

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
24 March 2011 (24.03.2011)

(10) International Publication Number  
**WO 2011/034584 A3**

(51) International Patent Classification:  
*G01B 11/24* (2006.01) *G01N 21/41* (2006.01)  
*G02B 6/10* (2006.01)

[US/US]; 404 Alleghany Street, Blacksburg, VA 24060 (US).

(21) International Application Number:  
PCT/US2010/002517

(74) Agent: **LASTOVA, John, R.**; Nixon & Vanderhye P.C., 901 North Glebe Road, 11th Floor, Arlington, VA 22203-1808 (US).

(22) International Filing Date:  
16 September 2010 (16.09.2010)

(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, 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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
61/243,746 18 September 2009 (18.09.2009) US  
61/255,575 28 October 2009 (28.10.2009) US  
61/350,343 1 June 2010 (01.06.2010) US  
12/874,901 2 September 2010 (02.09.2010) US

(71) Applicant (for all designated States except US): **LUNA INNOVATIONS INCORPORATED** [US/US]; 1 Riverside Circle, Suite 400, Roanoke, VA 24016 (US).

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **FROGGATT, Mark, E.** [US/US]; 1751 Brush Mountain Creek Road, Blacksburg, VA 24060 (US). **KLEIN, Justin, W.** [US/US]; 1747 Donlee Dr., Blacksburg, VA 24060 (US). **GIFFORD, Dawn, K.** [US/US]; 2175 Craig Creek Rd., Blacksburg, VA 24060 (US). **KREGGER, Stephen, Tod**

[Continued on next page]

(54) Title: OPTICAL POSITION AND/OR SHAPE SENSING

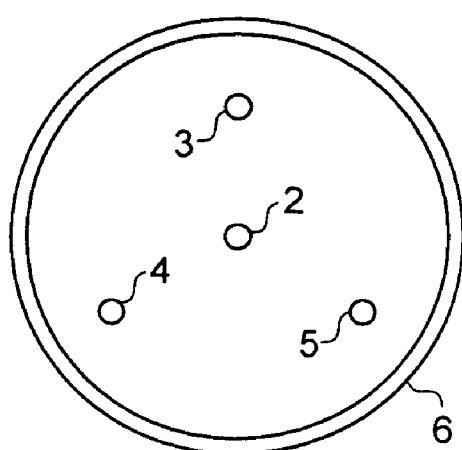


Figure 1

(57) Abstract: An accurate measurement method and apparatus are disclosed for shape sensing with a multi-core fiber. A change in optical length is detected in ones of the cores in the multi-core fiber up to a point on the multi-core fiber. A location and/or a pointing direction are/is determined at the point on the multi-core fiber based on the detected changes in optical length. The accuracy of the determination is better than 0.5% of the optical length of the multi-core fiber up to the point on the multi-core fiber. In a preferred example embodiment, the determining includes determining a shape of at least a portion of the multi-core fiber based on the detected changes in optical length.

WO 2011/034584 A3





**Published:**

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

21 July 2011

- *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))*

**A. CLASSIFICATION OF SUBJECT MATTER***G01B 11/24(2006.01)i, G02B 6/10(2006.01)i, G01N 21/41(2006.01)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)

G01B 11/24; G02B 6/34; G01N 21/00; G02B 6/00; H01J 5/16

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) &amp; Keywords: 'optical', 'position', 'shape', 'sensing', 'phase'

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0212082 A1 (FROGGATT MARK E. et al.) 04 September 2008 See the abstract; claims 1-14; figures 1-31.	1-41
Y	US 2007-0065077 A1 (Brooks A. Childers et al.) 22 March 2007 See the abstract; claims 1-21; figures 1-9.	1-41
A	US 2006-0013523 A1 (Brooks A. Childers et al.) 19 January 2006 See the abstract; claims 1-19; figures 1-9.	1-41
A	US 05798521A A (FROGGATT; MARK E.) 25 August 1998 See the abstract; claims 1-30; figures 1-6.	1-41

 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 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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

31 MAY 2011 (31.05.2011)

Date of mailing of the international search report

**01 JUNE 2011 (01.06.2011)**

Name and mailing address of the ISA/KR

Korean Intellectual Property Office  
Government Complex-Daejeon, 189 Cheongsu-ro,  
Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

LIM, Hyun-suk

Telephone No. 82-42-481-8138



**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2010/002517**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0212082 A1	04.09.2008	US 2006-0013523 A1 US 2007-0065077 A1 US 2008-212082 A1 US 7772541 B2 US 7781724 B2	19.01.2006 22.03.2007 04.09.2008 10.08.2010 24.08.2010
US 2007-0065077 A1	22.03.2007	US 2006-0013523 A1 US 2008-0212082 A1 US 7772541 B2 US 7781724 B2	19.01.2006 04.09.2008 10.08.2010 24.08.2010
US 2006-0013523 A1	19.01.2006	US 2007-0065077 A1 US 2008-0212082 A1 US 7772541 B2 US 7781724 B2	22.03.2007 04.09.2008 10.08.2010 24.08.2010
US 05798521A A	25.08.1998	None	