening treatment is performed to increase the surface roughness, and the roughening treatment can form a fine particle layer on the surface of the copper foil that will be in contact with the resin or active material.
- [36] Referring to FIG. 1, the copper foil (100) has irregularities (120) formed on the surface of the copper foil layer (110), and fine particles (131) form the fine particle layer (130) on the

irregularities (120). Referring together to FIG. 2, fine particles can be classified based on the mean line (m) according to the mean height of the irregularities (220) of the copper foil (210). In other words, the fine particles located above the mean line (m) can be called upper fine particles, and the fine particles located below the mean line (m) can be called lower fine particles.

- [37] The copper foil (100) according to the present invention has more upper fine particles than lower fine particles. The upper fine particles are located in the ridge part of the irregularities (120), and the lower fine particles are fine particles located in the valley part of the irregularities (120). When the upper fine particles are more than the lower fine particles or there are no lower fine particles, such as the copper foil (100) of the present invention, there are few or no fine particles in the valley of the irregularities (120). Thus, an empty space is created in the valley portion of the irregularities (120), and the porosity increases. For example, when the copper foil (100) is in contact with a resin or an active material in such an empty space, the resin or the active material fills the empty space, thereby improving adhesion.
- [38] The reason for roughening the surface of the copper foil is that the surface of the copper foil, which has become more irregular due to the roughening treatment, is embedded in the resin and provides an anchor effect to improve adhesion. However, in the case of the copper foil according to the present invention, in addition to this, less fine particles are generated in the valleys between the ridges of the irregularities to form empty spaces, and the resin filled in the empty spaces by forming fine particles on top of the empty spaces provides an anchor effect to improve adhesion.
- [39] For this purpose, it is desirable to secure the maximum porosity by placing fine particles above the mean line (m) of the copper foil (210) and placing less fine particles in the lower part. For example, the ratio of the number of upper fine particles and the number of lower fine particles may be 80:20 to 100:0.
- [40] Additionally, in order to maximize the anchor effect, the upper fine particles may form a triangle by connecting the center points. Referring to FIG. 3, three upper portions (331, 332, and 333) are located on the irregularities (320), and the central shape (340) connecting their center points (P1, P2, and P3) is a triangle.
- [41] The diameter of the fine particles may be 1 to 3 μm . If the diameter of the fine particles is too small, they may penetrate into the valleys of the irregularities and increase the proportion of lower fine particles, while if the diameter of the fine particles is too large, the overall irregularities become large, increasing the surface roughness of the copper foil, which is disadvantageous to etching properties.
- [42] The fine particles may be metal particles or copper alloy particles containing at least one metal from copper (Cu), iron (Fe), molybdenum (Mo), and cobalt (Co).
- [43] The peel strength of the copper foil may be 1.28 to 1.33 kgf/cm, the surface roughness R_z may be 5.2 to 6.5 μm , and the surface roughness R_{max} may be 6.5 to 7.7 μm . The copper foil according to the present invention has fine particles formed in the irregular portions biased toward the peak portions, which improves adhesion with low surface roughness and high peel strength.
- [44] According to another aspect of the present invention, an insulating substrate; and an electrical component including the copper foil attached to one surface of an insulating substrate is proposed. Copper foil included in electrical components includes a circuit formed by etching the copper foil.

- [45] Such electrical components include, for example, but are not necessarily limited to, TAB tape, printed circuit boards (PCBs), and flexible printed circuit boards (FPC, Flexible PCB), as long as the copper foil is attached to an insulating substrate and can be used in the technology.
- [46] According to another aspect of the present invention, a battery including the aforementioned copper foil is provided. Copper foil can be used as the entire negative electrode collector of a battery, but is not necessarily limited to this, and can also be used as other components used in batteries. The battery is not particularly limited and includes both primary and secondary batteries, and any battery that uses copper foil as a current collector, such as a lithium ion battery, a lithium polymer battery, or a lithium air battery, can be used as long as it can be used in the relevant technical field.
- [47] According to another aspect of the present invention, a surface treatment method of copper foil is provided, including preparing a copper foil with irregularities formed on at least one surface; and forming a fine particle layer on the surface where the irregularities are formed so that the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.
- [48] In the surface treatment method of copper foil according to the present invention, a fine particle layer is formed by immersing the copper foil in a surface treatment solution comprising copper sulfate; sulfuric acid; and metals including iron (Fe), molybdenum (Mo), and cobalt (Co); and electrolyzing to form a fine particle layer on the irregular surface.
- [49] The surface treatment solution contains 10 to 30 g of iron, 0.5 to 10 g of molybdenum, and 1 to 15 g of cobalt. If the concentration of metal contained in the surface treatment solution is too small, the copper alloy is not sufficiently formed, making it difficult to control the ratio of upper and lower fine particles, but if the concentration of metal is too high, too many fine particles are formed and the surface roughness increases, which may be disadvantageous in terms of etching properties.
- [50] The electrolytic plating process to form the fine particle layer may be performed at 20 to 60 A/dm² for 1 to 5 seconds.
- [51] The copper foil according to the present invention may be additionally surface treated. For example, the type of surface treatment to be performed, such as heat resistance and chemical resistance treatment, chromate treatment, silane coupling treatment, or a combination thereof, can be appropriately selected depending on the subsequent process.
- [52] For heat and chemical resistance treatment, for example, it can be performed by forming a thin film of any one of metals such as nickel, tin, zinc, chromium, molybdenum, and cobalt, or an alloy thereof, on a metal foil by sputtering, electroplating, or electroless plating. In terms of cost, electroplating is preferable. To facilitate precipitation of metal ions, complexing agents such as citrate, tartrate, and sulfamic acid may be added in the required amount.
- [53] For chromate treatment, an aqueous solution containing hexavalent to trivalent chromium ions is used. Chromate treatment can be performed by simple immersion treatment, but is preferably performed by cathode treatment. It is preferably carried out under the following conditions: sodium dichromate 0.1 to 70 g/L, pH 1 to 13, temperature 15 to 60°C, current

density 0.1 to 5 A/dm², and electrolysis time 0.1 to 100 seconds. This may also be done using chromic acid or potassium dichromate instead of sodium dichromate. In addition to this, it is preferable that the chromate treatment is performed on top of the rust prevention treatment, whereby moisture resistance and heat resistance can be further improved.

- [54] As for silane coupling agents used in silane coupling treatment, for example, epoxy functional silanes such as 3-glycidoxypentyltrimethoxysilane and 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, amino functional silanes such as 3-aminopentyltrimethoxysilane, N-2-(aminoethyl)-3-aminopentyltrimethoxysilane, and N-2-(aminoethyl)-3-aminopentylmethyldimethoxysilane, olefin functional silanes such as vinyltrimethoxysilane, vinylphenyltrimethoxysilane, and vinyltris (2-methoxyethoxy)silane, acrylic functional silanes such as 3-acryloxypentyl trimethoxysilane, methacryl functional silanes such as 3-methacryloxypentyl trimethoxysilane, and mercapto-functional silanes such as 3-mercaptopentyltri methoxy silane, etc. are used. These may be used individually, or multiple of them may be mixed and used.
- [55] Such coupling agents are dissolved in a solvent such as water at a concentration of 0.1 to 15 g/L and applied to metal foil at a temperature of room temperature to 70°C, or adsorbed by electrodeposition. These silane coupling agents form a film by condensation bonding with the hydroxyl group of the rust-preventing metal on the surface of the metal foil. After silane coupling treatment, a stable bond is formed by heating, ultraviolet irradiation, etc. Heating and drying is performed at a temperature of 100 to 200°C for 2 to 60 seconds. Ultraviolet irradiation is performed in the range of 200 to 400 nm and 200 to 2500 mJ/cm². In addition to this, the silane coupling treatment is preferably performed on the outermost layer of the copper foil, thereby further improving moisture resistance and adhesion between the insulating resin composition layer and the metal foil.
- [56]
- [57] The present invention will be described in more detail below with reference to preferred embodiments, but the present invention is not limited thereto.
- [58] (Manufacturing of copper foil)
- [59] To manufacture copper foil by electrolysis, a 3L capacity electrolyzer system capable of circulating at 20L/min was used, and the temperature of the copper electrolyte solution was kept constant at 45°C. The anode used was a DSE (Dimensionally Stable Electrode) plate with a thickness of 5 mm and a size of 10 x 10 cm², and a titanium electrode plate with the same size and thickness as the anode was used as the cathode.
- [60] To facilitate the movement of Cu²⁺ ions, plating was performed at a current density of 35A/dm², and copper foil with a thickness of 18μm was manufactured.
- [61]
- [62] * The basic composition of copper electrolyte is as follows:
- [63] CuSO₄·5H₂O: 250 to 400 g/L

- [64] H_2SO_4 : 80 to 150 g/L
- [65] Chlorine ions and additives were added to the copper electrolyte solution.
- [66]
- [67] (Example 1)
- [68] The manufactured copper foil was electrolyzed for 1 to 5 seconds at a current density of 35 A/dm² using the following copper electrolyte solution to form a fine particle layer. A scanning electron microscopy (SEM) image of the surface of the copper foil on which the fine particle layer was formed according to Example 1 is shown in FIG. 4.
- [69] $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$: 85 g/L
- [70] H_2SO_4 : 125 g/L
- [71] Fe: 19 g/L
- [72] Mo: 1.1 g/L
- [73] Co: 8 g/L
- [74]
- [75] (Example 2)
- [76] Except for the details below, electroplating was performed on the surface of the copper foil in the same manner as in Example 1 to form a fine particle layer. An SEM image of the surface of the copper foil with the fine particle layer is shown in FIG. 5.
- [77] $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$: 85 g/L
- [78] H_2SO_4 : 125 g/L
- [79] Fe: 25 g/L
- [80] Mo: 1.1 g/L
- [81] Co: 8 g/L
- [82]
- [83] (Example 3)
- [84] Except for the details below, electroplating was performed on the surface of the copper foil in the same manner as in Example 1 to form a fine particle layer. An SEM image of the surface of the copper foil with the fine particle layer is shown in FIG. 6.
- [85] $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$: 85 g/L
- [86] H_2SO_4 : 125 g/L
- [87] Fe: 19 g/L
- [88] Mo: 0.7 g/L
- [89] Co: 8 g/L
- [90]
- [91] (Example 4)
- [92]
- [93] * Except for the details below, electroplating was performed on the surface of the copper foil in the same manner as in Example 1 to form a fine particle layer. An SEM image of the surface of the copper foil with the fine particle layer is shown in FIG. 7.

- [94] $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$: 85 g/L
- [95] H_2SO_4 : 125 g/L
- [96] Fe: 19 g/L
- [97] Mo: 1.1 g/L
- [98] Co: 10 g/L
- [99]
- [100] (Comparative Example 1)
- [101] Except for the details below, electroplating was performed on the surface of the copper foil in the same manner as in Example 1 to form a fine particle layer. An SEM image of the surface of the copper foil with the fine particle layer is shown in FIG. 8.
- [102] $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$: 70 g/L
- [103] H_2SO_4 : 165 g/L
- [104] Mo: 0.57 g/L
- [105] W: 10 g/L
- [106]
- [107] (Comparative Example 2)
- [108] Except for the details below, electroplating was performed on the surface of the copper foil in the same manner as in Example 1 to form a fine particle layer. An SEM image of the surface of the copper foil with the fine particle layer is shown in FIG. 9.
- [109] $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$: 70 g/L
- [110] H_2SO_4 : 165 g/L
- [111] Mn: 1 g/L
- [112]
- [113] (Comparative Example 3)
- [114] Except for the details below, electroplating was performed on the surface of the copper foil in the same manner as in Example 1 to form a fine particle layer. An SEM image of the surface of the copper foil with the fine particle layer is shown in FIG. 10.
- [115] $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$: 70 g/L
- [116] H_2SO_4 : 165 g/L
- [117] Ga: 1 g/L
- [118]
- [119] The surface roughness (R_z , R_{max}) and peel strength of the surface-treated surfaces of the copper foils of Examples 1 to 4 and Comparative Examples 1 to 3 were measured and shown in Table 1. The surface roughness R_z and R_{max} were measured according to JISB 0601-1994 standard, and the peel strength was measured by attaching the prepared sample to the halogen-free prepreg in the size of 10X100mm and subjecting it to hot pressing at 210°C for 30 minutes to prepare the sample for peel strength measurement, and the prepared sample was run through the U.T.M machine at a speed of 50mm per minute. This means that the lower the surface roughness value, the smaller the irregularities.

120: Table 1

[Table 1]

	Rz (μm)	Rmax (μm)	Peel strength (kgf/cm)
Example 1	5.06	6.24	1.31
Example 2	5.43	7.37	1.30
Example 3	5.92	7.27	1.35
Example 4	5.60	7.36	1.32
Comparative Example 1	5.20	7.95	1.16
Comparative Example 2	5.66	9.25	1.15
Comparative Example 3	4.62	7.58	1.10

[121] FIGS. 4 to 7 are surface images of copper foil of Examples 1 to 4 according to the present invention. Referring to FIG. 4, it can be seen that fine particles are concentrated in the ridges of the irregular surface of the copper foil. Similar to FIG. 1, FIG. 5 to FIG. 7 show that fine particles are located densely in the uneven ridges of the copper foil surface, and are located less in the valleys than in the ridges.

[122] In comparison, in FIG. 8 to FIG. 10, which are surface images of the copper foils of Comparative Examples 1 to 3, it can be seen that fine particles are evenly located not only in the ridges of the irregularities, but also in the valleys. In the copper foils of Comparative Examples 1 to 3, fine particles covered the entire surface of the copper foil.

[123] On the surface of the copper foil of Example 1 to Example 4 according to the present invention, more upper fine particles located above the mean line of the irregularities are present than the lower fine particles, and fewer lower fine particles are present, so that resin or active substances are likely to penetrate into the valley part, and thus adhesion is predicted to be high.

[124] Accordingly, as can be seen in Table 1, the surface roughness of the copper foil of Example 1 is lower than that of Comparative Example 1, but the peeling strength is higher, indicating high adhesion to other materials such as resin or active material that will be contacted in the subsequent processes. In particular, the evaluation result that the peeling strength of the copper foil of Example 1, which had a lower surface roughness rather than the same surface roughness, was higher than that of Comparative Example 1 can be inferred from the fact that the positions of the fine particles of Example 1 were biased. There are variations in surface roughness values of the copper foils of Examples 2 to 4, but the surface roughness values are smaller than or similar to those of Comparative Examples 1 to 3, but the peel strength is 1.30 kgf/cm or more, respectively, which is higher than that of Comparative Examples 1 to 3.

[125] Therefore, when using the copper foil of Examples 1 to 4 according to the present invention, due to its high adhesion to other materials such as resins and active materials, the defect rate in the process is low and the yield is high, and the low surface roughness makes it possible to form fine circuit patterns due to excellent etching properties, thereby increasing product

reliability.

[126] The present invention is not limited by the above-described embodiments and the attached drawings, but should be construed by the appended claims. Furthermore, it will be apparent to those skilled in the art that various forms of substitution, modification, and change can be made to the present invention without departing from the technical idea of the present invention as set forth in the claims.

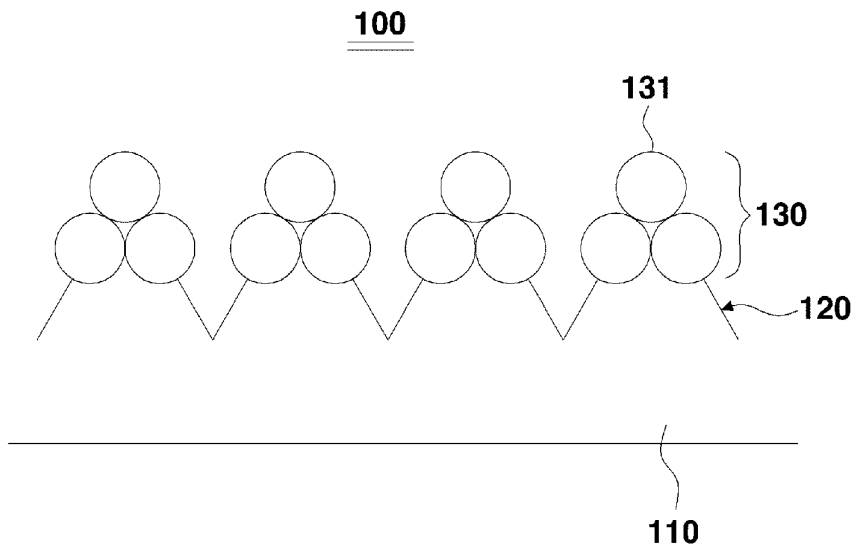
[127]

Scope of Claims

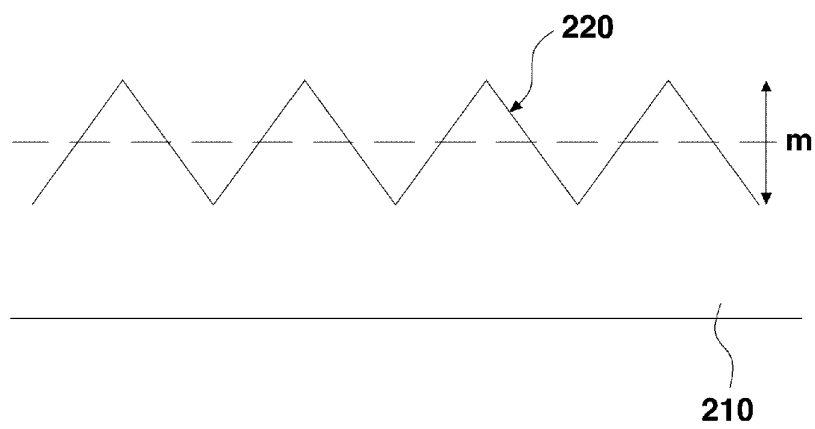
- [Claim 1] A copper foil in which irregularities are formed on at least one surface and a fine particle layer is formed on the surface, wherein the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.
- [Claim 2] The copper foil of Claim 1,
wherein the ratio of the number of said upper fine particles to the number of said lower fine particles is from 80:20 to 100:0.
- [Claim 3] The copper foil of Claim 1,
Copper foil wherein the upper fine particles have a triangular shape connecting the center points.
- [Claim 4] The copper foil of Claim 1,
Copper foil wherein the diameter of the fine particles is 1 to 3 μm .
- [Claim 5] The copper foil of Claim 1,
Copper foil wherein the fine particles are metal particles containing at least one metal from copper (Cu), iron (Fe), molybdenum (Mo), and cobalt (Co).
- [Claim 6] The copper foil of Claim 1,
Copper foil having a peel strength of 1.28 to 1.33 kgf/cm.
- [Claim 7] The copper foil of Claim 1,
Copper foil having a surface roughness Rz of 5.2 to 6.5 μm .
- [Claim 8] The copper foil of Claim 1,
Copper foil having a surface roughness Rmax of 6.5 to 7.7 μm .
- [Claim 9] An electrical component comprising an insulating substrate;
and the copper foil; according to any one of Claims 1 to 8 attached to one surface of the insulating substrate.
- [Claim 10] A battery comprising the copper foil according to any one of Claims 1 to 8.
- [Claim 11] A surface treatment method of copper foil is provided, including preparing a copper foil with irregularities formed on at least one surface; and forming a fine particle layer on the surface where the above irregularities are formed so that the upper fine particles located above the mean line according to the mean height of the surface are more than the lower fine particles located below the mean line.

- [Claim 12] The method of Claim 11,
wherein the step of forming the fine particle layer includes,
a surface treatment method of copper foil, which involves forming a fine
particle layer on the surface where the irregularities are formed by
immersing and electrolyzing in a surface treatment solution with the
copper foil containing copper sulfate; sulfuric acid; and metal containing
iron (Fe), molybdenum (Mo), and cobalt (Co).
- [Claim 13] The method of Claim 12,
a method of surface treatment of copper foil wherein the iron content is
10 to 30 g.
- [Claim 14] The method of Claim 12,
A method of surface treatment of copper foil wherein the molybdenum
content is 0.5 to 10 g.
- [Claim 15] The method of Claim 12,
A method of surface treatment of copper foil wherein the cobalt content
is 1 to 15 g.
- [Claim 16] The method of Claim 12,
A method of surface treatment of copper foil, wherein the electrolysis is
performed at 20 to 60 A/dm² for 1 to 5 seconds.

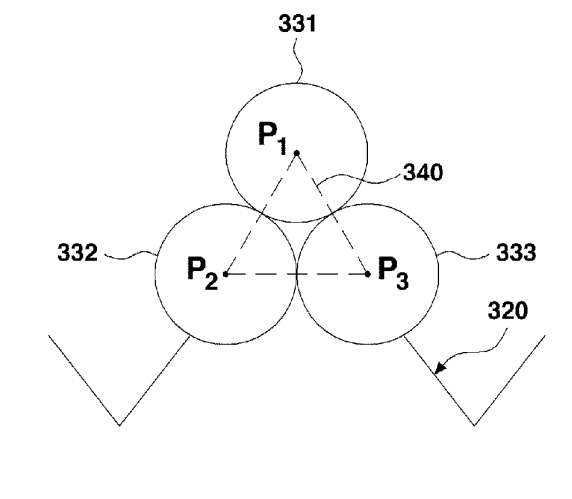
[Fig. 1]



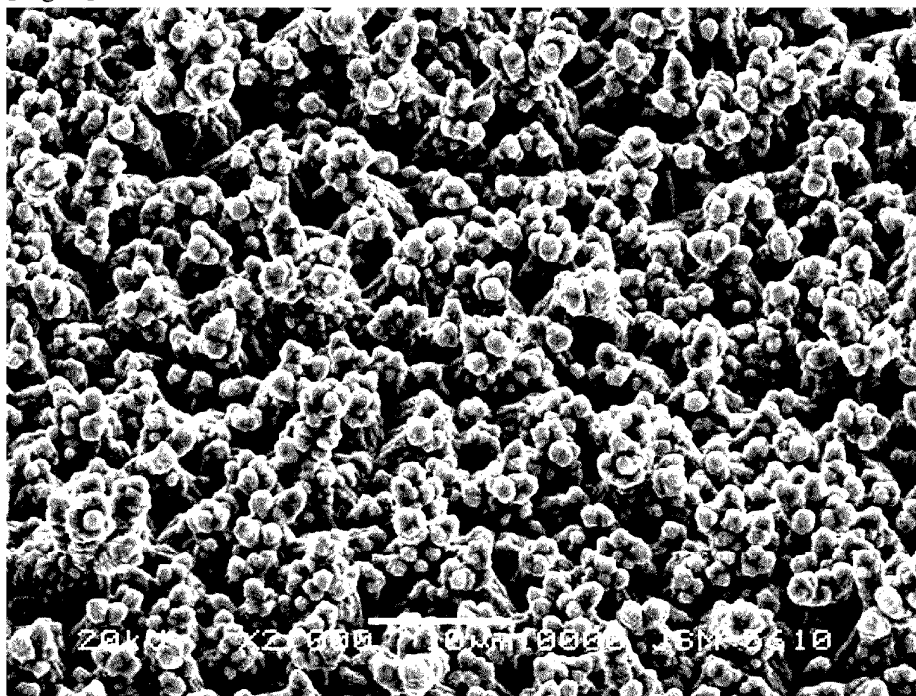
[Fig. 2]



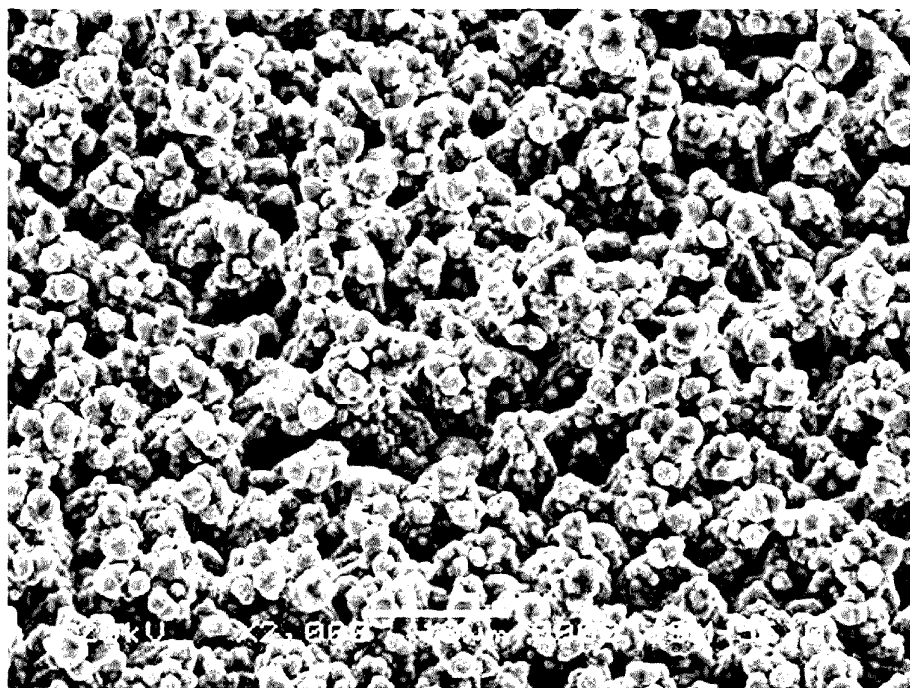
[Fig. 3]



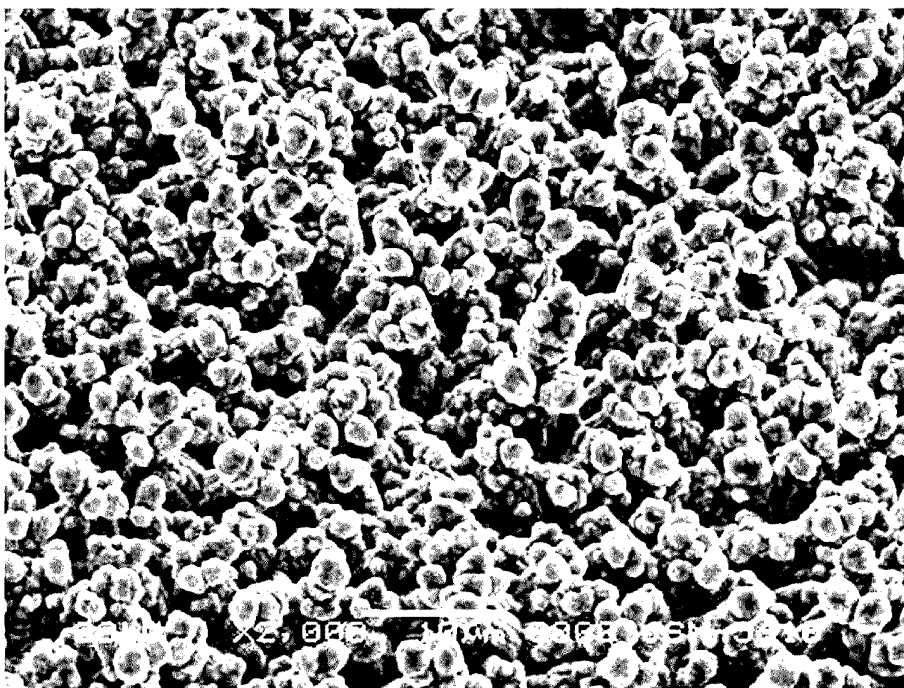
[Fig. 4]



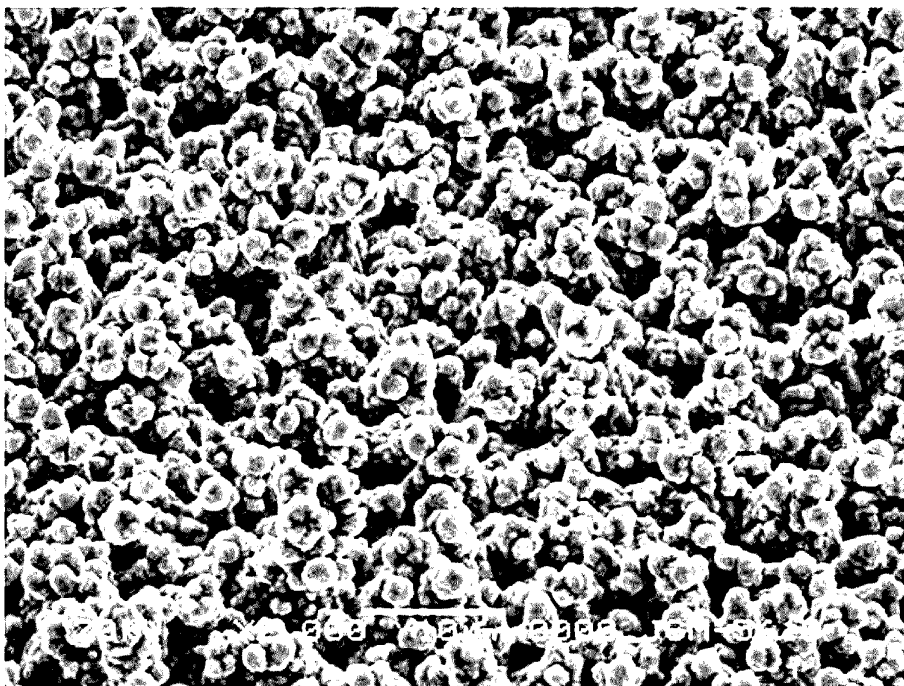
[Fig. 5]



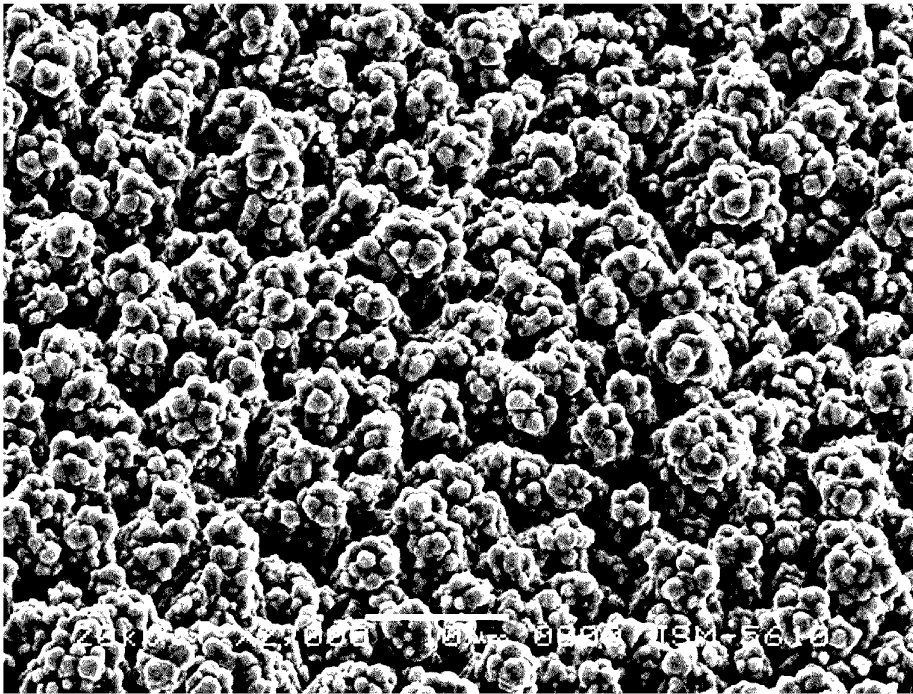
[Fig. 6]



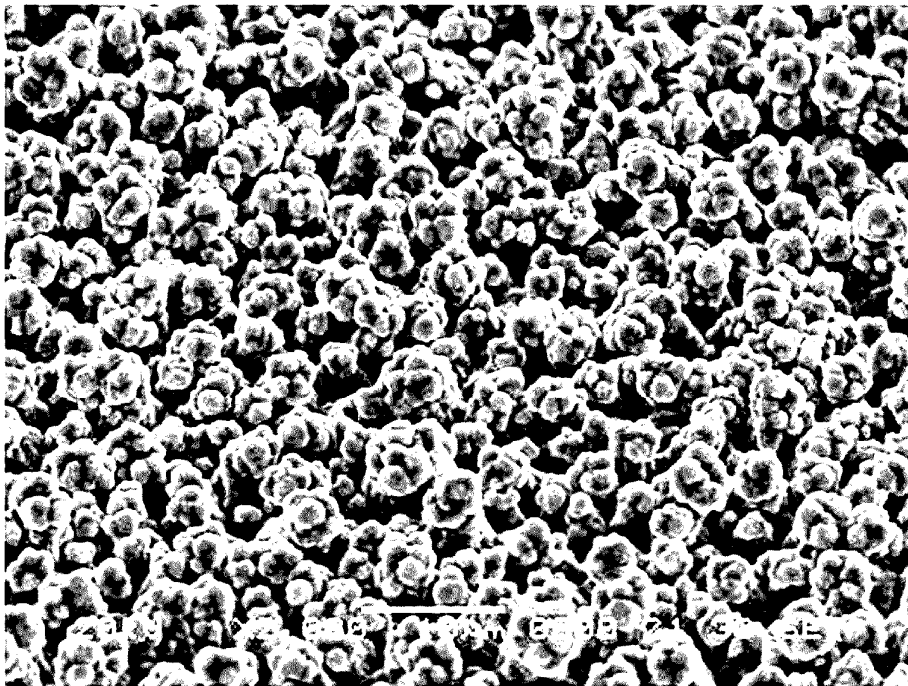
[Fig. 7]



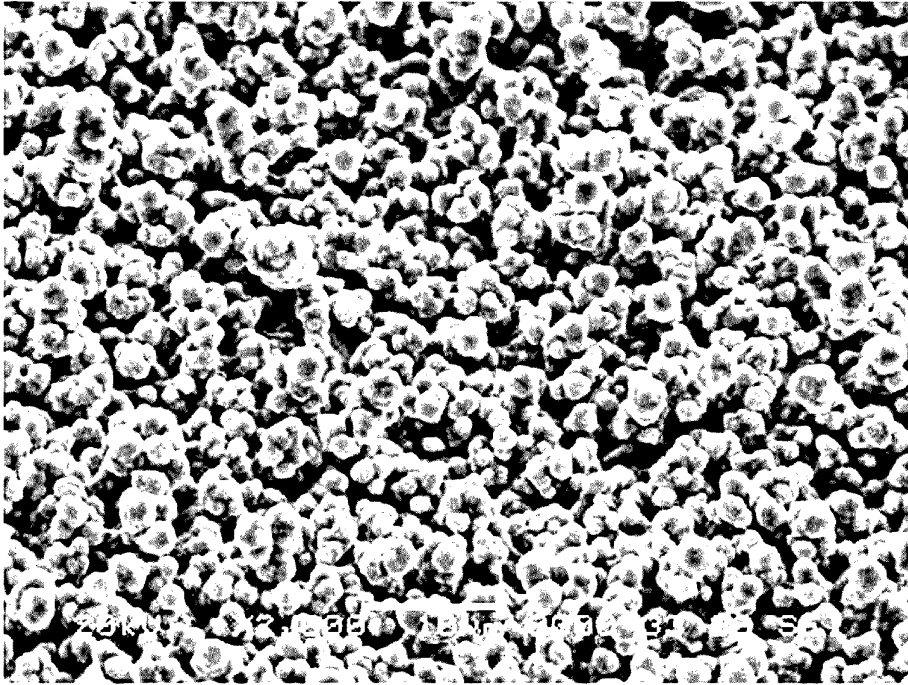
[Fig. 8]



[Fig. 9]



[Fig. 10]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2014/012942**A. CLASSIFICATION OF SUBJECT MATTER****H05K 1/03(2006.01)i, H05K 1/09(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)

H05K 1/03; H01M 4/38; H01M 4/66; H01M 4/26; H01M 4/02; C22C 9/00; H01M 10/02; H01M 4/70; H05K 1/09

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

Korean Utility models and applications for Utility models: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: copper foil, unevenness, micro particle, upper micro particle, surface roughnesss, peel strength

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-0842930 B1 (KNU-INDUSTRY COOPERATION FOUNDATION) 02 July 2008 See abstract, paragraphs [0048]-[0049], [0053], [0075], claim 1, and figure 1.	1-4,7-11,13-15
Y		5-6,12,16
Y	JP 2012-033475 A (FURUKAWA ELECTRIC CO., LTD.) 16 February 2012 See abstract, paragraphs [0037]-[0040], [0056]-[0063], claims 1, 3, 9, and figure 1.	5-6,12,16
A	KR 10-1012580 B1 (SANYO ELECTRIC CO., LTD.) 07 February 2011 See paragraphs [0032]-[0047], claims 1, 12, and figures 1-3.	1-16
A	JP 2006-216518 A (NIKKO KINZOKU K.K. et al.) 17 August 2006 See abstract, paragraphs [0011]-[0021], claim 1, and figures 5-6.	1-16
A	US 2011-0143195 A1 (SHUJI ITO et al.) 16 June 2011 See paragraphs [0028]-[0032], claims 1, 10, and figures 1, 5.	1-16

☐ 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

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"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

"I" 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

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"G" document member of the same patent family

Date of the actual completion of the international search

24 MARCH 2015 (24.03.2015)

Date of mailing of the international search report

26 MARCH 2015 (26.03.2015)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
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Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2014/012942

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US 2011-0143195 A1	16/06/2011	CN 102144320 A	03/08/2011
		WO 2011-001620 A1	06/01/2011

A. Technical classification to which the invention belongs (International Patent Classification (IPC))**H05K 1/03(2006.01)i, H05K 1/09(2006.01)i****B. Researched areas**

Minimum literature researched (includes international patent classification)

H05K 1/03 ; H01M 4/38 ; H01M 4/66 ; H01M 4/26 ; H01M 4/02 ; C22C 9/00 ; H01M 10/02 ; H01M 4/70 ; H05K 1/09

Literature other than the minimum literature belonging to the researched technical field

Korea Registered Utility Model Gazette and Korea Public Utility Model Gazette: IPC listed in the minimum literature researched section

Japan Registered Utility Model Gazette and Japan Public Utility Model Gazette: IPC listed in the minimum literature researched section

Computer database used in international research (database name and search term (if applicable))

eKOMPASS (Korean Intellectual Property Office internal search system) & keywords: Copper foil, irregularities, fine particles, upper fine particles, surface roughness, peel strength

C. Relevant literature

Category*	List of cited literature and related passages (if applicable)	Related Claims
X	KR 10-0842930 B1 (Kangwon National University Industry-Academic Cooperation Foundation) 2008.07.02	1-4,7-11,13-15
Y	See Summary, Paragraphs [0048]-[0049], [0053], [0075], Claim 1, and Fig. 1.	5-6,12,16
Y	JP 2012-033475 A (FURUKAWA ELECTRIC CO., LTD.) 2012.02.16 See Summary, Paragraphs [0037]-[0040], [0056]-[0063], Claims 1, 3, 9, and Fig. 1.	5-6,12,16
A	KR 10-1012580 B1 (Sanyo Denki Kabushiki Kaisha) 2011.02.07 See Paragraphs [0032]-[0047], Claims 1 and 12, and Fig. 1-3.	1-16
A	JP 2006-216518 A (NIKKO KINZOKU K.K. and 1 other) 2006.08.17 See Summary, Paragraphs [0011]-[0021], Claim 1, and Fig. 5-6.	1-16
A	US 2011-0143195 A1 (SHUJI ITO and 5 others) 2011.06.16 See Paragraphs [0028]-[0032], Claims 1 and 10, and Fig. 1 and 5.	1-16

☐ Additional literature is listed in C (continued).☒ Please refer to the Annex regarding corresponding patents.

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“A” Literature that defines a general level of technology that does not appear to be particularly relevant

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“Y” Specially relevant literature In the case where the relevant literature is combined with one or more other literatures, and the combination is obvious to those skilled in the art, the claimed invention is considered to have no inventive step.

“O” Literature that refers to oral disclosure, use, display, or other means

“&” Literature belonging to the same corresponding patent literature

“P” Literature published after the priority date but before the international application date

Actual completion date of international research

March 24, 2015 (24.03.2015)

Date of sending of the international research report

March 26, 2015 (26.03.2015)

Name and mailing address of IS/KR

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Gon Kim

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