



(43) International Publication Date
2 August 2012 (02.08.2012)

- (51) International Patent Classification:
G01B 7/28 (2006.01) *G01B 7/16* (2006.01)
- (21) International Application Number:
PCT/US2012/022338
- (22) International Filing Date:
24 January 2012 (24.01.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/435,377 24 January 2011 (24.01.2011) US
- (71) Applicant (for all designated States except US): **PRESIDENT AND FELLOWS OF HARVARD COLLEGE** [US/US]; 17 Quincy Street, Boston, Massachusetts 02138 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **MAJIDI, Carmel Shamim** [US/US]; 401 Amberson Avenue, Apartment 307, Pittsburgh, Pennsylvania 15232 (US). **KRAMER, Rebecca K.** [US/US]; 7 Craigie Circle, Cambridge, Massachusetts 02138 (US). **WOOD, Robert J.** [US/US]; 1 Wood Street, Cambridge, Massachusetts 02140 (US).
- (74) Agents: **RESNICK, David S.** et al.; Nixon Peabody LLP, 100 Summer Street, Boston, Massachusetts 02110 (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, 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, QA, RO, RS, RU, RW, 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, 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, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

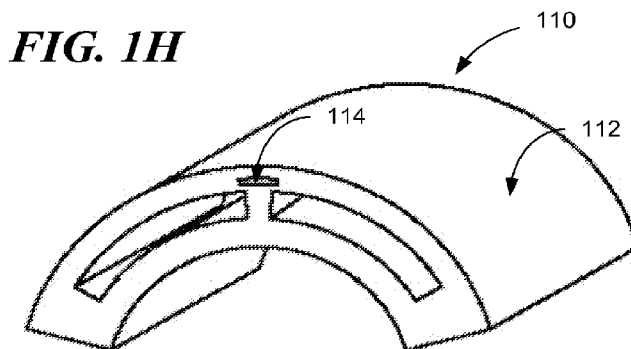
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

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

[Continued on next page]

(54) Title: NON-DIFFERENTIAL ELASTOMER CURVATURE SENSOR



(57) Abstract: A hyperelastic, soft microfluidic film measures bending curvature using a novel non-differential mechanism. Disclosed embodiments of the elastomer-based solution allows for curvature sensing directly on a bending plane and thus eliminates limitations imposed by strain gauge factor (GF) and sensor thickness (Z). Due to soft lithography microfabrication and design methods the disclosed curvature sensors are elastically soft (modulus 0.1-1 MPa) and stretchable (100-1000% strain). In contrast to existing curvature sensors that measure differential strain, embodiments of the present invention measures curvature directly and allows for arbitrary gauge factor and film thickness. Moreover, the sensor is composed entirely of soft elastomer (PDMS or Ecoflex® and conductive liquid (eutectic gallium indium, (eGaIn)) and thus remains functional even when stretched to several times its natural length. Electrical resistance in the embedded eGaIn microchannel is measured as a function of bending curvature for a variety of sensor designs.



— *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:
1 November 2012

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/022338**A. CLASSIFICATION OF SUBJECT MATTER****G01B 7/28(2006.01)i, G01B 7/16(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 7/28; G01C 9/06; G01B 7/16; G01C 9/24; H01C 17/28

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: curvature, bending, strain, sensor, PDMS, conductive fluid, strut, and resistivity.**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2010-0132476 A1 (CHENG; CHING-HSIANG et al.) 03 June 2010 See abstract; paragraphs [48]-[58]; claim 1; Figs. 4-6.	1 2-14
X A	US 7500399 B2 (CHENG; CHING HSIANG et al.) 10 March 2009 See abstract; col. 1, l. 53-col. 3, l. 58; Figs. 1, 2.	1 2-14
A	US 04570354 A (HINDES; CHARLES S.) 18 February 1986 See the whole document.	1-14
A	JP 06-258076 A (TOPCON CORP.) 16 September 1994 See the whole document.	1-14

☐ 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

"&" document member of the same patent family

Date of the actual completion of the international search

27 AUGUST 2012 (27.08.2012)

Date of mailing of the international search report

28 AUGUST 2012 (28.08.2012)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan
City, 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM Sang Woo

Telephone No. 82-42-481-8384



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2012/022338

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010-0132476 A1	03.06.2010	CN 101839703 A US 7854173 B2	22.09.2010 21.12.2010
US 7500399 B2	10.03.2009	CN 101339001 A CN 101339001 B US 2009-0007685 A1	07.01.2009 13.04.2011 08.01.2009
US 04570354 A	18.02.1986	None	
JP 06-258076 A	16.09.1994	None	