



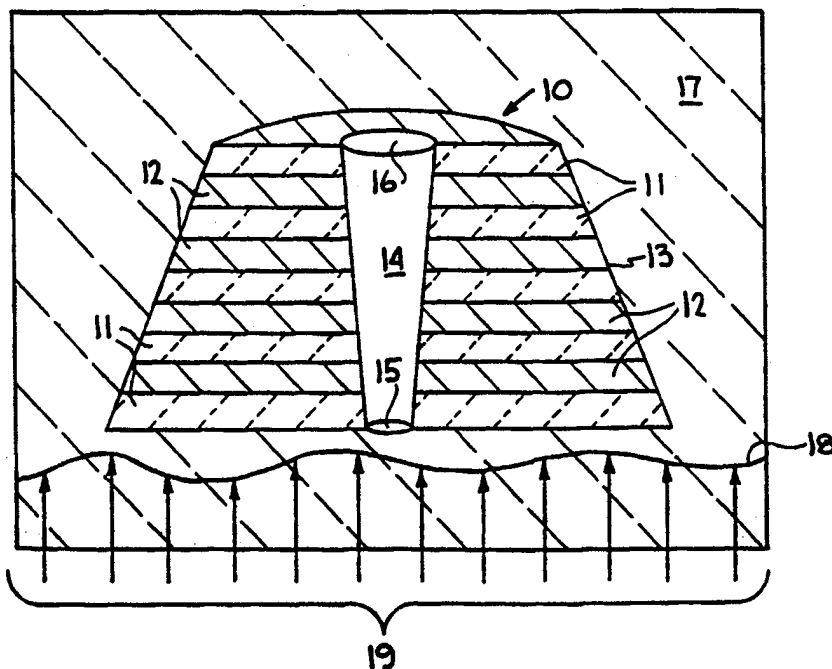
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                          |                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| <b>(51) International Patent Classification<sup>6</sup>:</b><br><b>H04R 17/00, H01L 41/083, 41/24</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>A3</b>                                                                                                                                                                                                                                                                                                | <b>(11) International Publication Number:</b> <b>WO 98/24296</b><br><b>(43) International Publication Date:</b> 11 June 1998 (11.06.98) |
| <b>(21) International Application Number:</b> PCT/US97/21302<br><b>(22) International Filing Date:</b> 20 November 1997 (20.11.97)<br><b>(30) Priority Data:</b><br>60/031,465 20 November 1996 (20.11.96) US<br><b>(71) Applicant (for all designated States except US):</b> THE REGENTS OF THE UNIVERSITY OF CALIFORNIA [US/US]; 22nd floor, 300 Lakeside Drive, Oakland, CA 94612 (US).<br><b>(72) Inventors; and</b><br><b>(75) Inventors/Applicants (for US only):</b> O'BRIEN, Dennis, W. [US/US]; 864 Plaza Avenue, Livermore, CA 94550 (US). BARBEE, Troy, W., Jr. [US/US]; 4061 Sutherland Drive, Palo Alto, CA 94303 (US).<br><b>(74) Agent:</b> SARTORIO, Henry, P.; P.O. Box 808, L-703, Livermore, CA 94550 (US). | <b>(81) Designated States:</b> CA, JP, KR, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).<br><b>Published</b><br><i>With international search report.</i><br><b>(88) Date of publication of the international search report:</b><br>1 October 1998 (01.10.98) |                                                                                                                                         |

**(54) Title:** MULTILAMINATE PIEZOELECTRIC HIGH VOLTAGE STACK

**(57) Abstract**

A shock or strain driven multilaminate piezoelectric high voltage stack (10) and fabrication process. The nanostructure includes alternating layers of piezoelectric (12) and conductor materials (11) forming a cylinder or similarly shaped stack of piezoelectric layers (12). For accelerator application the piezoelectric layers (12) have a coaxial cavity (14). Very high voltages can be generated when the piezoelectric stack (10) is subjected to mechanical shock. As shock propagates through piezoelectric stack (10) each layer of piezoelectric material (12) generates a voltage potential between its two adjacent conductor layers (11). For accelerator applications, charged particles at one end (15) of cavity in stack (10) are accelerated through cavity (14) to target (16). The piezoelectric stack (10) can be fabricated with discrete layers of piezoelectric (12) and conductor materials (11) stacked and mechanically bound within packaging (17). Alternatively, integrated solid state piezoelectric stacks (10) can be fabricated by successive masked deposition of piezoelectric (12) and conductor materials (11). Deposition of materials can be by physical or chemical vapor deposition, including RF sputtering and similar techniques.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

|           |                          |           |                                          |           |                                              |           |                          |
|-----------|--------------------------|-----------|------------------------------------------|-----------|----------------------------------------------|-----------|--------------------------|
| <b>AL</b> | Albania                  | <b>ES</b> | Spain                                    | <b>LS</b> | Lesotho                                      | <b>SI</b> | Slovenia                 |
| <b>AM</b> | Armenia                  | <b>FI</b> | Finland                                  | <b>LT</b> | Lithuania                                    | <b>SK</b> | Slovakia                 |
| <b>AT</b> | Austria                  | <b>FR</b> | France                                   | <b>LU</b> | Luxembourg                                   | <b>SN</b> | Senegal                  |
| <b>AU</b> | Australia                | <b>GA</b> | Gabon                                    | <b>LV</b> | Latvia                                       | <b>SZ</b> | Swaziland                |
| <b>AZ</b> | Azerbaijan               | <b>GB</b> | United Kingdom                           | <b>MC</b> | Monaco                                       | <b>TD</b> | Chad                     |
| <b>BA</b> | Bosnia and Herzegovina   | <b>GE</b> | Georgia                                  | <b>MD</b> | Republic of Moldova                          | <b>TG</b> | Togo                     |
| <b>BB</b> | Barbados                 | <b>GH</b> | Ghana                                    | <b>MG</b> | Madagascar                                   | <b>TJ</b> | Tajikistan               |
| <b>BE</b> | Belgium                  | <b>GN</b> | Guinea                                   | <b>MK</b> | The former Yugoslav<br>Republic of Macedonia | <b>TM</b> | Turkmenistan             |
| <b>BF</b> | Burkina Faso             | <b>GR</b> | Greece                                   | <b>ML</b> | Mali                                         | <b>TR</b> | Turkey                   |
| <b>BG</b> | Bulgaria                 | <b>HU</b> | Hungary                                  | <b>MN</b> | Mongolia                                     | <b>TT</b> | Trinidad and Tobago      |
| <b>BJ</b> | Benin                    | <b>IE</b> | Ireland                                  | <b>MR</b> | Mauritania                                   | <b>UA</b> | Ukraine                  |
| <b>BR</b> | Brazil                   | <b>IL</b> | Israel                                   | <b>MW</b> | Malawi                                       | <b>UG</b> | Uganda                   |
| <b>BY</b> | Belarus                  | <b>IS</b> | Iceland                                  | <b>MX</b> | Mexico                                       | <b>US</b> | United States of America |
| <b>CA</b> | Canada                   | <b>IT</b> | Italy                                    | <b>NE</b> | Niger                                        | <b>UZ</b> | Uzbekistan               |
| <b>CF</b> | Central African Republic | <b>JP</b> | Japan                                    | <b>NL</b> | Netherlands                                  | <b>VN</b> | Viet Nam                 |
| <b>CG</b> | Congo                    | <b>KE</b> | Kenya                                    | <b>NO</b> | Norway                                       | <b>YU</b> | Yugoslavia               |
| <b>CH</b> | Switzerland              | <b>KG</b> | Kyrgyzstan                               | <b>NZ</b> | New Zealand                                  | <b>ZW</b> | Zimbabwe                 |
| <b>CI</b> | Côte d'Ivoire            | <b>KP</b> | Democratic People's<br>Republic of Korea | <b>PL</b> | Poland                                       |           |                          |
| <b>CM</b> | Cameroon                 | <b>KR</b> | Republic of Korea                        | <b>PT</b> | Portugal                                     |           |                          |
| <b>CN</b> | China                    | <b>KZ</b> | Kazakhstan                               | <b>RO</b> | Romania                                      |           |                          |
| <b>CU</b> | Cuba                     | <b>LC</b> | Saint Lucia                              | <b>RU</b> | Russian Federation                           |           |                          |
| <b>CZ</b> | Czech Republic           | <b>LI</b> | Liechtenstein                            | <b>SD</b> | Sudan                                        |           |                          |
| <b>DE</b> | Germany                  | <b>LK</b> | Sri Lanka                                | <b>SE</b> | Sweden                                       |           |                          |
| <b>DK</b> | Denmark                  | <b>LR</b> | Liberia                                  | <b>SG</b> | Singapore                                    |           |                          |
| <b>EE</b> | Estonia                  |           |                                          |           |                                              |           |                          |

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US97/21302

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04R 17/00; H01L 41/083, 41/24

US CL : 310/328,338,364

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)

U.S. : 310/328,338,364

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

N/A

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

USPTO APS, WPID on STN

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category*   | Citation of document, with indication, where appropriate, of the relevant passages                                                                      | Relevant to claim No.    |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| X<br>—<br>Y | US 5,196,756 A (KOHNO et al) 23 March 1994 (23.03.94)<br>col. 5, ll. 64-67; col. 3, ll. 49-50; figs. 1, 2                                               | 1,4,5<br>—<br>6,9        |
| X<br>—<br>Y | US 5,191,687 A (DAM et al) March 09, 1993 (09/03/93)<br>col. 2, ll. 53-56; col. 4, ll. 43-45; col. 4, ll 13-16;<br>col. 4, ll. 24-26; col. 3, ll. 55-58 | 16,19 4-8<br>—<br>14, 15 |
| X<br>—<br>Y | US 5,163,209 A (HARADA et al) 17 November 1992 (17.11.92)<br>col. 7, ll. 33-47, col. 10, l. 29; col. 11, ll. 20-25                                      | 16, 17, 19<br>—<br>4     |



Further documents are listed in the continuation of Box C.



See patent family annex.

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Special categories of cited documents:                                                                                                                                | *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                                              |
| *A* document defining the general state of the art which is not considered to be of particular relevance                                                                | *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                                                                     |
| *B* earlier document published on or after the international filing date                                                                                                | *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 |
| *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) | *G* document member of the same patent family                                                                                                                                                                                                    |
| *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                                                                  |                                                                                                                                                                                                                                                  |

Date of the actual completion of the international search

02 FEBRUARY 1998

Date of mailing of the international search report

23 JUN 1998

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

Thomas M. Dougherty  
Telephone No. (703) 308-1628

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/21302

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

| Category*     | Citation of document, with indication, where appropriate, of the relevant passages                                        | Relevant to claim No.      |
|---------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------|
| X<br>—<br>Y   | US 4,570,098 A (TOMITA et al) 11 February 1986 (11.02.86)<br>figs. 2, 4; col. 2, ll 24-35; col. 5, ll. 31-32              | 16<br>5, 7,<br>8, 14, 15   |
| X,P<br>—<br>Y | US 5,631,463 A (KAWASAKI et al) 20 May 1997 (20.05.97)<br>fig. IE; col. 4, ll 16-21; col. 4, ll. 49-55; col. 6, ll. 51-56 | 16,17,19<br>1816           |
| X<br>—<br>Y   | US 4,632,856 A (MARCUS et al) 30 December 1986 (30.12.86)<br>Figs. 1-3; col. 5, ll. 42-46 and ll. 65-68                   | 16,17,19<br>41             |
| Y             | US 3,281,612 A (HATSCHEK) 25 October 1966 (25.10.66)<br>Fig. 1, col. 4, ll. 31-35                                         | 18                         |
| Y             | US 3,111,741 A (ALLEN et al) 26 November 1963 (26.11.63)<br>Fig. 2                                                        | 18                         |
| Y             | US 5,325,012 A (SATO et al) 28 June 1994 (28.06.94)<br>col. 2, l. 46; col. 4, l.65                                        | 181                        |
| X<br>—<br>Y   | US 4,835,436 A (LEW) 30 May 1989 (30.05.89)<br>Fig. 3                                                                     | 1,2,11-13<br>4-9, 14,15    |
| X<br>—<br>Y   | US 5,036,240 A (LEW) 30 July 1991 (30.07.91)<br>Fig. 11                                                                   | 1,2,11-13<br>4-9, 14, 15   |
| X<br>—<br>Y   | US 3,390,287 A (SONDEREGGER) 25 June 1968 (25.06.68)<br>Fig. 8; col. 1, ll. 11-14                                         | 1,2, 11-13<br>4-9, 14, 151 |
| X<br>—<br>Y   | US 4,752,712 A (TOMITA et al) 21 June 1988 (21.06.88) Fig. 5;<br>cl. 1; col. 5, ll. 24-30                                 | 1, 5<br>6, 9               |
| X<br>—<br>Y   | US 4,978,881 A (WAKITA et al) 18 December 1990 (18.12.90)<br>Fig. 3; col. 3, ll. 15-17                                    | 1, 5<br>6, 9               |
| A             | US 2,479,926 A (GRAVELY) 23 August 1949 (23.08.49)<br>Fig. 9                                                              | 1, 111                     |
| X             | US 5,568,679 A (OHYA et al) 29 October 1996 (29.10.96) col. 3,                                                            | 16                         |

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/21302

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

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------|-----------------------|
| Y         | US 3,824,352 A (ADLER et al ) 16 July 1974 (16.07.74)<br>Fig. 2                    | 9                     |
| Y         | US 5,410,208 A (WALTERS et al) 25 April 1995 (25.04.95)<br>Fig. 6                  | 9                     |
| Y         | US 4,812,698 A (CHIDA et al) 14 March 1989 (14.03.89)<br>claim 9                   | 6                     |