(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 August 2016 (25.08.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/133571 A3

(51) International Patent Classification:
B32B 9/00 (2006.01) *B32B 3/00* (2006.01)

(21) International Application Number:
PCT/US2015/062832

(22) International Filing Date:
27 November 2015 (27.11.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/085,125 26 November 2014 (26.11.2014) US
62/171,095 4 June 2015 (04.06.2015) US

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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, 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, KR, 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 every kind of regional protection available)*: ARIPO (BW, GH,

[Continued on next page]

(54) Title: LASER INDUCED GRAPHENE HYBRID MATERIALS FOR ELECTRONIC DEVICES

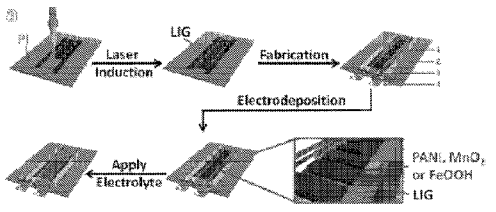


FIG. 2A

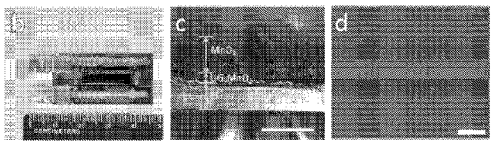


FIG. 2B FIG. 2C FIG. 2D

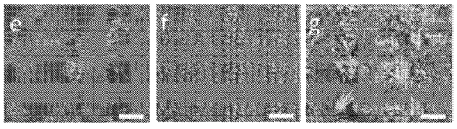


FIG. 2E FIG. 2F FIG. 2G

FIG. 2

(57) Abstract: In some embodiments, the present disclosure pertains to methods of producing a graphene hybrid material by exposing a graphene precursor material to a laser source to form a laser-induced graphene, where the laser-induced graphene is derived from the graphene precursor material. The methods of the present disclosure also include a step of associating a pseudocapacitive material (e.g., a conducting polymer or a metal oxide) with the laser-induced graphene to form the graphene hybrid material. The formed graphene hybrid material can become embedded with or separated from the graphene precursor material. The graphene hybrid materials can also be utilized as components of an electronic device, such as electrodes in a microsupercapacitor. Additional embodiments of the present disclosure pertain to the aforementioned graphene hybrid materials and electronic devices.

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

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
13 October 2016

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 15/62832

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B32B 9/00; B32B 3/00 (2016.01)
CPC - C04B 41/009; C23C 16/26; B82Y 30/00
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)
IPC(8): B32B 9/00; B32B 3/00 (2016.01)
CPC: C04B 41/009; C23C 16/26; B82Y 30/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 428/408, 428/206, 423/447.2 (key word limited; see search terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google Scholar
Search terms used: graphene hybrid material, graphene precursor material, laser source, laser-induced graphene, pseudocapacitive

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012/0214068 A1 (DAI et al.) 23 August 2012 (23.08.2012); para [0006], [0009], [0072], [0075], [0078]-[0079], [0081], [0084], [0092], [0095], [0098], [0112], [0120], [0123], [0133]	1-99
Y	WO 2011/112598 A1 (WILLIAM MARSH RICE UNIVERSITY) 15 September 2011 (15.09.2011); para [0040], [0043], [0048], [0061], [0073], [0076], [0084], [00103], [00105]-[00106], [00114]-[00115], [00117]	1-99
Y	US 2012/0048195 A1 (LIN) 01 March 2012 (01.03.2012); para [0019], [0021], [0023], [0025]	6-11
Y	WO 2013/134207 A1 (THE REGENTS OF THE UNIVERSITY OF CALIFORNIA) 05 March 2013 (05.03.2013); para [0010], [0076], [0095], [00103], [00113]	14, 22, 56, 63, 67, 93, 99
Y	US 8,617,669 B1 (QUICK et al.) 31 December 2013 (31.12.2013); col 11 ln 18-19; col 18 ln 2-3	15, 47, 51, 82, 88
Y	US 2014/0272172 A1 (ZHAMU et al.) 18 September 2014 (18.09.2014); para [0038]	24-25, 69
Y	US 2014/0087192 A1 (LAI et al.) 27 March 2014 (27.03.2014); para [0049], [0052]-[0053]	27-29, 71-73
Y	LEE S. et al., "Production of novel FeOOH/reduced graphene oxide hybrids and their performance as oxygen reduction reaction catalysts", Carbon [online], 22 August 2014 (22.08.2014) [retrieved on 2016-07-09], Volume 80, retrieved from the Internet: <DOI: 10.1016/j.carbon.2014.08.047>, pp. 127-134; see entire document, especially pg 128	32, 76
Y	KHDARY, N. H. et al., "Mesoporous Polyaniline Films for High Performance Supercapacitors", Journal of The Electrochemical Society [online], 04 June 2014 (04.06.2014) [retrieved on 2016-07-09], Volume 161, Issue 9, retrieved from the Internet: <DOI: 10.1149/2.0441409jes>, pp. G63-G68; see entire document, especially pg G64 and G66	38-39

☒ Further documents are listed in the continuation of Box C. ☐

* 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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"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	Date of mailing of the international search report
08 July 2016	18 AUG 2016

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 15/62832

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2014/081387 A1 (NANYANG TECHNOLOGICAL UNIVERSITY) 30 May 2014 (30.05.2014); para [0019], [0065], [0069], [0096]	60-62, 96-98
A	US 2014/0313636 A1 (TOUR et al.) 23 October 2014 (23.10.2014); entire document	1-99
A	US 2013/0323158 A1 (XU et al.) 05 December 2013 (05.12.2013); entire document	1-99