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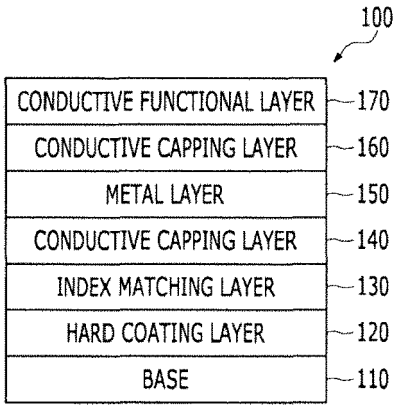
(54) ELECTRODE FOR LOW RESISTANCE-HIGH CURRENT AND FABRICATION METHOD FOR THE SAME

(57) An electrode for low resistance and high-current is disclosed. The electrode for low resistance and high-current of the present disclosure comprises: a base; a hard coating layer disposed over the base; a metal layer disposed over the hard coating layer; conductive capping layers disposed over and under the metal layer, respectively; and a conductive functional layer disposed over the conductive capping layer disposed over the metal layer.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present disclosure relates to an electrode for low resistance-high current and a fabrication method for the same.

Description of the Related Art

[0002] A smart window product is a window that performs various functions such as adjusting whether to transmit light, heat blocking, heat insulating, etc. by employing a Polymer Dispersed Liquid Crystal (PDLC), Electrochromic (EC), Electroluminescence (EL), etc.

[0003] In particular, an active smart window is a technology of electronically changing optical and thermal characteristics of a window and an ITO electrode was usually applied thereto in the related art. However, an ITO electrode is difficult to be applied to foldable and rollable products because it has low flexibility, so there is limitation to apply the ITO electrode to flexible smart window product and there is a problem that energy efficiency is not stable because it is difficult to be driven at low voltage.

[0004] Meanwhile, silver (Ag) is an excellent material as a flexible transparent electrode because it has high visible light transmittance and very low resistivity in a thin film, but it is difficult to commercialize silver due to a problem with durability such as oxidation. There is limitation that it is required to effectively prevent oxidation and suppress migration in order to use silver (Ag), and conductive substances are required to connect silver as an electrode.

SUMMARY OF THE INVENTION

[0005] An objective of the present disclosure is to provide an electrode for low resistance-high current that has improved fluidity of a current and excellent flexibility by implement low resistance and enabling charges to easily move by forming the electrode in a multi-layer structure, and a method of fabricating the electrode.

[0006] In order to achieve the objectives, an electrode for low resistance and high-current according to an embodiment of the present disclosure comprises: a base; a hard coating layer disposed over the base; a metal layer disposed over the hard coating layer; conductive capping layers disposed over and under the metal layer, respectively; and a conductive functional layer disposed over the conductive capping layer disposed over the metal layer, in which a composite forming the hard coating layer may comprise photo-curing oligomer, the conductive capping layers may comprise any one selected from ITO, IZO, ZIST, and IZTO, and the conductive functional may comprise any one selected from ITO, IZO, ZIST, and IZTO.

[0007] In an embodiment of the present disclosure, the metal layer may be an alloy comprising silver (Ag) as a main constituent and added with at least one of niobium (Nb) and gold (Au).

[0008] In an embodiment of the present disclosure, the electrode for low resistance and high-current may further comprise an index matching layer formed between the base and the hard coating layer and having a medium and a thickness selected for determining transmittance of an entire film.

[0009] In an embodiment of the present disclosure, the metal layer may comprise silver (Ag) of 89.5 at% to 96.5 at%, niobium (Nb) of 0.5 at% to 1.5 at%, and gold (Au) of 3.0 at% to 9.0 at%.

[0010] In an embodiment of the present disclosure, the base may be formed in 125μm using PET, the hard coating layer may be formed in 3μm using an acrylate-based substance, the conductive capping layers each may be formed in 10nm using IZO, the metal layer may be formed in 10nm, and the conductive functional layer may be formed in 20nm using ITO.

[0011] The present disclosure forms an electrode in a multi-layer structure, thereby having an effect that low resistance is implemented, high current can be applied, and flexibility is also secured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The above and other objectives, features and other advantages of the present invention will be more clearly understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 shows an electrode for low resistance-high current according to an embodiment of the present disclosure;

FIG. 2 shows a method of fabricating the electrode for low resistance-high current according to an embodiment of the present disclosure;

FIG: 3 is a cyclic voltammogram obtained by performing an anode test using the electrode for low resistance-high current according to an embodiment of the present disclosure; and

FIG. 4 is a sample picture after +1.5 cycling is applied to the electrode according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The present disclosure may be modified in various ways and implemented by various exemplary embodiments, so that specific exemplary embodiments are shown in the drawings and will be described in detail herein. However, it is to be understood that the present disclosure is not limited to the specific exemplary embodiments, but includes all modifications, equivalents,

and substitutions included in the spirit and the scope of the present disclosure.

[0014] In description of the present disclosure, detailed descriptions of well-known technologies will be omitted not to obscure the description of the present disclosure with unnecessary details.

[0015] Hereafter, an embodiment of the present disclosure is described in detail with reference to the accompanying drawings.

[0016] FIG. 1 shows an electrode 100 for low resistance-high current according to an embodiment of the present disclosure.

[0017] Referring to FIG. 1, an electrode 100 for low resistance-high current according to an embodiment of the present disclosure includes: a base 110, a hard coating layer 120, an index matching layer 130, conductive capping layers 140 and 160, a metal layer 150, and a conductive functional layer 170.

[0018] The base 110 may include an inorganic substance or an organic substance.

[0019] The inorganic substance may be any one of glass, quartz, Al2O3, SiC, Si, GaAs, and InP, or a combination thereof, and is not limited thereto.

[0020] The organic substance may be selected from kapton foil, polyimide (PI), polyethersulfone (PES), polyacrylate (PAR), polyetherimide (PEI), polyethylene naphthalate (PEN), polyethyleneterephthalate (PET), polyphenylene sulfide (PPS), polyarylate, polycarbonate (PC), cellulose triacetate (CTA), cellulose acetate propionate (CAP), but is not limited thereto.

[0021] However, since the present disclosure intends to achieve low resistance and high light transmissivity, it is preferable to select the base 110 in consideration of appropriate thickness, index, etc.

[0022] The base 110 according to an embodiment of the present disclosure includes polyethyleneterephthalate (PET).

[0023] The hard coating layer 120 may be formed on the base 110.

[0024] The hard coating layer 120 may be made of a photo-curing type composite. The photo-curing composite is a composite of which is cured by electromagnetic waves. The electromagnetic wave is used as a general term of particle beams such as microwaves, infrared light (IR), ultraviolet light (UV), an X-ray, a γ-ray or an α-particle beam, a proton beam, a neutronbeam, and an electron beam.

[0025] The composite for forming the hard coating layer 120 may include photo-curing oligomer. As the photo-curing oligomer, oligomer constituents that are used to produce photo-curing (e.g., UV curing) composites in the field may be freely used. For example, the oligomer may be: urethane acrylate obtained by reaction of polyisocyanate having two or more isocyanate groups in the molecule and hydroxyalkyl (meta) acrylate; ester-based acrylate obtained by dehydration reaction of polyester polyol and (meta) acryl acid; ester-based urethane acrylate obtained by reaction of hydroxyalkyl with ester-based urethane resin obtained by reaction polyester polyol and polyisocyanate; ester-based acrylate such as polyalkylene glycol di(meta) acrylate; ester-based urethane acrylate obtained by reaction of polyester polyol and (meta) acrylate and ester-based urethane resin obtained by reaction of polyester polyol and polyisocyanate; epoxy acrylate obtained by addition reaction of epoxy resin and (meta) acryl acid, or the like, but is not limited thereto.

[0026] The index matching layer 130 is formed on the hard coating layer 120.

[0027] The index matching layer 130 may be introduced to optimize transmittance. The material (i.e., refractive index) and the thickness of the index matching layer 130 may be selected to achieve optimal transmittance under given conditions. For example, when the refractive index of the medium of each layer is high, a relatively low refractive index may be selected for the index matching layer 130.

[0028] This is because if a relatively high refractive index is selected for the medium of each layer, the reflectivity increases, and as a result, the transmittance may decrease. Accordingly, at least one of a material and a thickness of the index matching layer 130 may be selected to adjust the entire transmittance, as in the above example.

[0029] In an embodiment of the present disclosure, the index matching layer 130 may include a compound of a binary or more system having a refractive index over 2.0 such that transmittance is easily adjusted. For example, the index matching layer 130 may include any one of Nb2Ox, SiNx, SiOx, ZnO, AZO, TiOx, AiNx, WOx, ZTS, and ZIST. In this case, x may be any integer or real number. In this case, the visible light region may be light within a wavelength range of 380nm to 780nm.

[0030] The thickness of the index matching layer 130 may be selected from between 10nm and 35nm.

[0031] The index matching layer 130 is a layer connecting the hard coating layer 120 and the conductive capping layer 140, so it is preferable to select a high attachment ability for both sides.

[0032] For example, the index matching layer 130 may include an Si-based ceramic material. In this case, it is preferable to use ceramic-based hard coating for the hard coating layer 120 too.

[0033] The conductive capping layers 140 and 160 are formed over and under the metal layer 150, respectively.

[0034] A compound of a ternary or more system may be used for the conductive capping layers 140 and 160, and in this case, it may be preferable that the refractive index is high, but is lower than that of the index matching layer 13.

[0035] The conductive capping layers 140 and 160 may include any one selected from ITO, IZO, ZIST, and IZTO.

[0036] The conductive capping layers 140 and 160 may be formed in a thickness of 5nm to 40nm.

[0037] When the thickness of the conductive capping layers 140 and 160 is less than 5nm, forming itself of a

layer is difficult, so it is difficult to perform a capping function, but when the thickness exceeds 40nm, the optical characteristic is influenced, so there is a problem that the transmittance decreases and chrominance comes out of the center.

[0038] The conductive capping layers 140 and 160 made of the material with the thickness described above effectively prevent oxidation of the metal layer 150 and have conductivity, thereby contributing to form a low-resistance electrode.

[0039] In an embodiment of the present disclosure, the conductive capping layers 140 and 160 may include IZO. It is preferable that the IZO of the conductive capping layers 140 and 160 is configured such that the ratio of In2Ox:ZnO is 7:3 to 8:2. When the IZO of the conductive capping layers 140 and 160 is configured in this way, conductivity can be minimized and the capping function can be improved.

[0040] The metal layer 150 is disposed between the two conductive capping layers 140 and 160.

[0041] In an embodiment of the present disclosure, the metal layer 150 may include an alloy having silver (Ag) as a main constituent and added with at least one of niobium (Nb) and gold (Au).

[0042] Preferably, the metal layer 150 may include silver (Ag) of 89.5 at% to 96.5 at%, niobium (Nb) of 0.5 at% to 1.5 at%, and gold (Au) of 3.0 at% to 9.0 at%. However, the metal layer 160 may include metals such as Pd, Cu, Fe, Ni, Pb, Sn, Zn, Mg, Cd, C, and Ta as unavoidable constituents and the concentration may be 100mass ppm or less.

[0043] The concentration of oxygen unavoidably included in the metal layer 150 may be 1000mass ppm or less.

[0044] In an embodiment of the present disclosure, it is possible to decrease resistance of the entire electrode by forming the metal layer 150 including silver (Ag) as a main constituent.

[0045] The conductive functional layer 170 is disposed over the conductive capping layer 160 formed over the metal layer 150.

[0046] The conductive functional layer 170 may be made of a substance having excellent conductivity and durability (solvent resistance, etc.).

[0047] A compound of a ternary or more system may be used for the conductive functional layer 170. For example, the conductive functional layer 170 may include any one of ITO, IZO, ZIST, and IZTO. For example, the conductive functional layer 170 may include a conductive polymer such as PEDOT.

[0048] The conductive functional layer 170 may be formed in a thickness of 5nm to 40nm. When the thickness of the conductive functional layer 170 is less than 5nm, forming itself of a layer is difficult, so it is difficult to perform a capping function, but when the thickness exceeds 40nm, the optical characteristic is influenced, so there is a problem that the transmittance decreases and chrominance comes out of the center.

[0049] In an embodiment of the present disclosure, the conductive functional layer 170 may include ITO.

[0050] FIG. 2 shows a method of fabricating the electrode 100 for low resistance-high current according to an embodiment of the present disclosure.

[0051] Referring to FIG. 2, a base 110 is prepared in step S210.

[0052] The base 110 may include an inorganic substance or an organic substance and any one of the bases 110 of the example described above may be selected. The base 110 according to an embodiment of the present disclosure includes polyethyleneterephthalate (PET).

[0053] In step S220, a hard coating layer 120 is formed over the base 110.

[0054] The hard coating layer 120 may be made of the material of the hard coating layer 120 of the example described above. The hard coating layer 120 may be formed using any one composite of the example described above through wet coating such as spin coating, roll coating, spray coating, flow coating, inkjet printing, nozzle printing, deep coating, electrophoretic deposition, tape casting, screen printing, pad printing, doctor blade coating, gravure printing, gravure offset printing, and Langmuir-Blogett.

[0055] In step S230, an index matching layer 130 is formed over the hard coating layer 120.

[0056] As the index matching layer 130, any one of the index matching layers 130 of the example described above may be selected.

[0057] The index matching layer 130 may be formed over the hard coating layer 120 by preparing a solution related to a material that can achieve a desired refractive index and by performing any one selected from spin coating, roll coating, spray coating, flow coating, inkjet printing, nozzle printing, deep coating, electrophoretic deposition, tape casting, screen printing, pad printing, doctor blade coating, gravure printing, gravure offset printing, and Langmuir-Blogett.

[0058] In step S240, a conductive capping layer 140 is formed over the index matching layer 130.

[0059] The conductive capping layer 140 may include any one selected from ITO, IZO, ZIST, and IZTO.

[0060] The conductive capping layer 140 may be formed in a thickness of 5nm to 40nm.

[0061] In step S250, a metal layer 150 is formed over the conductive capping layer 140.

[0062] The metal layer 150 is, silver (Ag), niobium (Nb) and gold (Au) may determined as a sputtering target at a desired ratio.

[0063] Preferably, the metal layer 150 may include silver (Ag) of 89.5 at% to 96.5 at%, niobium (Nb) of 0.5 at% to 1.5 at%, and gold (Au) of 3.0 at% to 9.0 at%. However, the metal layer 150 may include metals such as Pd, Cu, Fe, Ni, Pb, Sn, Zn, Mg, Cd, C, and Ta as unavoidable constituents of a sputtering target and the concentration may be 100mass ppm or less.

[0064] The concentration of oxygen unavoidably included in the metal layer 150 may be 1000mass ppm or

less.

[0065] In step S260, a conductive capping layer 160 is formed over the metal layer 150.

[0066] The conductive capping layer 160 over the metal layer 150 may have the same substance and thickness as those of the conductive capping layer 140 under the metal layer 150, but the same substance and thickness are not necessarily required. The conductive capping layer 160 is selected within the substance and thickness range in the example described above, and a substance and a material that are different from those of the conductive capping layer 140 formed at the lower portion may be applied.

[0067] In step S270, a conductive functional layer 170 is formed over the conductive capping layer 140 formed over the metal layer 150.

[0068] The conductive functional layer 170 may include any one selected from ITO, IZO, ZIST, and IZTO. THE conductive functional layer 170 may include a conductive polymer such as PEDOT.

[0069] The conductive functional layer 170 may be formed in a thickness of 5nm to 40nm.

[0070] FIG. 3 is a cyclic voltammogram obtained by performing an anode test using the electrode 100 for low resistance-high current according to an embodiment of the present disclosure.

[0071] In the test, an electrode employing ITO as the metal layer 150 and electrodes according to the structures of embodiments of the present disclosure were compared. The dash-dotted line shows a +1V cycling result and the solid line shows a +1.5V cycling result. Conditions of a comparative example and an embodiment are as follows.

[Comparative example]

[0072]

Base: PET, 125nm
Hard coating layer: acrylate-based substance, 3μm
Index matching layer: SiOx, 20nm
Metal layer: ITO, 25nm
[Embodiment]
Base: PET, 125nm
Hard coating layer: acrylate-based substance, 3μm
Index matching layer: SiNx, 30nm
Conductive capping layer: IZO, 10nm
Metal layer: Ag alloy, 10nm
Conductive functional layer: ITO, 20nm

[0073] As the test result, the electrode according to an embodiment of the present disclosure showed high a quantity of electric charge larger than the ITO electrode and there was little damage even in the +1.5 cycling.

[0074] FIG. 4 is a sample picture after +1.5 cycling is applied to the electrode according to an embodiment of the present disclosure.

[0075] Referring to FIG. 4, specific damage was not observed throughout the entire electrode 100 for low resistance-high current according to an embodiment of the present disclosure even +1.5 cycling was applied, so the electrode was evaluated as having excellent durability.

[0076] Terms used in the present specification are used only to describe specific exemplary embodiments rather than limiting the present disclosure. It will be further understood that the terms "comprises" or "have" used in this specification, specify the presence of stated features, steps, operations, components, parts, or a combination thereof, but do not preclude the presence or addition of one or more other features, numerals, steps, operations, components, parts, or a combination thereof.

[List of reference numerals]

[0077]

110: BASE
120: HARD COATING LAYER
130: INDEX MATCHING LAYER
140, 160: CONDUCTIVE CAPPING LAYER
150: METAL LAYER
170: CONDUCTIVE FUNCTIONAL LAYER
S210: BASE IS PREPARED
S220: HARD COATING LAYER IS FORMED
S230: INDEX MATCHING LAYER IS FORMED
S240: CONDUCTIVE CAPPING LAYER IS FORMED
S250: METAL LAYER IS FORMED
S260: CONDUCTIVE CAPPING LAYER IS FORMED
S270: CONDUCTIVE FUNCTIONAL LAYER IS FORMED

Claims

1. An electrode for low resistance and high-current, comprising:

a base;
a hard coating layer disposed over the base;
a metal layer disposed over the hard coating layer;
conductive capping layers disposed over and under the metal layer, respectively; and
a conductive functional layer disposed over the conductive capping layer disposed over the metal layer,
wherein a composite forming the hard coating layer comprises photo-curing oligomer,
the conductive capping layers comprises any one selected from ITO, IZO, ZIST, and IZTO, and
the conductive functional layer comprises any one selected from ITO, IZO, ZIST, and IZTO.

2. The electrode of claim 1, wherein the metal layer is an alloy comprising silver (Ag) as a main constituent and added with at least one of niobium (Nb) and gold (Au).

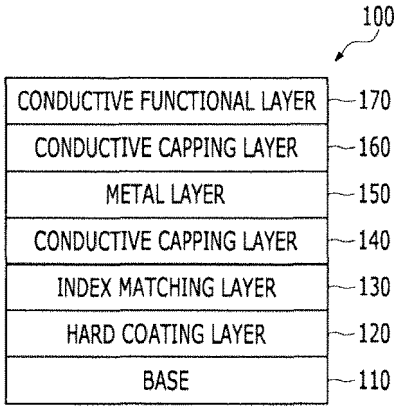
3. The electrode of any one of claims 1 and 2, further comprising an index matching layer formed between the base and the hard coating layer and having a medium and a thickness selected for determining transmittance of an entire film.

4. The electrode of any one of the preceding claims, wherein the metal layer comprises silver (Ag) of 89.5 at% to 96.5 at%, niobium (Nb) of 0.5 at% to 1.5 at%, and gold (Au) of 3.0 at% to 9.0 at%.

5. The electrode of any one of the preceding claims, wherein the base is formed in 125μm using PET,

the hard coating layer is formed in 3μm using an acrylate-based substance,
the conductive capping layers are each formed in 10nm using IZO,
the metal layer is formed in 10nm, and
the conductive functional layer is formed in 20nm using ITO.

FIG. 1


100
CONDUCTIVE FUNCTIONAL LAYER
170
CONDUCTIVE CAPPING LAYER
160
METAL LAYER
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CONDUCTIVE CAPPING LAYER
140
INDEX MATCHING LAYER
130
HARD COATING LAYER
120
BASE
110

FIG. 2

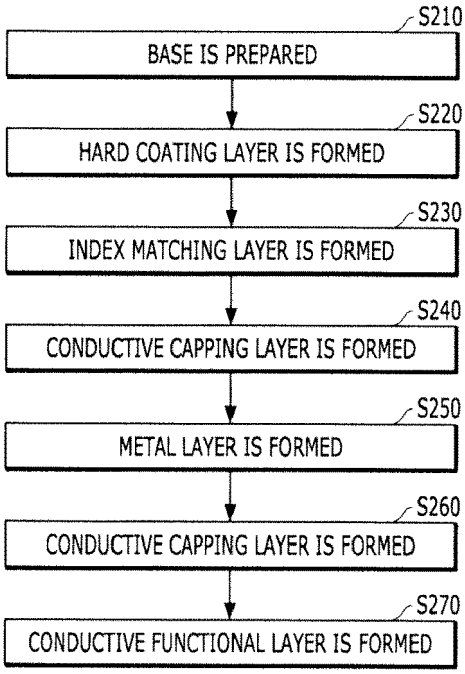

S210
BASE IS PREPARED
S220
HARD COATING LAYER IS FORMED
S230
INDEX MATCHING LAYER IS FORMED
S240
CONDUCTIVE CAPPING LAYER IS FORMED
S250
METAL LAYER IS FORMED
S260
CONDUCTIVE CAPPING LAYER IS FORMED
S270
CONDUCTIVE FUNCTIONAL LAYER IS FORMED

FIG. 3

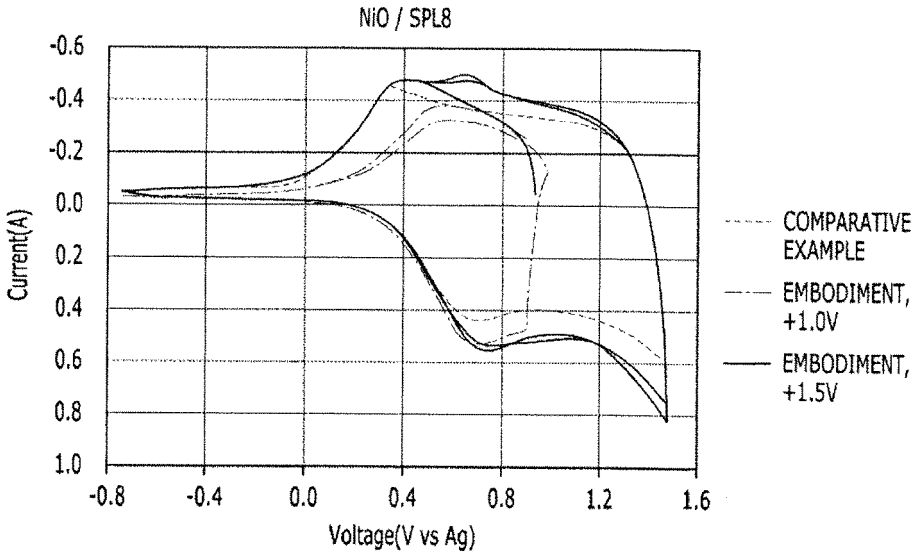
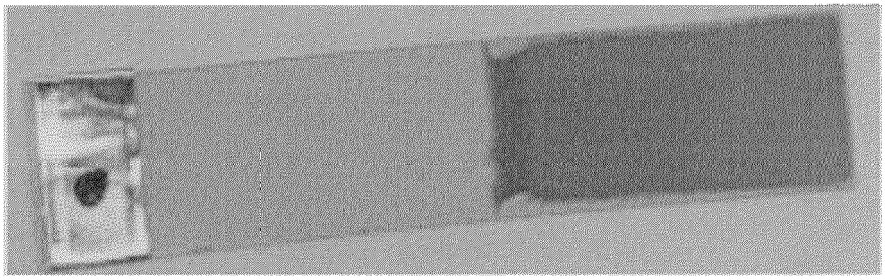

NiO / SPL8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Current(A)
-0.8
-0.4
0.0
0.4
0.8
1.2
1.6
Voltage(V vs Ag)
COMPARATIVE EXAMPLE
EMBODIMENT, +1.0V
EMBODIMENT, +1.5V

FIG. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 7244

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	US 2018/253170 A1 (NOH SUNG JIN [KR] ET AL) 6 September 2018 (2018-09-06) * figure 3 * * paragraph [0045] - paragraph [0088] * * example 1 *	1-5	
A	KR 2019 0113098 A (DONGWOO FINE CHEM CO LTD [KR]) 8 October 2019 (2019-10-08) * figure 1 * * paragraph [0063] - paragraph [0067] * * table 1 *	1-5	
A	KR 2020 0037956 A (LG CHEMICAL LTD [KR]) 10 April 2020 (2020-04-10) * figure 2 * * paragraph [0062] - paragraph [0070] * * example 3 *	1-5	TECHNICAL FIELDS SEARCHED (IPC) H01B B32B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 December 2022	Poole, Robert

CATEGORY OF CITED DOCUMENTS

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18-12-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82