



(51) International Patent Classification:

B29C 64/106 (2017.01) *B33Y 30/00* (2015.01)
B29C 64/264 (2017.01) *B33Y 40/00* (2015.01)
B29C 64/393 (2017.01) *B33Y 50/02* (2015.01)

(21) International Application Number:

PCT/US2018/024475

(22) International Filing Date:

27 March 2018 (27.03.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

15/593,947 12 May 2017 (12.05.2017) US

(71) Applicant: **LAWRENCE LIVERMORE NATIONAL SECURITY, LLC** [US/US]; 2300 First Street, Suite 204, Livermore, California 94550 (US).

(72) Inventors: **KELLY, Brett**; c/o Lawrence Livermore National Laboratory, 7000 East Avenue, P.O. Box 808, L-703, Livermore, California 94550 (US). **PANAS, Robert**; c/o Lawrence Livermore National Laboratory, 7000 East Avenue, P.O. Box 808, L-703, Livermore, California 94550 (US). **SHUSTEFF, Maxim**; c/o Lawrence Livermore National Laboratory, 7000 East Avenue, P.O. Box 808, L-703, Livermore, California 94550 (US). **SPADACCINI, Christopher**; c/o Lawrence Livermore National Laboratory, 7000 East Avenue, P.O. Box 808, L-703, Livermore, California 94550 (US). **TAYLOR, Hayden**; 2760 Shasta Road, Berkeley, California 94708 (US). **BHAT-TACHARYA, Indrasen**; 2025 Francisco Street, Apt. E, Berkeley, California 94709 (US).

(74) Agent: **ELCHUK, Mark D.** et al.; Harness, Dickey & Pierce, P.L.C., P.O. Box 828, Bloomfield Hills, Michigan 48303 (US).

(54) Title: SYSTEM AND METHOD FOR COMPUTED AXIAL LITHOGRAPHY (CAL) FOR 3D ADDITIVE MANUFACTURING

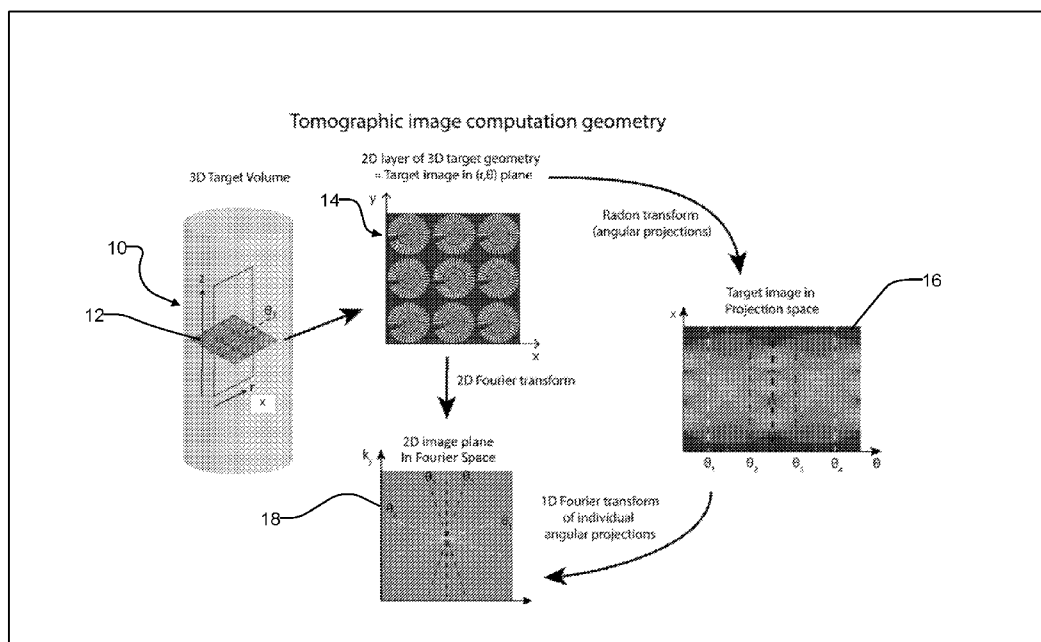


FIGURE 1A

(57) Abstract: A method of forming a three dimensional (3D) object is disclosed. The method may involve providing a volume of photo-curable resin contained within an optically transparent resin container, and simultaneously directing optical projections from an optical subsystem at a plurality of angles θ through the volume of photo-curable resin. The optical beams are directed about a z axis extending through the volume of photo-curable resin. Each of the projections is provided with a calculated 2D spatial intensity function which creates a 3D intensity map. The projections act over a fixed temporal exposure period, during which the net exposure dose is sufficient to cure select portions of the volume of photo-curable resin, and to leave other portions uncured, to form a desired 3D part.



(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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, 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, 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 December 2018 (13.12.2018)

A. CLASSIFICATION OF SUBJECT MATTER

B29C 64/106(2017.01)i, B29C 64/264(2017.01)i, B29C 64/393(2017.01)i, B33Y 30/00(2015.01)i, B33Y 40/00(2015.01)i, B33Y 50/02(2015.01)i

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)

B29C 64/106; B22D 11/01; B22F 9/00; C08F 2/46; G02B 26/06; G02B 27/18; G02B 27/22; H04N 13/04; H04N 5/225; H04N 7/18; B29C 64/264; B29C 64/393; B33Y 30/00; B33Y 40/00; B33Y 50/02

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: 3D printing, CT imaging, optical projection, angles

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010-0029801 A1 (MOSZNER, N. et al.) 04 February 2010 See paragraphs [0002], [0090], [0091]; and figure 1.	1-25
Y	US 8579620 B2 (WU, A.) 12 November 2013 See paragraphs [0001], [0005], [0045].	1-25
Y	US 2010-0321478 A1 (SLIWA, JOHN W. et al.) 23 December 2010 See paragraphs [0147]-[0150], [0152]-[0154]; and figures 2g and 3	1-25
A	WO 2016-023133 A1 (MTT INNOVATION INCORPORATED) 18 February 2016 See the whole document.	1-25
A	US 2016-0182782 A1 (OSTENDO TECHNOLOGIES, INC.) 23 June 2016 See the whole document.	1-25
A	WO 2016-209654 A1 (THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY) 29 December 2016 See the whole document.	1-25

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

"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

07 November 2018 (07.11.2018)

Date of mailing of the international search report

07 November 2018 (07.11.2018)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

KWON, Yong Kyong

Telephone No. +82-42-481-3371



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/024475

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010-0029801 A1	04/02/2010	EP 2151214 A1 JP 2010-031279 A JP 5571917 B2 US 7927538 B2	10/02/2010 12/02/2010 13/08/2014 19/04/2011
US 8579620 B2	12/11/2013	US 2012-0224755 A1 US 2014-0025190 A1 US 2014-0330418 A1 US 2014-0330421 A1 US 2015-0084956 A1 US 2015-0088291 A1 US 2016-0207257 A9 US 2016-0210779 A9 US 8817332 B2	06/09/2012 23/01/2014 06/11/2014 06/11/2014 26/03/2015 26/03/2015 21/07/2016 21/07/2016 26/08/2014
US 2010-0321478 A1	23/12/2010	US 08289274 B2	16/10/2012
WO 2016-023133 A1	18/02/2016	CA 2956844 A1 CN 106662753 A EP 3180652 A1 JP 2017-527111 A US 2017-0138545 A1 US 9874319 B2	18/02/2016 10/05/2017 21/06/2017 14/09/2017 18/05/2017 23/01/2018
US 2016-0182782 A1	23/06/2016	CN 104509088 A EP 2631060 A1 EP 2856747 A1 JP 2015-524202 A JP 6177897 B2 KR 10-2015-0023574 A US 2013-0321581 A1 US 2016-0028935 A1 US 2016-0191765 A1 US 2016-0191823 A1 US 2017-236295 A1 US 9179126 B2 US 9681069 B2 US 9712764 B2 US 9774800 B2 US 9779515 B2 US 9930272 B2 WO 2013-180748 A1	08/04/2015 28/08/2013 08/04/2015 20/08/2015 09/08/2017 05/03/2015 05/12/2013 28/01/2016 30/06/2016 30/06/2016 17/08/2017 03/11/2015 13/06/2017 18/07/2017 26/09/2017 03/10/2017 27/03/2018 05/12/2013
WO 2016-209654 A1	29/12/2016	None	