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(81) Designated States (unless otherwise indicated, for every kind of national protection available):

AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, 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, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,

(54) Title: THERMOFORMABLE ELECTRONIC SUBSTRATES

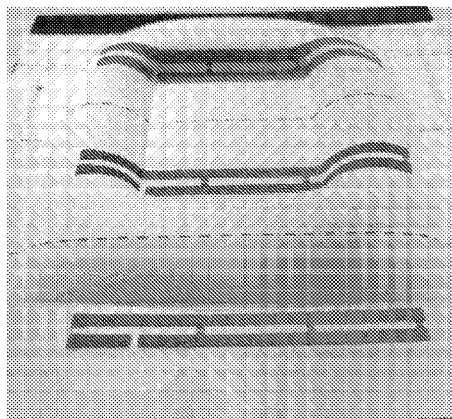


FIG. 5B

(57) Abstract: A thermoformable electronic substrate having a first substrate layer of 4-way stretch fabric that includes at least one conductive trace printed thereon and a second substrate layer of a thermoformable polymer or textile. The first substrate layer may be laminated to a surface of the second substrate layer via an extensible adhesive, heat, or both. The conductive trace is formed by printing a particle-free conductive ink on the first substrate layer either before or after lamination to the second substrate layer. The conductive traces may form connecting wires for standard electronic elements, or electronic elements such as resistive heaters, circuits, sensors such as thermal sensors, humidity sensors, proximity sensors, pressure sensors, and the like. The thermoformable electronic substrates may be thermoformed to create three dimensional parts useful in a wide range of industries.

SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*

(88) Date of publication of the international search report:

24 April 2025 (24.04.2025)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/34359

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. B32B 37/14, B32B 27/00, C09D 11/52, B29C 51/02 (2024.01)

ADD. H05B 3/34, B29C 65/02 (2024.01)

CPC - INV. B32B 37/14, B32B 27/00, C09D 11/52, B29C 51/02

ADD. H05B 3/34, B29C 65/02

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.
Y	US 2003/0121140 A1 (ARX et al.) 03 July 2003 (03.07.2003) entire document; especially Fig. 5; para [0008], para [0048]-[0050]	1-27
Y	WO 2022/251742 A1 (LIQUID X PRINTED METALS, INC.) 01 December 2022 (01.12.2022) entire document; especially para [0008], para [0019], para [0168]	1-27
A	US 2019/0249026 A1 (LIQUID X PRINTED METALS, INC.) 15 August 2019 (15.08.2019) entire document	1-27

☐ 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

15 October 2024

Date of mailing of the international search report

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Name and mailing address of the ISA/US

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/34359

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.: 28-31, 54-62
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:
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 1-27 are directed to a thermoformable printed electronic substrate.

Group II: Claims 32-53 are directed to a method for forming a thermoformable printed electronic substrate

---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.:
1-27

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 24/34359

Continuation of Box No. III -- Observations where unity of invention is lacking

The groups of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features

Group I includes the special technical feature of the particle-free conductive ink comprises a silver amine carboxylate and at least one polar protic solvent and is absent hydrocarbons, not included in the other group.

Group II includes the special technical feature of inkjet or aerosol jet printing, not included in the other group.

Common Technical Features:

The only technical feature shared by Groups I-II that would otherwise unify the groups is a thermoformable printed electronic substrate comprising: a first substrate layer comprising a stretchable textile having at least one conductive trace printed thereon with a particle free conductive ink; and a second substrate layer comprising a thermoformable substrate, wherein the first substrate layer is laminated to the second substrate layer via extensible liquid adhesive or an extensible adhesive tape. However, this shared technical feature does not represent a contribution over the prior art, because the shared technical feature is disclosed by US 2022/0239236 A1 to Liquid X Printed Metals, Inc. (hereinafter "Liquid").

Liquid discloses a thermoformable printed electronic substrate (para [0005]- power electronic devices and may be stably integrated on a flexible substrate such as a textile; para [0017]- the raised pattern may be formed by thermoforming or embossing the second flexible layer) comprising: a first substrate layer (corresponding to the lower fabric of layer 2) comprising a stretchable textile having at least one conductive trace printed thereon with a particle free conductive ink; and a second substrate layer comprising a thermoformable substrate (corresponding to the electron accepting material) (Fig. 2; para [0007]- a first flexible layer having a first electron donating material coated on at least a first surface and an electron accepting material coated over the first electron donating material; para [0025]; para [0051]- the electron donating material may be a conductive film deposited by a particle-free conductive ink; para [0055]- The electron accepting material may be a flexible polymeric material, such as polyimide (e.g., KAPTON) (It is noted KAPTON is a thermoformable material)), wherein the first substrate layer is laminated to the second substrate layer via an extensible liquid adhesive or an extensible adhesive tape (Fig. 2; para [0136]- all or a portion of the electron donating layer may be coated with a polymer coating, such as an adhesive, flexible polymer film...polymer films that provide a balance of hardness and flexibility are preferred. Suitable coatings may be comprised of polyurethane film formers and may be waterborne or solvent base.).

Accordingly, the inventions listed as Groups I-II above lack unity of invention under PCT Rule 13 because they do not share a same or corresponding special technical feature providing contribution over prior art.

NOTE: Item 4: Claims 28-31, 54-62 have been held unsearchable because they are not drafted in accordance with the second and third sentences of Rule 6.4(a).