



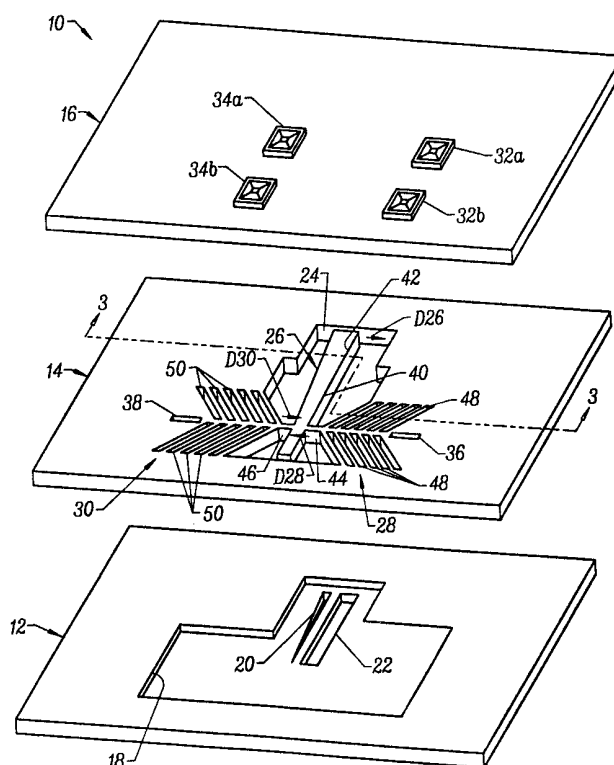
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>F15C 5/00, B60T 8/36</b>		A3	(11) International Publication Number: <b>WO 00/14415</b>
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(21) International Application Number: PCT/US99/19971 (22) International Filing Date: 31 August 1999 (31.08.99) (30) Priority Data: 09/148,026                      3 September 1998 (03.09.98)                      US (71) Applicant (for all designated States except US): LUCAS NOVASENSOR [US/US]; 1055 Mission Court, Fremont, CA 94539 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): MALUF, Nadim, I. [US/US]; 347 Sierra Vista Avenue, Mountain View, CA 94043 (US). WILLIAMS, Kirt, R. [US/US]; 185 Willowbrook Drive, Portola Valley, CA 94028 (US). VAN DRIEËNHUIZEN, Bert, P. [NL/US]; 37250 Sequoia Terrace #1032, Fremont, CA 94536 (US). FULLER, Edward, Nelson [US/US]; 17750 Sharon Valey Road, Manchester, MI 48158 (US). BARRON, Richard, J. [GB/US]; 3407 Cromwell Court, Ann Arbor, MI 48105 (US). (74) Agents: HOLLAND, Charles, D. et al.; Morrison & Foerster LLP, 755 Page Mill Road, Palo Alto, CA 94304-1018 (US).			(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>  (88) Date of publication of the international search report: 6 July 2000 (06.07.00)

(54) Title: PROPORTIONAL MICROMECHANICAL DEVICE

## (57) Abstract

The present invention provides a proportional microvalve (10) having a first (12), second (14) and third layer (16), and having high aspect ratio geometries. The first layer (12) defines a cavity (24) with inlet (20) and outlet (22) ports. The second layer (14), doped to have a low resistivity and bonded between the first (12) and third (16) layers, defines a cavity (24) having a flow area to permit fluid flow between the inlet (20) and outlet (22) ports. The second layer (14) further defines an actuatable displaceable member (26), and one or more thermal actuators (28, 30) for actuating the displaceable member (26) to a position between and including an open and a closed position to permit or occlude fluid flow. The third layer (16) provides one wall of the cavity (24) and provides electrical contacts (32a, 32b, 34a, 34b) for electrically heating the thermally expandable actuators (28, 30). The thermal actuators (28, 30) and the displaceable member (26) have high aspect ratios and are formed by deep reactive ion etching such that they are displaceable in the plane of the second layer (14) while being very stiff out of the plane. Thus, both actuation and displacement of the displaceable member (26) are in the plane of the layer.



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# INTERNATIONAL SEARCH REPORT

International Application No

PL /US 99/19971

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 F15C5/00 B60T8/36

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 7 F15C B60T H01H

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 practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NOWOROLSKI J M ET AL: "Process for in-plane and out-of-plane single-crystal-silicon thermal microactuators" SENSORS AND ACTUATORS A,CH,ELSEVIER SEQUOIA S.A., LAUSANNE, vol. 55, no. 1, 1996, page 65-69 XP004031715 ISSN: 0924-4247 page 66, paragraph 3.1; figures 3-6 --- -/--	1-50, 56-70, 76-97

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

20 December 1999

Date of mailing of the international search report

15. 03. 2000

Name and mailing address of the ISA

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/19971

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 41 01 575 A (ROBERT BOSCH) 23 July 1992 (1992-07-23)  column 6, line 38 -column 7, line 27; figures 1,3,4 ---	1-5, 7-10, 12-16, 18-29, 31-37, 39, 41-45, 47-50, 56-71, 76-79, 81,82, 87-89, 91-95,97
P,X	WO 99 16096 A (MAHADEVAN RAMASWAMY ;WOOD ROBERT L (US); MCNC (US); DHULER VIJAYAK) 1 April 1999 (1999-04-01) abstract; figure 1 ---	1-50, 56-70, 76-97
A	DE 44 17 251 A (ROBERT BOSCH) 23 November 1995 (1995-11-23) column 2, line 59 - line 62; figure 1 ---	23
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A	DE 44 22 942 A (ROBERT BOSCH) 4 January 1996 (1996-01-04) ---	
A	US 5 179 499 A (YAO) 12 January 1993 (1993-01-12) -----	

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 99/ 19971

### Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

CLAIMS : 1-50, 56-97  
CLAIMS : 51-55

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
  
1-50, 56-97

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

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Information on patent family members

International Application No

PC., US 99/19971

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