



(51) International Patent Classification:

H05B 3/00 (2006.01) C01B 21/064 (2006.01)
H05B 3/14 (2006.01) C01B 32/15 (2017.01)

(21) International Application Number:

PCT/US2023/067000

(22) International Filing Date:

15 May 2023 (15.05.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/341,934 13 May 2022 (13.05.2022) US

(71) Applicant: **WILLIAM MARSH RICE UNIVERSITY**
[US/US]; 6100 Main Street, Houston, Texas 77005 (US).

(72) Inventors: **TOUR, James M.**; 6100 Main Street, Houston, Texas 77005 (US). **LI, John Tianci**; 6100 Main Street, Houston, Texas 77005 (US). **WYSS, Kevin**; 6100 Main Street, Houston, Texas 77005 (US). **CHEN, Jinhang**; 6100 Main Street, Houston, Texas 77005 (US). **CHEN, Weiyin**; 6100 Main Street, Houston, Texas 77005 (US). **EDDY, Lucas**; 6100 Main Street, Houston, TX 77005 (US). **SCOT-**

LAND, Phelecia; 6100 Main Street, Houston, TX 77005 (US).

(74) Agent: **GARSSON, Ross Spencer**; DICKINSON WRIGHT PLLC, International Square, 1825 Eye St. N.W., Suite 900, Washington, District of Columbia 20006 (US).

(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.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): 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,

(54) Title: FLASH JOULE HEATING FOR PRODUCTION OF 1D CARBON AND/OR BORON NITRIDE NANOMATERIALS

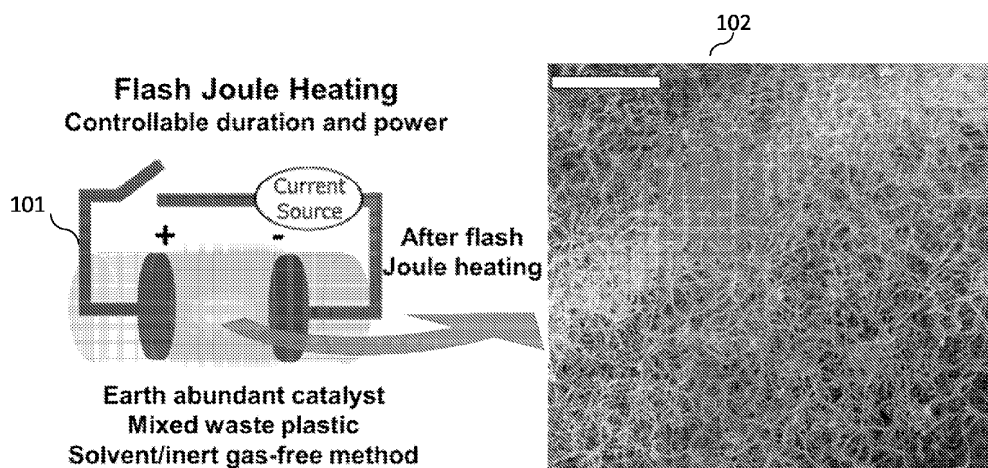


FIG. 1A

(57) Abstract: Flash Joule heating (FJH) for production of one-dimensional (1D) carbon and/or boron nitride nanomaterials, and 1D materials integrated with 0D, 1D, 2D, and 3D nanomaterials, composites, nanostructures, networks, and mixtures thereof. Such materials produced by FJH include 1D carbon and hybrid nanomaterials, boron nitride nanotubes (BNNTs), turbostratic boron-carbon-nitrogen (BCN), doped (substituted) graphene, and heteroatom doped (substituted) re-flashed graphene.

[Continued on next page]

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,
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 the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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:

01 February 2024 (01.02.2024)