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(54) Title: COPPER HALIDE LAYERS

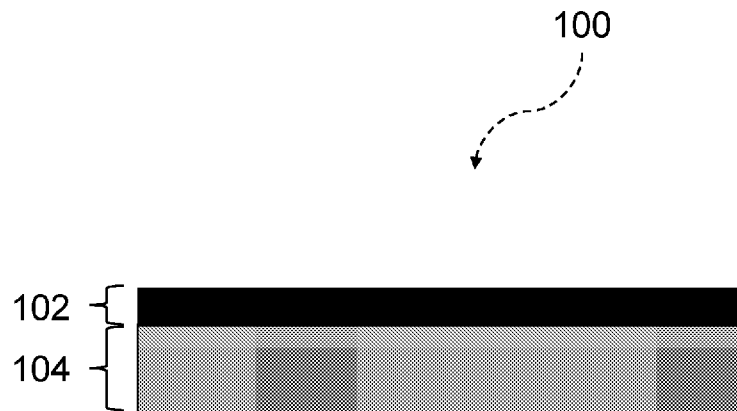


FIG. 1A

(57) Abstract: Articles are described including a substrate and a copper halide layer on the substrate, where the interfacial free energy between the substrate and the copper halide layer allows the copper halide layer to form continuously, wherein the copper halide layer conforms to the shape of the substrate. The articles may further include an adhesion layer disposed in-between the substrate and the copper halide layer, where the surface free energy between the adhesion layer and the copper halide layer allows the copper halide layer to form continuously, wherein the copper halide layer or the adhesion layer conform to the shape of the substrate. Also described are methods of forming an article using chemical vapor deposition.



GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
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KM, ML, MR, NE, SN, TD, TG).

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 20/37537

A. CLASSIFICATION OF SUBJECT MATTER

IPC - H01G 9/20; H01L 51/42; H01L 51/46 (2020.01)

CPC - H01G 9/2059; H01L 51/0032; H01L 51/4226; H01L 51/4253

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)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 7,772,556 B2 (Reddy et al.) 10 August 2010 (10.08.2010) Entire document, especially Abstract, col 3 ln 16-23, 46-57; col 4 ln 3-6; col 5 ln 63-65	1-3, 7, 19, 29/(2, 19) ----- 8, 20, 29/20, 41-44
Y	CN 103,764,769 B (Fuji Photo Film Co. Ltd.) 17 August 2016 (17.08.2016) Entire document, especially para [0251]; [0334]	8, 20, 29/20, 41-44
A	US 5,440,664 A (Harrington et al.) 8 August 1995 (08.08.1995) Entire document	1-3, 7-8, 19-20, 29/(2, 19-20), 41-44
A	US 8,486,252 B2 (Hsiang Lin) 16 July 2013 (16.07.2013) Entire document	1-3, 7-8, 19-20, 29/(2, 19-20), 41-44
A	US 8,679,587 B2 (Chang et al.) 25 March 2014 (25.03.2014) Entire document	1-3, 7-8, 19-20, 29/(2, 19-20), 41-44
A	US 2010/0304954 A1 (Sogabe et al.) 2 December 2010 (02.12.2010) Entire document	1-3, 7-8, 19-20, 29/(2, 19-20), 41-44
A	US 5,075,171 A (Kondo et al.) 24 December 1991 (24.12.1991) Entire document	1-3, 7-8, 19-20, 29/(2, 19-20), 41-44

☐ 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

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

19 August 2020

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 20/37537

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-6, 16-18, 30-40, 45-46, 65-69, 76-77
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

-- See Extra Sheet --

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-3, 7-8, 19-20, 29/(2, 19-20), 41-44

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 20/37537

Continuation of:

Box III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I+: Claims 1-3, 7-15, 19-29, and 41-44 directed to an article comprising: a substrate; and a copper halide layer on the substrate; wherein the interfacial free energy between the substrate and the copper halide layer allows the copper halide layer to be free of discontinuations of sizes of about 5 nm² or greater; and wherein the copper halide layer conforms to the shape of the substrate. The article will be searched to the extent that the article encompasses an article comprising: a metal substrate; and a copper halide layer on the metal substrate; wherein the interfacial free energy between the metal substrate and the copper halide layer allows the copper halide layer to be free of discontinuations of sizes of about 5 nm² or greater; and wherein the copper halide layer conforms to the shape of the metal substrate.

It is believed that claims 1-3, 7-8, 19-20, 29/(2, 19-20), and 41-44 read on this first named invention, and thus these claims will be searched without fee to the extent that they encompass the combination, composition and method, described above.

Applicant is invited to elect additional composition(s) and method(s), wherein each additional composition and method elected will require one additional invention fee. Applicants must specify the claims that encompass any additionally elected composition and method. Applicants must further indicate, if applicable, the claims which encompass the first named invention, if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the '+' group(s) will result in only the first claimed invention to be searched. Additionally, an exemplary election wherein different actual variables are selected is suggested.

An exemplary selection would be an article comprising comprising: a metalloid substrate; and a copper halide layer on the metalloid substrate; wherein the interfacial free energy between the metalloid substrate and the copper halide layer allows the copper halide layer to be free of discontinuations of sizes of about 5 nm² or greater; and wherein the copper halide layer conforms to the shape of the metalloid substrate (claims 1-3, 9, 21, 29/(2, 21), 41-44).

Group II: Claims 47-64 and 70-75 directed to a method of fabricating an article, comprising: providing a substrate; and depositing a copper halide layer on the substrate using a chemical vapor deposition process; wherein the interfacial free energy between the substrate and the copper halide layer allows the copper halide layer to form free of discontinuations of sizes of about 5 nm² or greater; and wherein the copper halide layer conforms to the shape of the substrate, and a method of fabricating a CuCl, CuBr, or CuI layer comprising: providing a substrate; and depositing the CuCl, CuBr, or CuI layer on the substrate using a chemical vapor deposition process, wherein the chemical vapor deposition process comprises a reaction between vinyltrimethylsilane(hexafluoroacetylacetonato)copper(I) and a hydrogen halide selected from the group consisting of HCl, HBr, and HI.

Group II requires a method of fabricating a CuCl, CuBr, or CuI layer comprising: providing a substrate; and depositing the CuCl, CuBr, or CuI layer on the substrate using a chemical vapor deposition process, wherein the chemical vapor deposition process comprises a reaction between vinyltrimethylsilane(hexafluoroacetylacetonato)copper(I) and a hydrogen halide selected from the group consisting of HCl, HBr, and HI, not specifically required by Group I+.

Common Technical Features:

The inventions of Group I+ share the technical features of an article comprising: a substrate; and a copper halide layer on the substrate; wherein the interfacial free energy between the substrate and the copper halide layer allows the copper halide layer to be free of discontinuations of sizes of about 5 nm² or greater; and wherein the copper halide layer conforms to the shape of the substrate.

Groups I+ and II share the technical feature of an article comprising: a substrate; and a copper halide layer on the substrate.

However, these shared technical features do not represent a contribution over prior art, because the shared technical feature is obvious over US 7,772,556 B2 to Reddy et al. (hereinafter 'Reddy'). Reddy discloses an article (Abstract - '...This invention relates to a detection system for detecting an analyte in a fluid medium...') comprising: a substrate (Abstract - '...The detection system comprises a substrate that provides mechanical stability and is sized and shaped to intercept an infrared beam...'); and a copper halide layer on the substrate (col 3 in 46-57 - '...Any suitable reactive material or combinations of different reactive materials can be coated on the substrate. The reactive material is infrared amenable... In a particular embodiment, the reactive material is a metal halide, and more particularly a copper halide such as CuI or CuBr...'); and wherein the copper halide layer conforms to the shape of the substrate (col 4 in 3-6 - '...The coating of reactive material can have any suitable thickness, which can vary widely depending on a particular application. In one embodiment, the reactive material forms a relatively thin coating or film on the substrate...'), but does not further specifically disclose wherein the interfacial free energy between the substrate and the copper halide layer allows the copper halide layer to be free of discontinuations of sizes of about 5 nm² or greater. However, as Reddy discloses that the films may be uniform (col 5 in 63-65 - '...In a second approach, uniform films were deposited by thermal evaporation in an evaporation chamber using approximately 50 mg of pure CuI...') it would have been obvious to one of ordinary skill in the art to create the article wherein the interfacial free energy between the substrate and the copper halide layer allows the copper halide layer to be free of discontinuations of sizes of about 5 nm² or greater, through routine experimentation.

As the shared technical features were known in the art at the time of the invention, they cannot be considered common technical features that would otherwise unify the groups. Therefore, Groups I+ and II lack unity under PCT Rule 13.