



(43) International Publication Date
26 October 2012 (26.10.2012)

- (51) International Patent Classification:
H01L 21/311 (2006.01)
- (21) International Application Number:
PCT/EP2012/056901
- (22) International Filing Date:
16 April 2012 (16.04.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
11305473.8 20 April 2011 (20.04.2011) EP
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(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).

Published:

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

(54) Title: METHOD FOR ETCHING A BST LAYER

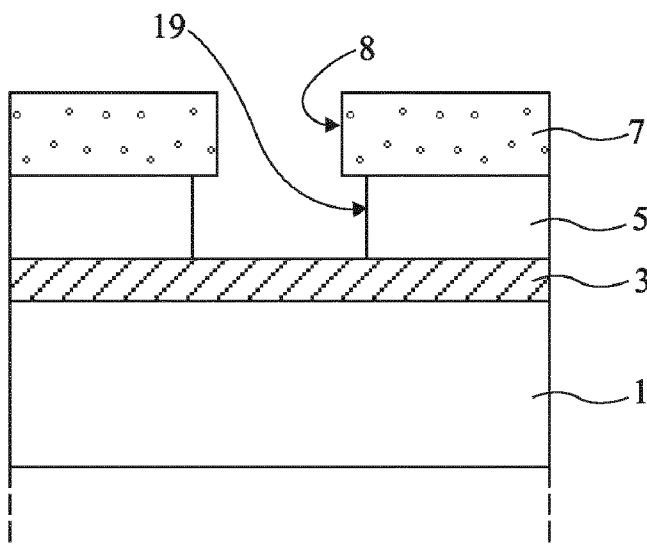


Fig 2A

(57) Abstract: The invention concerns a method for etching a PVD deposited barium strontium titanate (BST) layer, wherein a non-ionic surfactant at a concentration between 0.1 and 1 percent is added to an acid etching solution.

METHOD FOR ETCHING A BST LAYER

FIELD OF THE INVENTION

The present invention relates to a method of etching a ferroelectric material. It more specifically relates to a method for etching a barium strontium titanate layer (BST), used in the
5 fabrication of tunable capacitors.

BACKGROUND OF THE INVENTION

In some specific structures, there is a need for the fabrication of tunable capacitors, the capacitance of which varies as a function of the applied voltage. To manufacture such
10 capacitors, it has been proposed to use barium strontium titanate, $(\text{BaSr})\text{TiO}_3$, or BST, as a dielectric.

Figure 1A shows such a capacitor during an intermediate manufacturing step. On a substrate 1 is formed a metallic layer 3, generally in platinum. On this layer, a BST
15 layer 5 has been deposited, itself covered with a photoresist 7, in which an opening 8 has been formed by photolithography at the position where it is desired to form an opening 9 in the BST layer.

Figure 1A shows the structure after photolithography
20 of layer 7 and etching of layer 5. Figure 1B is a top view of the structure at this step. The etching of the BST layer is conventionally performed using an acid etching solution of hydrofluoric acid and nitric acid. It can be noticed that the etching of the BST layer 5 suffers from several drawbacks.
25 Firstly, the etching extends relatively far laterally under the photoresist layer 7. The lateral etching may extend under layer

7 by up to five times the thickness of the BST layer. Secondly,
this lateral etching is irregular, as shown in Figure 1B, and
some cracks 10 extend from the edge of the opening 9 into the
BST layer. These cracks are responsible for infiltrations and
5 may damage the dielectric properties of the BST layer where they
appear. As a result, a capacitor manufactured in this way does
not present the characteristics that should be expected.

SUMMARY OF THE INVENTION

10 An object of an embodiment of the present invention is
to solve at least one of the drawbacks of the conventional
methods of etching a BST layer.

A more specific embodiment of the present invention
provides an etching solution providing a regular etching of a
BST layer.

15 Thus, an embodiment of the present invention provides
a method for etching a PVD deposited barium strontium titanate
(BST) layer, wherein a non-ionic surfactant at a concentration
between 0.1 and 1 percent is added to an acid etching solution.

20 According to an embodiment, the concentration of the
surfactant is between 0.2 and 0.4 percent.

According to an embodiment, the etching solution is an
aqueous solution of hydrofluoric acid and nitric acid.

According to an embodiment, the surfactant is alkyl-
phenoxy-polyglycidol.

25 According to an embodiment, the BST layer lies on a
platinum layer.

An embodiment of the present invention provides a
tunable capacitor with a BST dielectric obtained by the above
method.

BRIEF DESCRIPTION OF THE DRAWINGS

30 The foregoing and other purposes, features, aspects
and advantages of the invention will become apparent from the
following detailed description of embodiments, given by way of
illustration and not limitation with reference to the
35 accompanying drawings, wherein:

Figure 1A, previously described, illustrates schematically an etched BST layer;

Figure 1B, previously described, is a top view of the etched BST layer of Figure 1A;

5 Figure 2A illustrates schematically an etched BST layer;

Figure 2B is a top view of the etched BST layer of Figure 2A.

For clarity, the same elements have been designated
10 with the same reference numerals in the different drawings, and furthermore, as is usual in the representation of semiconductor components, the various drawings are not to scale.

DETAILED DESCRIPTION OF THE INVENTION

Figure 2A is a cross section illustrating a tunable
15 capacitor during an intermediate manufacturing step. On a substrate 1, which is for example made of glass, sapphire, alumina, quartz or which is a silicon substrate covered with an isolating layer that constitutes the top layer of a structure, is formed a layer 3 in platinum that will form the lower
20 electrode of the capacitor. On this layer, a sputtered BST film 5 has been formed by physical vapor deposition (PVD), itself covered with a photoresist layer 7, in which an opening 8 has been formed by photolithography at the position where it is desired to form an opening 19 in the BST layer.

25 Figure 2A shows the structure after photolithography of layer 7 and etching of layer 5. Figure 2B is a top view of the structure at this particular step. The etching of the BST layer has been performed by an acid etching solution that is a mixture of hydrofluoric acid and nitric acid in an aqueous
30 solution, into which a non-ionic surfactant has been added. The surfactant is for example alkyl-phenoxy-polyglycidol, at a concentration between 0.1 and 1 percent, preferably between 0.2 and 0.4 percent in volume. The etching solution is for example obtained from a mixture of 1.6 liters of HF at a concentration
35 of 1 percent, 0.14 liter of HNO₃ at a concentration of 70 percent and 26.25 liters of water.

The lateral etching of the BST layer is regular, as shown schematically by Figure 2B, and the amount that this lateral etching of the BST layer extends under the photoresist layer 7 is roughly reduced by a factor 2 compared to the use of the same etching solution without surfactant. Additionally, no cracks appear in the BST layer from the edge of the opening formed in this BST layer.

Moreover, the inventors observed that the addition of a surfactant in the acid etching solution has no influence on the etch rate of the BST layer compared to the use of the same etching solution without surfactant. It is considered that the conservation of the etch rate is related to the conservation of the acidity levels of the etching solution thanks to the non-ionic nature of the surfactant used.

By conserving the BST etch rate as compared to the use of the same etching solution without surfactant, the man skilled in the art is able to re-use the know-how concerning the etching of the BST layer, while taking advantage of the benefits related to the method described herein.

The improvement in the lateral etching (thinner and more regular) is attributed to the fact that the surfactant forms aggregates (for example micelles), that obstruct the edge of the etching area under the photoresist layer.

For example, the dimensions of the opening in the photoresist layer may be chosen such that the opening in the BST layer is between several micrometers and several hundred micrometers across.

The invention is subject to various modifications, in particular as regards the acids usable for the etching solution. Various surfactants can also be used. The metallic layer 3 that supports the BST layer and will form the lower electrode of the capacitor can be formed in a metal other than platinum. However, it will be noted that the invention specifically applies to BST layers deposited by PVD, and not to BST layers resulting from a solgel coating.

CLAIMS

1. A method for etching a PVD deposited barium strontium titanate (BST) layer, wherein a non-ionic surfactant at a concentration between 0.1 and 1 percent in volume is added to a BST acid etching solution.

5 2. The method of claim 1, wherein the concentration of the surfactant is between 0.2 and 0.4 percent in volume.

3. The method of claim 1 or 2, wherein the etching solution is an aqueous solution of hydrofluoric acid and nitric acid.

10 4. The method of any of claims 1 to 3, wherein the surfactant is alkyl-phenoxy-polyglycidol.

5. The method of any of claims 1 to 4, wherein the BST layer lies on a platinum layer.

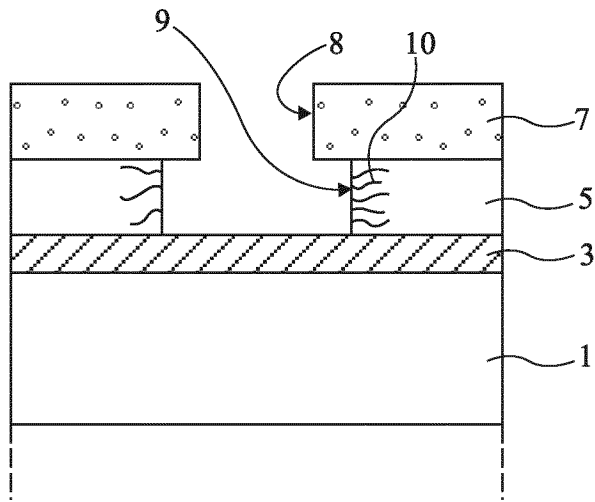


Fig 1A

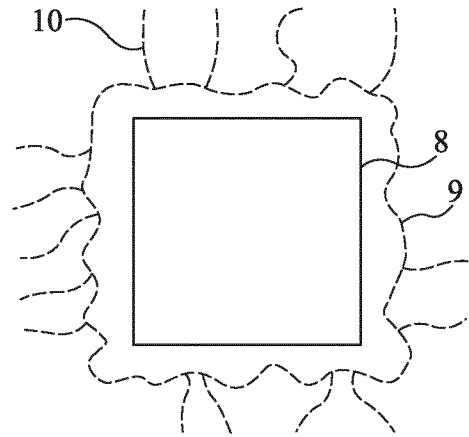


Fig 1B

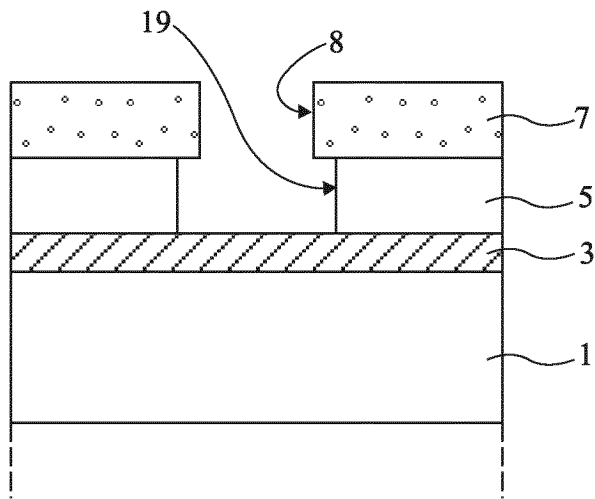


Fig 2A

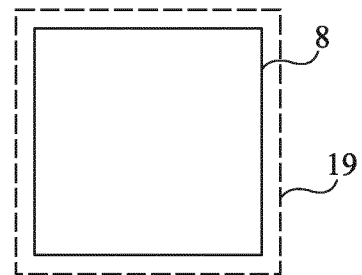


Fig 2B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/056901

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/311
ADD.

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)
H01L

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)

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ZHANG R T ET AL: "Wet chemical etching method for BST thin films annealed at high temperature", APPLIED SURFACE SCIENCE, ELSEVIER, AMSTERDAM, NL, vol. 254, no. 21, 30 August 2008 (2008-08-30), pages 6697-6700, XP023977138, ISSN: 0169-4332, DOI: DOI:10.1016/J.APSUSC.2008.05.233 [retrieved on 2008-08-20] page 6697	1-5
A	EP 0 278 628 A2 (OLIN CORP [US]) 17 August 1988 (1988-08-17) page 2 - page 3 ----- -/-	1,4



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

2 May 2012

Date of mailing of the international search report

09/05/2012

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/056901

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KOUTSAROFF I P ET AL.: "Microwave properties of parallel plate capacitors based on (Ba,Sr)TiO₃ thin films grown on SiO₂/Al₂O₃ substrates", FERROELECTRIC THIN FILMS, 12TH SYMPOSIUM 1-4 DEC. 2003 BOSTON, MA, USA, vol. 784, 2004, pages 319-325, XP002647241, Ferroelectric Thin Films, 12th Symposium (Mater. Res. Soc. Symposium Proceedings Vol.784) Mater. Res. Soc. Warrendale, PA, USA ISBN: 1-55899-722-9 page 320 -----	5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/056901

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
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