Forum *Romanians in Micro- and Nanoelectronics,* *6 November 2018, Romanian Academy, Bucharest, Romania*

From Thin Films to Nanosensor Technology

Cornel Cobianu[1], Cristian Pavelescu*, Bogdan Serban[1], Octavian Buiu[1]

[1]CENASIC - IMT Bucharest, Romania

National Institute for Research and Development in Microtechnologies

*Retired

Outline

Thin Film Technology

- Chemical Vapor Deposition
- Atomic Layer Deposition
- Sol-Gel
- Sonochemistry

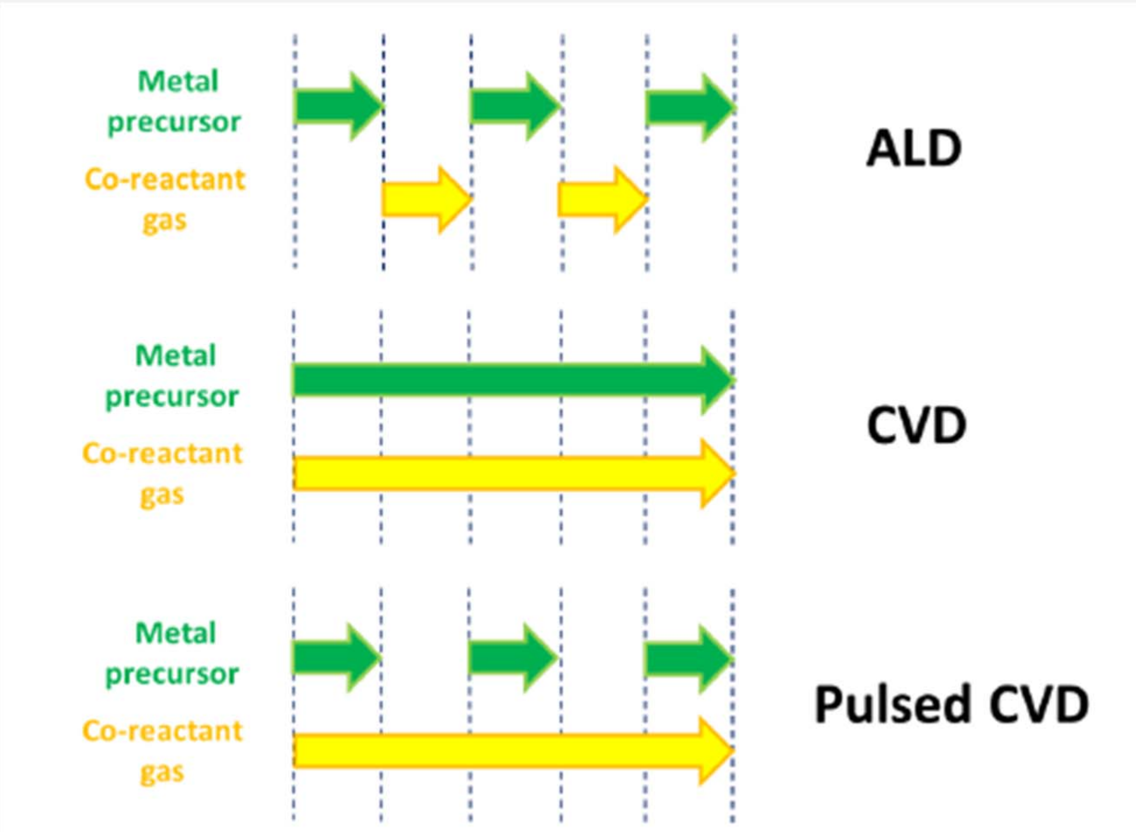
Sensor Technology

- Industrial Research
- Academic Research

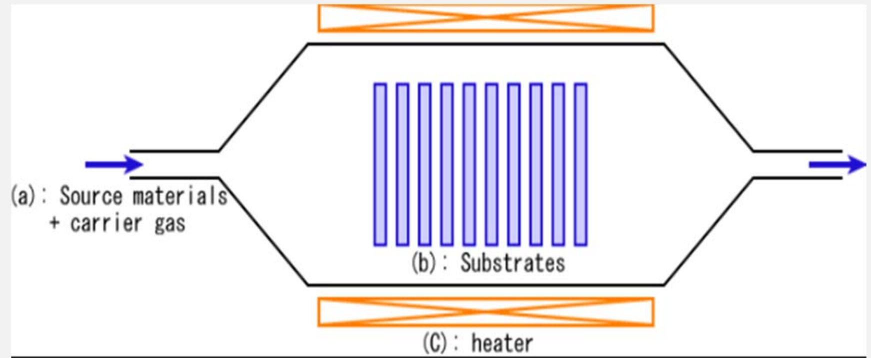
Conclusions

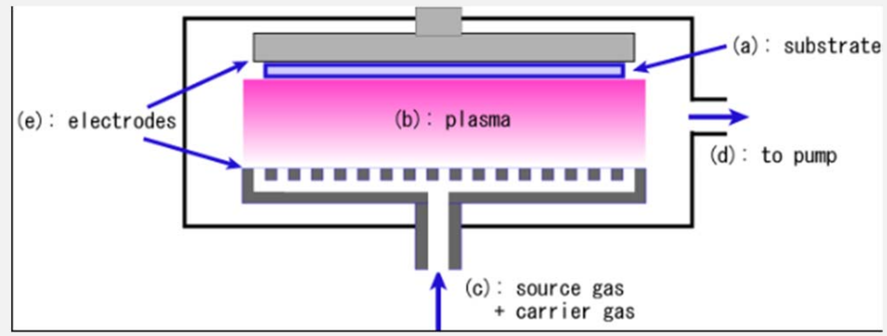
Chemical Vapor Deposition of Thin Films for Micro-Nanoelectronics

CVD Basics



Wang, Xinwei. 2012. Applications of Vapor Deposition in Microelectronics and Dye-Sensitized Solar Cells. Doctoral dissertation, Harvard University.





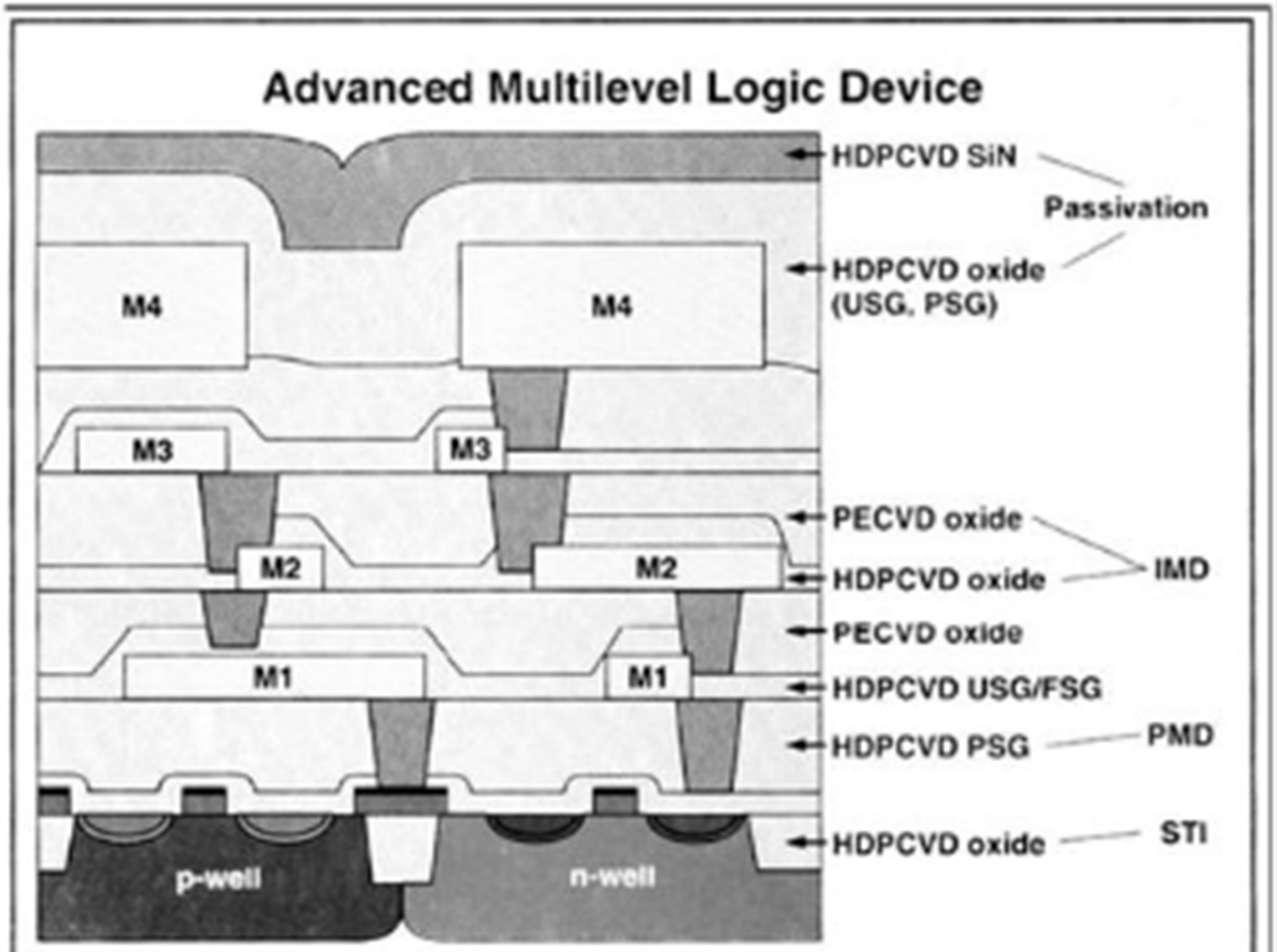
$SiH_4 + O_2 \rightarrow SiO_2 + 2\ H_2$ (LTO)

$SiCl_2H_2 + 2\ N_2O \rightarrow SiO_2 + 2\ N_2 + 2\ HCl$ (HTO)

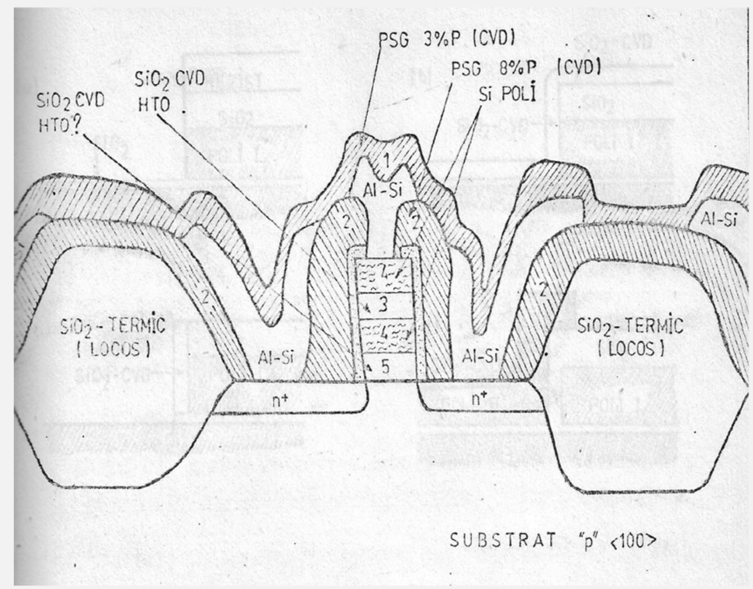
$3\ SiCl_2H_2 + 4\ NH_3 \rightarrow Si_3N_4 + 6\ HCl + 6\ H_2$

$WF_6 \rightarrow W + 3\ F_2$

$SiH_4 \rightarrow Si + 2\ H_2$



Device fabrication I:Chapter13 :Metallization
Moein Moshtaq Ebadghorbandoost Keyvanalirezazad



Cornel Cobianu-Ph.D. Thesis, 1991

A Theoretical Study of the Low-Temperature Chemical Vapor Deposition of SiO_2 Films

C. Cobianu and C. Pavelescu

1888 *J. Electrochem. Soc.:* SOLID-STATE SCIENCE AND TECHNOLOGY *September 1983*

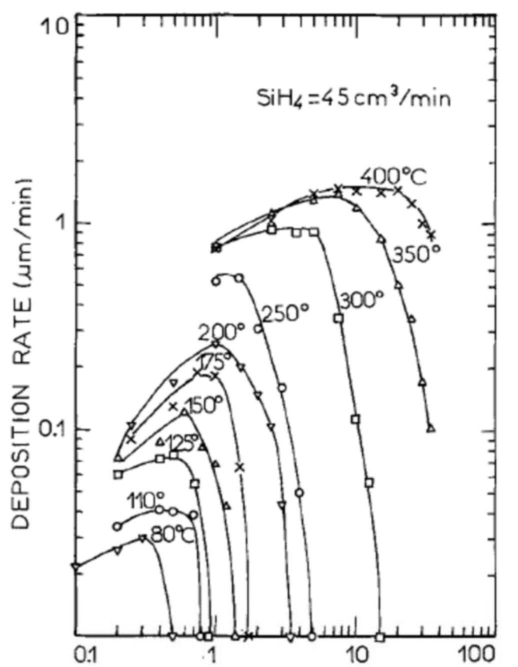
Microelectronica, R-72996, Bucharest, Romania

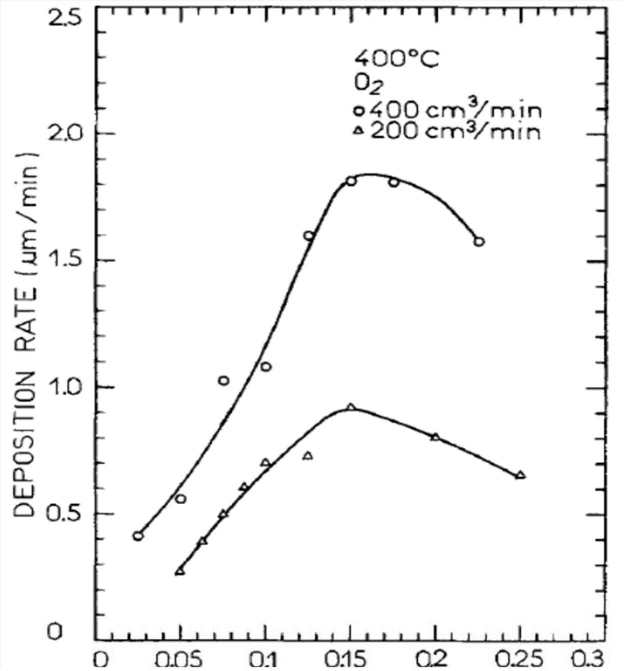
The silicon dioxide deposition on silicon substrates in the SiH_4-O_2-N_2 system was investigated in the temperature range from 80° to 400°C on a nozzle-type reactor at atmospheric pressure. An exponential temperature dependence (of Arrhenius type) with a break at 250°C has been observed for the O_2/SiH_4 ratio corresponding to the maximum deposition rate and also for the O_2/SiH_4 ratio corresponding to near-zero deposition rate in the retardation region. Within the bimolecular surface reaction theory (Langmuir-Hinshelwood mechanism), these results are explained, and the break is interpreted as a change in the adsorption mechanism of the reactant gases with temperature. The apparent activation energy of the surface reaction (5.2-6.5 kcal/mol) in the temperature range from 80° to 400°C has been derived from the Arrhenius plot of the maximum deposition rate, in agreement with the above theory. An empirical reaction rate equation has been proposed which, in addition, explains the linear dependence of the maximum deposition rate on silane flow rate at constant O_2/SiH_4 ratio.

$$v = k_r K_{O_2} K_{SiH_4} p_{O_2} p_{SiH_4} / (1 + K_{O_2} p_{O_2} + K_{SiH_4} p_{SiH_4})^2$$

A Theoretical Study of the Low-Temperature Chemical Vapor Deposition of SiO_2 Films

C. Cobianu and C. Pavelescu





A Theoretical Study of the Low-Temperature Chemical Vapor Deposition of SiO2 Films 50 1983

Journal of The Electrochemical Society 130 (9), 1888-1893

EFFICIENCY OF THE SiH_4 OXIDATION REACTION IN CHEMICAL VAPOUR DEPOSITION OF SiO_2 FILMS AT LOW TEMPERATURE

Thin Solid Films, *102* (1983) 361–366
PREPARATION AND CHARACTERIZATION 361

C. COBIANU AND C. PAVELESCU
Microelectronica, Str. Erou Iancu Nicolae 34B, R-72996 Bucharest (Romania)

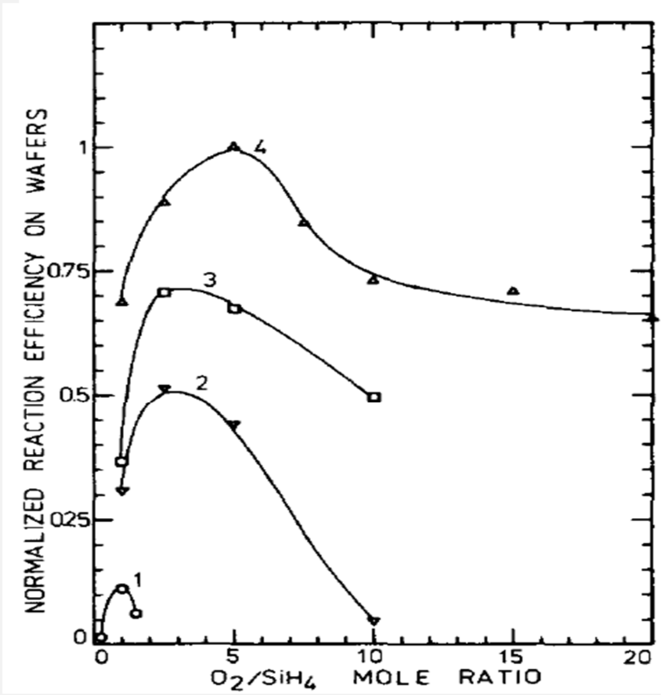
(Received August 25, 1982; accepted January 26, 1983)

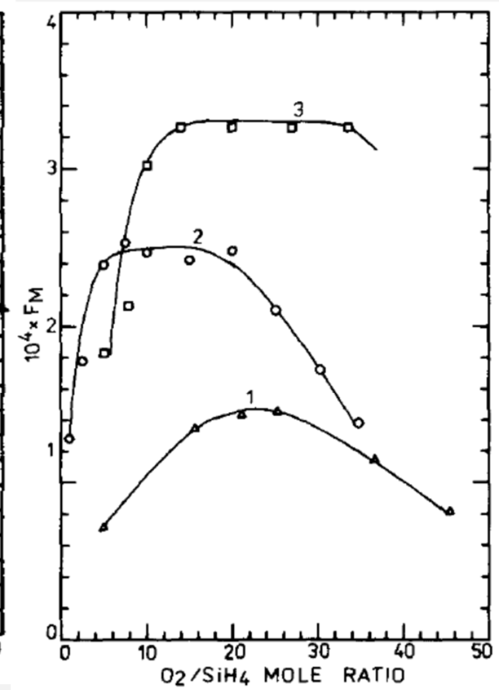
Our purpose in this paper is to evaluate the efficiency of the SiH_4 oxidation reaction in the heterogeneous low temperature chemical vapour deposition (CVD) of SiO_2 films onto wafers at atmospheric pressure in SiH_4–O_2–N_2 systems as a function of the CVD conditions. We obtained an increase–maximum–decrease type of dependence of the reaction efficiency on the $[O_2]/[SiH_4]$ mole ratio with temperature as a parameter, in the temperature range 200–400 °C. At a given $[O_2]/[SiH_4]$ mole ratio the reaction efficiency increases with temperature. These results are qualitatively explained in terms of the bimolecular surface reaction theory and of the dependence of the film density on the CVD conditions. A reactor figure of merit is defined to compare the reaction efficiency on wafers for different CVD reactors.

$$e = \frac{V_M}{M_{SiO_2}} \frac{\rho_{SiO_2} v_d S_d}{F_{SiH_4}} = \frac{V_M}{M_{SiO_2}} \rho_{SiO_2} \frac{v_d S_d}{F_{SiH_4}}$$

EFFICIENCY OF THE SiH_4 OXIDATION REACTION IN CHEMICAL VAPOUR DEPOSITION OF SiO_2 FILMS AT LOW TEMPERATURE

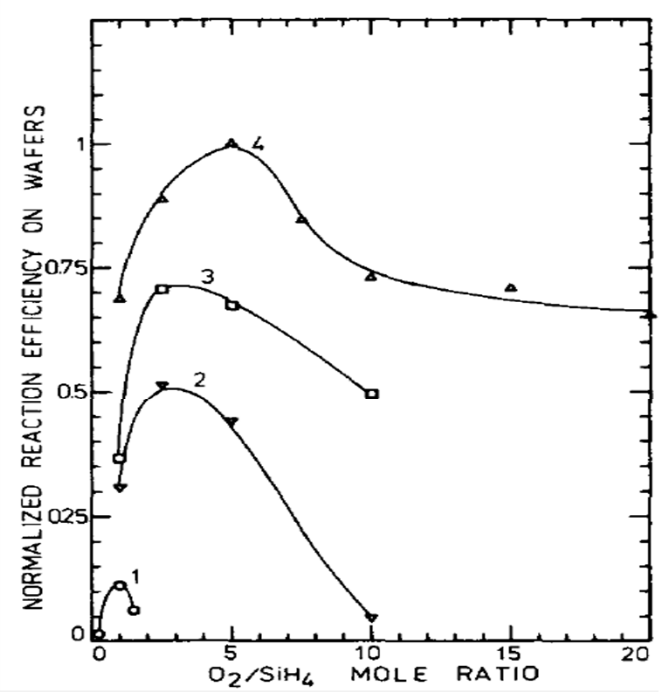
C. COBIANU AND C. PAVELESCU

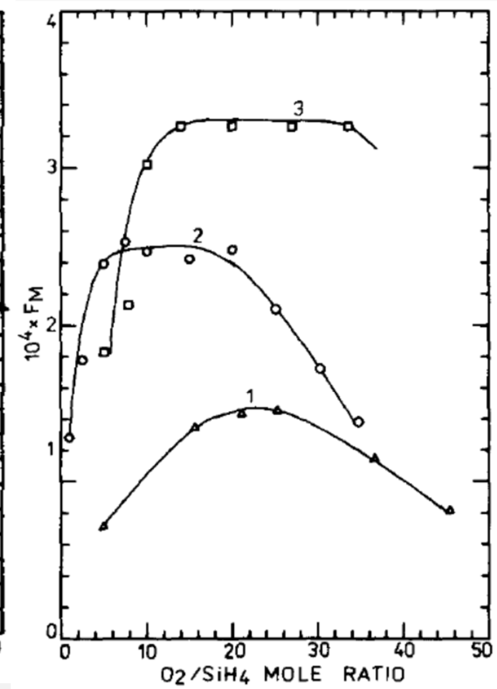




EFFICIENCY OF THE SiH_4 OXIDATION REACTION IN CHEMICAL VAPOUR DEPOSITION OF SiO_2 FILMS AT LOW TEMPERATURE

C. COBIANU AND C. PAVELESCU





Efficiency of the SiH4 oxidation reaction in chemical vapour deposition of SiO2 films at low temperature — 27 — 1983
C Cobianu, C Pavelescu
Thin Solid Films 102 (4), 361-366

SILANE OXIDATION STUDY: ANALYSIS OF DATA FOR SiO_2 FILMS DEPOSITED BY LOW TEMPERATURE CHEMICAL VAPOUR DEPOSITION*

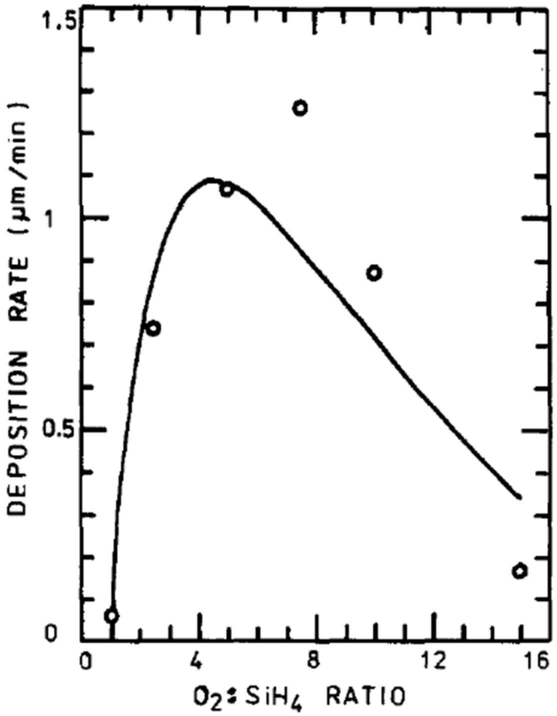
C. COBIANU AND C. PAVELESCU

Microelectronica, Str. Erou Iancu Nicolae 34 B, R-72996, Bucharest (Romania)

(Received July 7, 1983; accepted May 25, 1984)

The purpose of this paper is to determine the rate constant k_r of the reaction and the equilibrium constants of oxygen (K_{O_2}) and silane (K_{SiH_4}) adsorption on the surface in the low temperature chemical vapour deposition (CVD) of SiO_2 films from the fit of the experimental dependence of the deposition rate on the CVD conditions to the theory of bimolecular surface reactions.

The results obtained are discussed in terms of (i) an exponential temperature dependence of k_r with an activation energy of 7.7 kcal mol^{-1} and (ii) a temperature dependence of K_{O_2} and K_{SiH_4} which involves a transition in the adsorption process of the reactant species from physical adsorption to chemisorption as the temperature is increased over 200 °C.



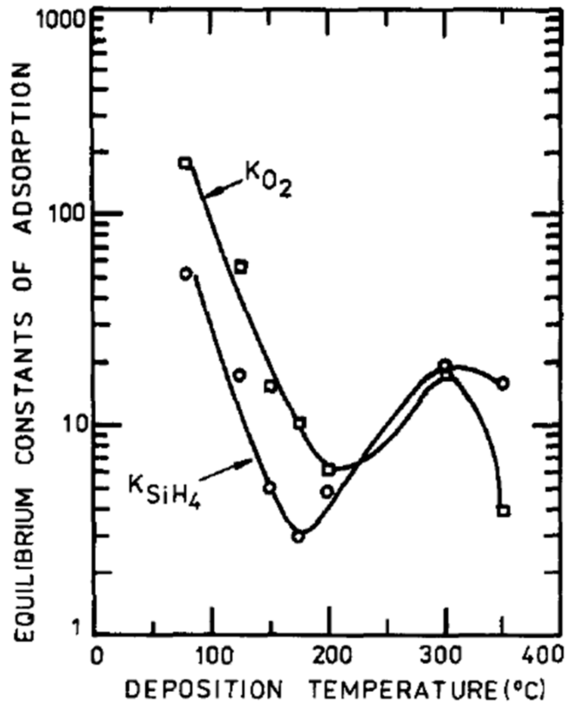


Fig. 1. Theoretical (——) and experimental (○) dependence of the deposition rate on the O_2:SiH_4 ratio (T = 350 °C; SiH_4 flow rate, 45 cm^3 min^{-1}).

Fig. 2. The adsorption equilibrium constants K_{O_2} and K_{SiH_4} *vs.* the deposition temperature.

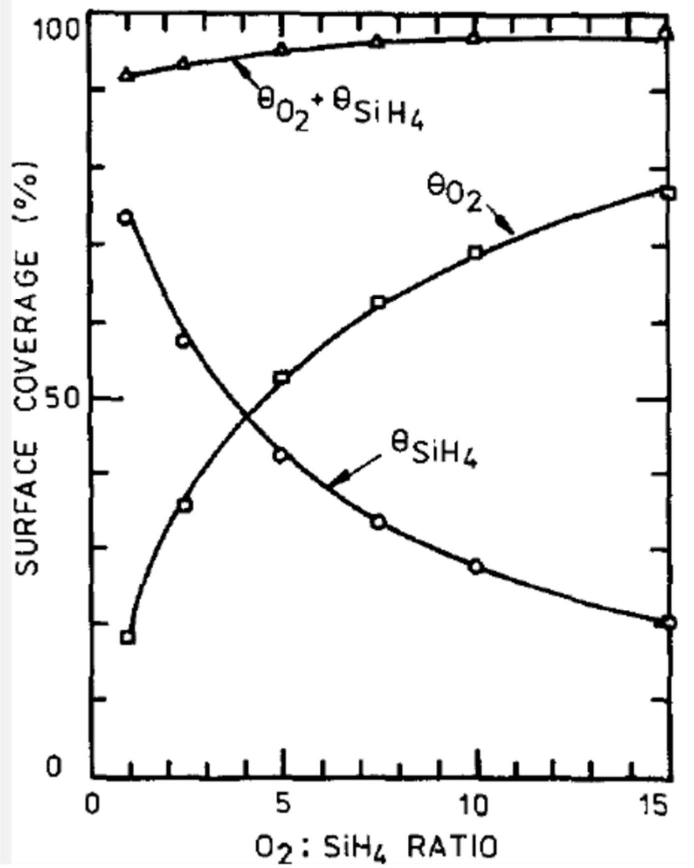


Fig. 3. The surface fractions covered by silane (θ_{SiH_4}) and oxygen (θ_{O_2}) *vs.* the O_2:SiH_4 ratio (T = 350 °C).

VLSI Technology , S.M. SZE
Second edition, 1988
Page 251

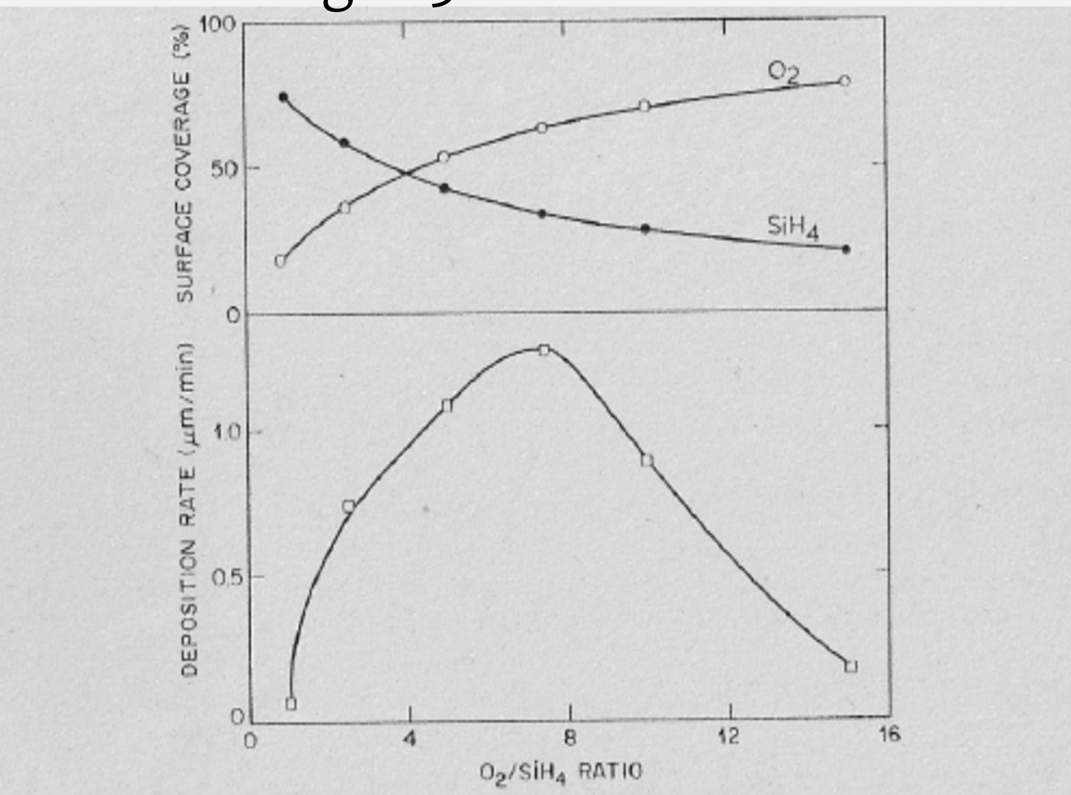


FIGURE 11
The deposition rate and surface coverage for the silane-oxygen reaction at atmospheric pressure and 350°C. (*After Cobianu and Pavelescu, Ref. 28.*)

Spectroscopic Analysis, ...

27 C. Cobianu and C. Pavelescu, "A Theoretical Study of the Low-Temperature Chemical Vapor Deposition of SiO_2 Films," *J. Electrochem. Soc.*, **130**, 1888 (1983).

28 C. Cobianu and C. Pavelescu, "Silane Oxidation Study: Analysis of Data for SiO_2 Films Deposited by Low Temperature Chemical Vapour Deposition," *Thin Solid Films*, **117**, 211 (1984).

On the Electrical Conduction in the Interpolysilicon Dielectric Layers

Cornel Cobianu, *Member, IEEE,* Ovidiu Popa, *Member, IEEE,* and
Dan Dascalu, *Senior Member, IEEE*

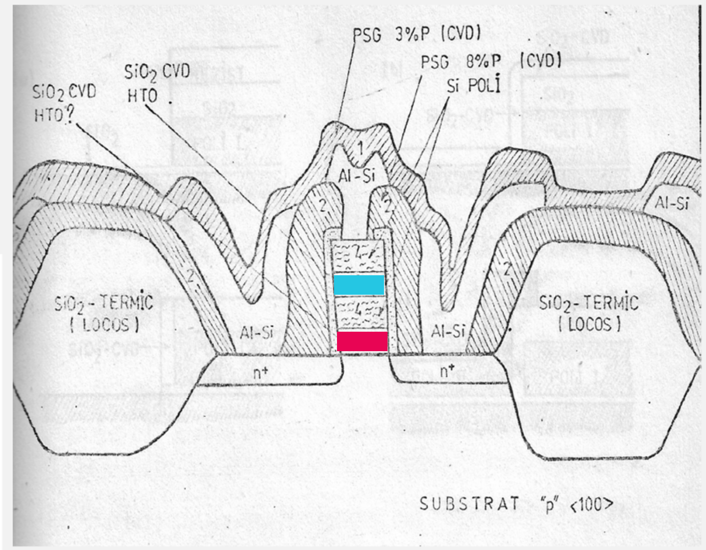
IEEE ELECTRON DEVICE LETTERS, VOL. 14, NO. 5, MAY 1993 213

C. Cobianu and D. Dascalu are with the Center of Microtechnology, Str. Erou Iancu Nicolae 34 B, Bucharest 72996, Romania.

O. Popa is with Microelectronica S. A., Str. Erou Iancu Nicolae 34 B, Bucharest 72996, Romania, and with the Center of Microtechnology, Str. Erou Iancu Nicolae 34 B, Bucharest 72996, Romania.

IEEE Log Number 9208391.

***Abstract*—Up to now, to reduce the low field electrical conductivity of interpolysilicon dielectrics used in EEPROM devices, the roughness of the poly-SiO_2 interface has been decreased in two ways: 1) by increasing the temperature of oxidation and doping of polysilicon combined with the silicon (undoped or *in-situ* doped) low-pressure chemical vapor deposition (LPCVD) in the amorphous phase, or 2) by the use of LPCVD high-temperature oxide (HTO) deposited over polycrystalline silicon. In this paper we combine the advantages of each method and present the electrical conduction results of the interpoly structure based on LPCVD smooth surface polysilicon and LPCVD HTO SiO_2. The data are interpreted in terms of the Fowler–Nordheim mechanism.**



On the electrical conduction in the interpolysilicon dielectric layers
C Cobianu, O Popa, D Dascalu
IEEE Electron Device Letters 14 (5), 213-215
53 1993

On the Electrical Conduction in the Interpolysilicon Dielectric Layers

Cornel Cobianu, *Member, IEEE*, Ovidiu Popa, *Member, IEEE*, and Dan Dascalu, *Senior Member, IEEE*

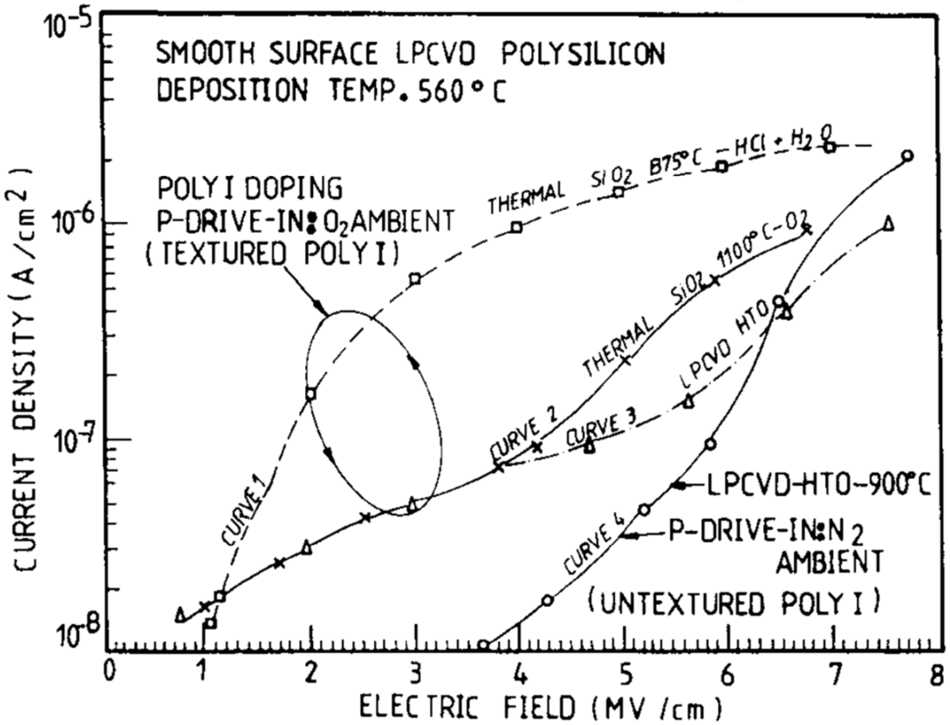


Fig. 1. Current density versus electric field through interpolysilico[n] structures with different dielectrics: a) thermal SiO_2 grown on texture[d] poly (curves 1, 2), and b) LPCVD HTO SiO_2 deposited on textured pol[y] (curve 3) or on untextured poly (curve 4).

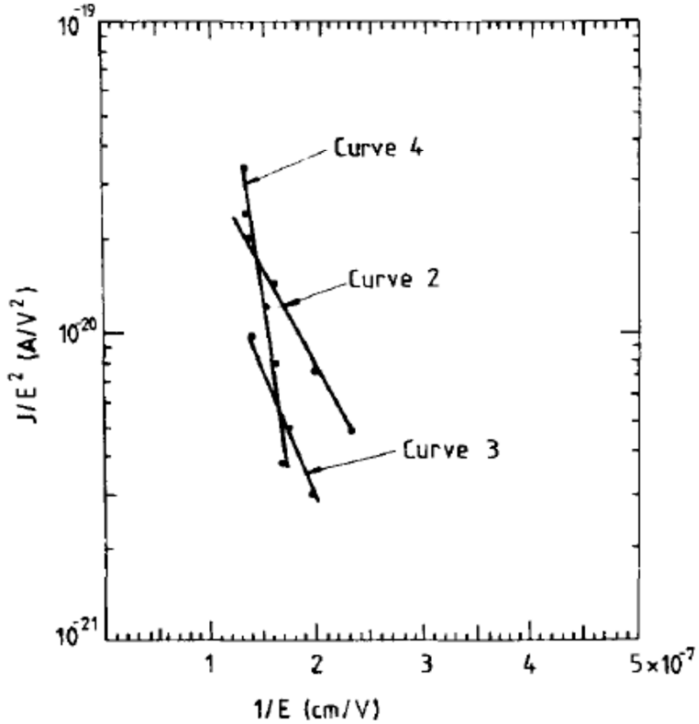


Fig. 2. F–N plots of J–E data from Fig. 1 corresponding to SiO_2 grown at 1100°C on textured poly (curve 2), and LPCVD HTO SiO_2 deposited on textured poly (curve 3) and untextured poly (curve 4). (The same numbers as in Fig. 1 were assigned to the corresponding F–N curves.)

IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 46, NO. 7, JULY 1999

Deposited Inter-Polysilicon Dielectrics for Nonvolatile Memories

Johan H. Klootwijk, *Member, IEEE*, Herma van Kranenburg, Pierre H. Woerlee, and Hans Wallinga

Manuscript received October 20, 1998; revised March 8, 1999. This work was supported by the Dutch Foundation for Fundamental Research on Matter (FOM) and the Netherlands Technology Foundation (STW). The review of this paper was arranged by Editor W. Weber.

J. H. Klootwijk was with the MESA Research Institute, University of Twente, 7500 AE Enschede, The Netherlands. He is now with Philips Research Laboratories, 5656 AA Eindhoven, The Netherlands.

P. H. Woerlee is with the MESA Research Institute, University of Twente, 7500 AE Enschede, The Netherlands, and also with Philips Research Laboratories, 5656 AA Eindhoven, The Netherlands.

H. van Kranenburg and H. Wallinga are with the MESA Research Institute, University of Twente, 7500 AE Enschede, The Netherlands.

Publisher Item Identifier S 0018-9383(99)05097-2.

Acknowledgment

The authors wish to thank Dr. C. Cobianu for valuable discussions. The MESA cleanroom staff is kindly acknowledged for their support. Dr. R. Woltjer is kindly acknowledged for reading the final manuscript.

References

[1] C. Cobianu, O. Popa, and D. Dascalu, "On the electrical conduction in the inter-polysilicon dielectric layers," *IEEE Electron Device Lett.*, vol. 14, p. 213, 1993.

Optical properties of silicon thin films related to LPCVD growth condition

M. Modreanu[a,*], M. Gartner[b], C. Cobianu[c], B. O'Looney[a], F. Murphy[a]

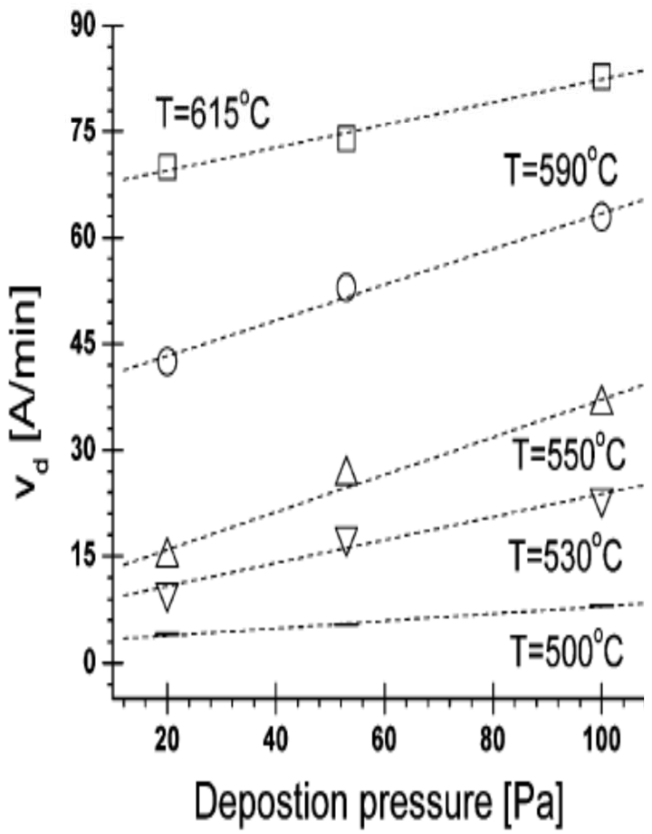
Thin Solid Films 450 (2004) 105–110

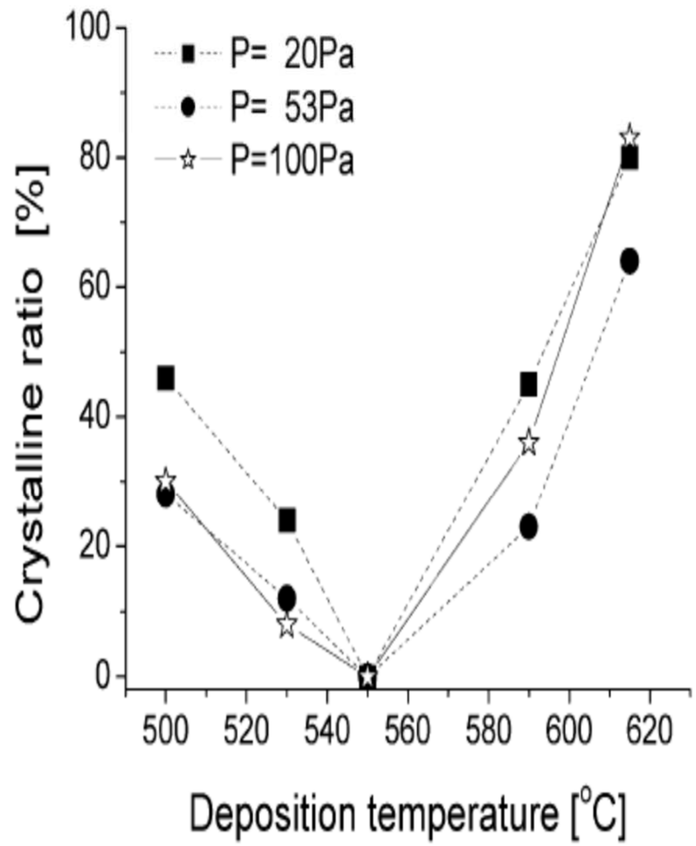
[a]NMRC, Lee Maltings, Prospect Row, Cork, Ireland
[b]Institute of Physical Chemistry, Spl. Independentei 202, Bucharest 77208, Romania
[c]Valahia' Univ. from Târgoviste, P.O. Box 27-17, Bucharest 77550, Romania

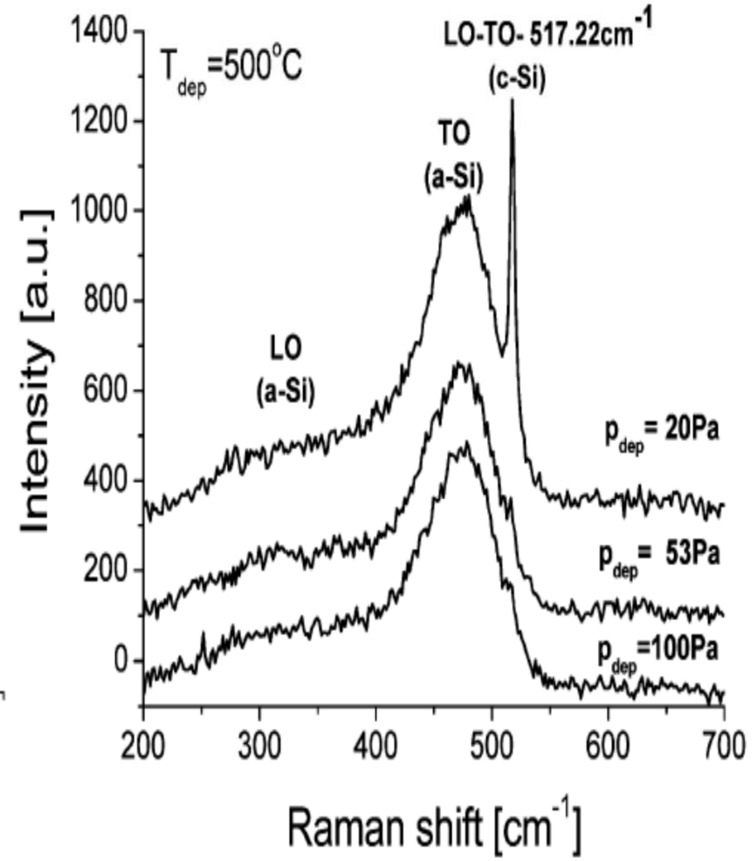
In this paper we study the changes in the microstructural and optical properties of silicon thin films produced by the variation of the parameters (temperature and pressure) of the low-pressure chemical vapour deposition (LPCVD) process. Silicon thin films prepared by LPCVD on oxidized silicon substrates over a large range of process parameters (T_{dep} = 500–615°C, p_{dep} = 20–100 Pa) have been characterized by Raman spectroscopy, spectroscopic ellipsometry (SE), X-ray diffraction (XRD) and atomic force microscopy (AFM) techniques. The phase transition of as-deposited silicon from an amorphous to a crystalline phase via an intermediate mixed phase (few grains in amorphous silicon matrix) can be monitored by the changes in the optical properties and in the Raman spectra. LPCVD parameters, which control the deposition kinetics, are able to influence the optical properties, the structure and/or morphology of the as-deposited LPCVD silicon films. The SE and Raman results prove that it is possible to grow by LPCVD (from pure silane), a silicon film in a (poly)crystalline state at a temperature as low as 500°C.

Optical properties of silicon thin films related to LPCVD growth condition

M. Modreanu[a,*], M. Gartner[b], C. Cobianu[c], B. O'Looney[a], F. Murphy[a]



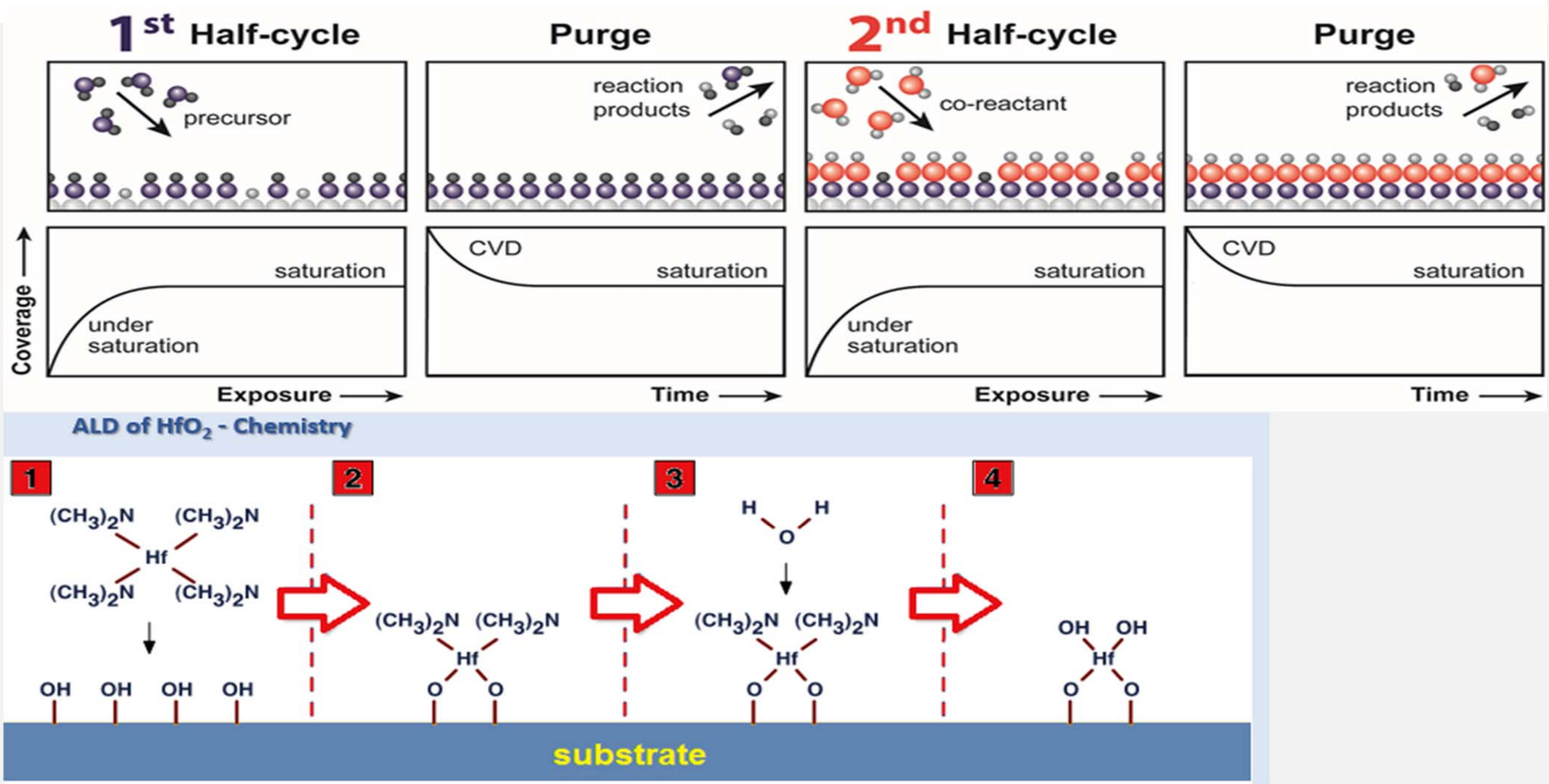




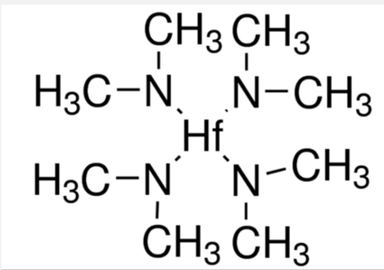
Atomic Layer Deposition for Nanoelectronics

HfO_2-High k Ultrathin Gate Dielectrics

Atomic Layer Deposition of HfO_2 ultrathin films



Mechanism of ALD film Deposition from Tetrakis Dimethylamino Hafnium (TDMAH) and H_2O



I. HfO_2 ALD on OH-terminated surface

1. $Hf(N(CH_3)_2)_4$ half-reaction

$Si\text{-}OH^* + Hf(N(CH_3)_2)_4 = Si\text{-}O\text{-}Hf(N(CH_3)_2)_3^* + HN(CH_3)_2$

$Si\text{-}O\text{-}Hf(N(CH_3)_2)_3^* + Si\text{-}OH^* = Si\text{-}O\text{-}Hf(N(CH_3)_2)_2^* + HN(CH_3)_2$

2. Water half-reaction

$Si\text{-}O\text{-}Hf(N(CH_3)_2)_2^* + 2H_2O = Si\text{-}O\text{-}Hf\text{-}(OH)_2 + 2HN(CH_3)_2$

II. HfO_2 ALD on H-Terminated Si Surface

1. $Hf(N(CH_3)_2)_4$ half-reaction

$Si\text{-}H^* + Hf(N(CH_3)_2)_4 = Si\text{-}Hf(N(CH_3)_2)_3^* + HN(CH_3)_2$

$Si\text{-}Hf(N(CH_3)_2)_3 + Si\text{-}H^* = Si\text{-}Hf(N(CH_3)_2)_2^* + HN(CH_3)_2$

2. Water half reaction

$Si\text{-}Hf(N(CH_3)_2)_2^* + 2H_2O = Si\text{-}Hf\text{-}(OH)_2 + 2HN(CH_3)_2$

Silicon Wafer-Cleaning Process

RCA-1 : 5 parts DI-H_2O+1 part 27% NH_4OH + 1 part 30% H_2O_2

-Remove organic residues from Si surface

-Leaves an ultrathin SiO_2 film on the Si surface

RCA-2 : 6 parts DI-H_2O + 1 part 27% HCl + 1 part 30% H_2O_2

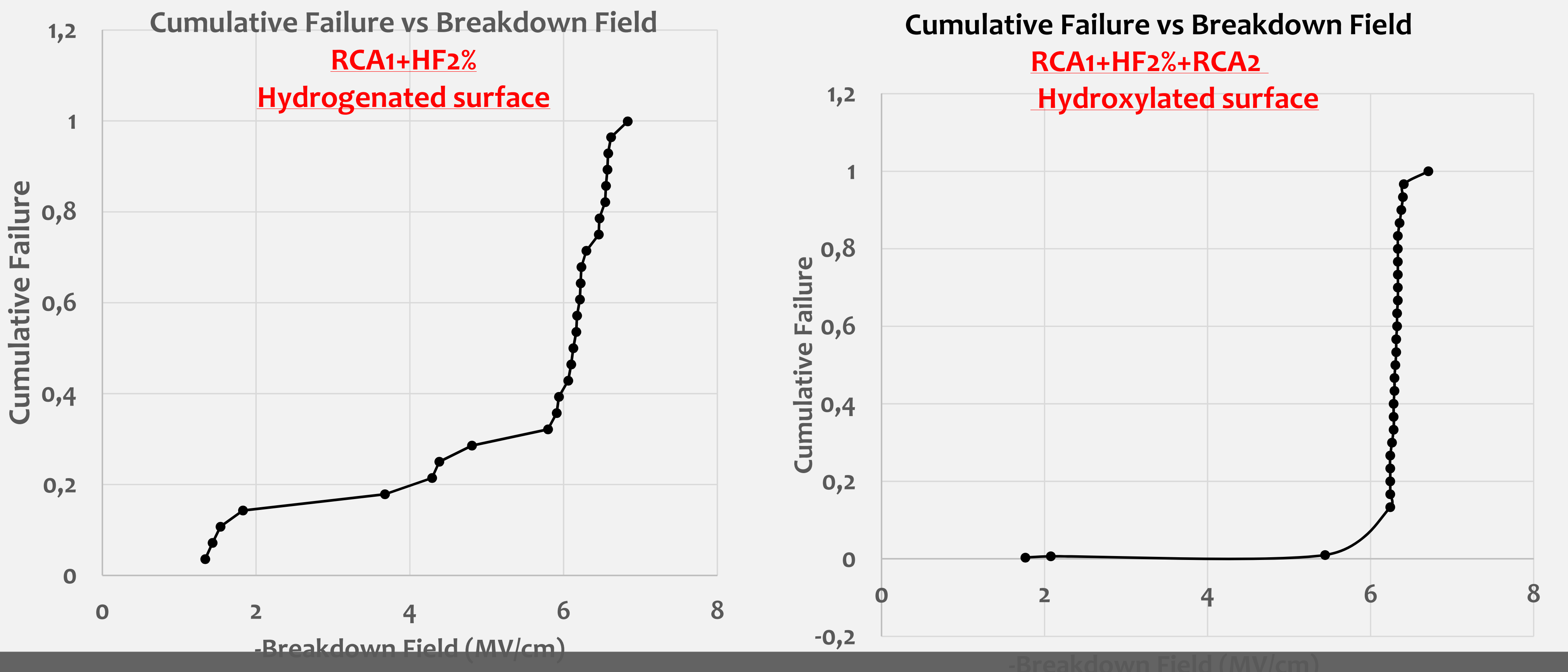
-Removes metal ions from silicon surface

-Leaves an ultrathin SiO_2 film on the Si surface

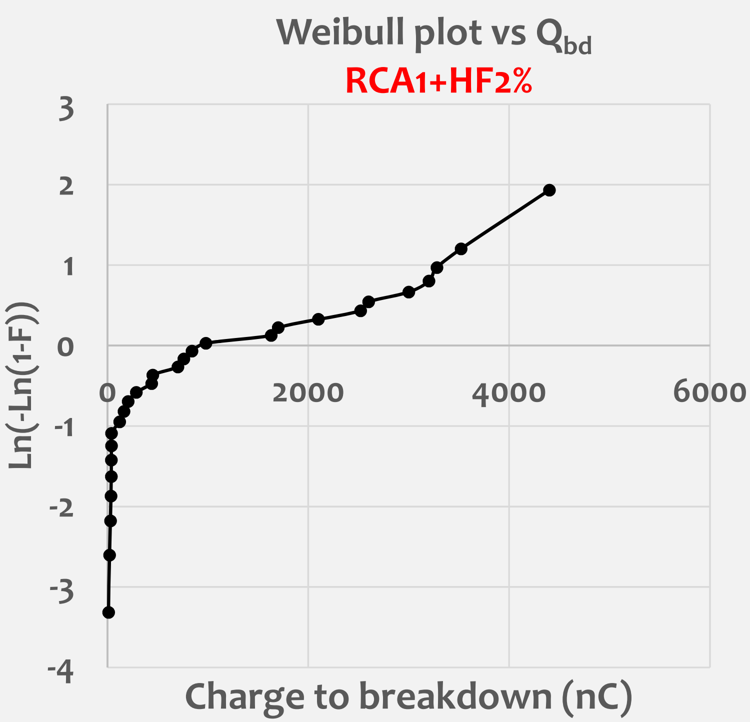
Cleaning processes : RCA1+ HF2% : H-terminated silicon

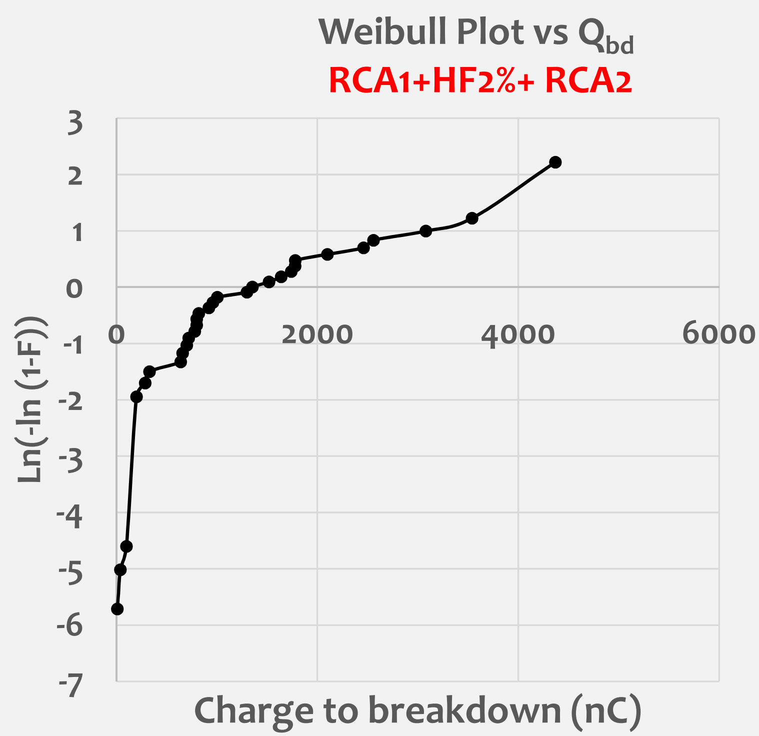
RCA1-HF2%-RCA2: OH-terminated silicon

Comparison of the Cumulative Failure Distributions vs Breakdown Field HfO2 films



Comparison of Weibull Distribution vs Q_{bd}





ELECTRICAL PROPERTIES OF AS-DEPOSITED ALD HfO_2 FILMS RELATED TO SILICON SURFACE STATE

Cornel Cobianu[1,2], Florin Nastase[1,2], Niculae Dumbravescu[1,2], Octavian Buiu[1,2], Adrian Albu[1], Bogdan Serban[1,2], Mihai Danila[1], Cosmin Romanitan[1], Octavian Ionescu[1,2]

CAS 2018 PROCEEDINGS

[1] National Institute for Research and Development in Microtechnologies-IMT Bucharest, Romania.
[2] Research Center for Integrated Systems, Nanotechnologies and Carbon-Based Nanomaterials (CENASIC)-IMT Bucharest, Romania.

Abstract-In this paper, we present an experimental study of the electrical properties of the as-deposited HfO_2 films obtained by atomic layer deposition (ALD) method from tetrakis dimethylamino hafnium and water vapors at 200ºC as a function of the silicon substrate preparation, in terms of Si-H and Si-OH terminated surfaces. High frequency C-V characteristics have proven that relatively higher effective dielectric constant, lower fixed charge at the Si-HfO_2 interface and lower oxide trapped charge were obtained on MOS capacitors with HfO_2 dielectric performed on Si-OH terminated Si surface with respect Si-H terminated surface, proving a more robust Si-O-Hf interface with respect to Si-Hf-O interface.

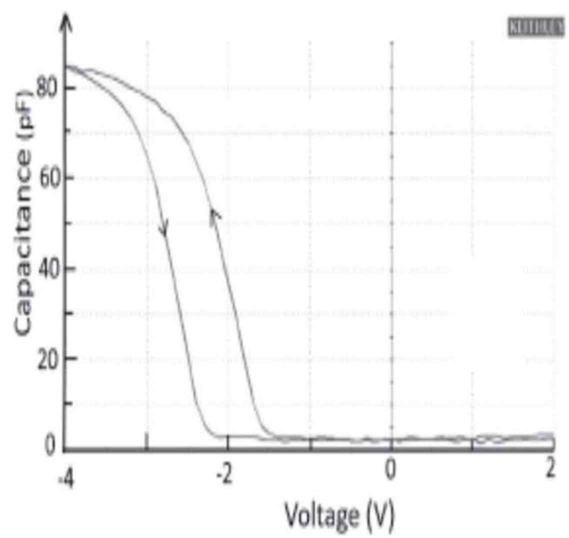


Fig. 1. High frequency (1 MHz) C-V plot of a MOS capacitor having as-deposited ALD HfO_2 film deposited on Si-H terminated silicon (p type) and Al gate, annealed in N_2 at 250ºC.

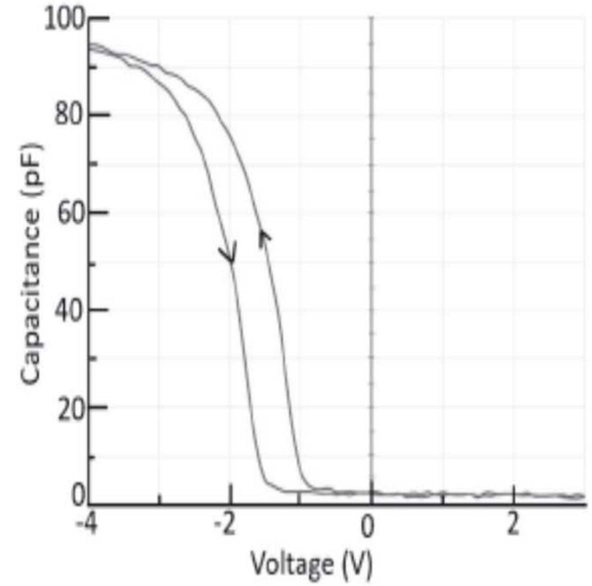
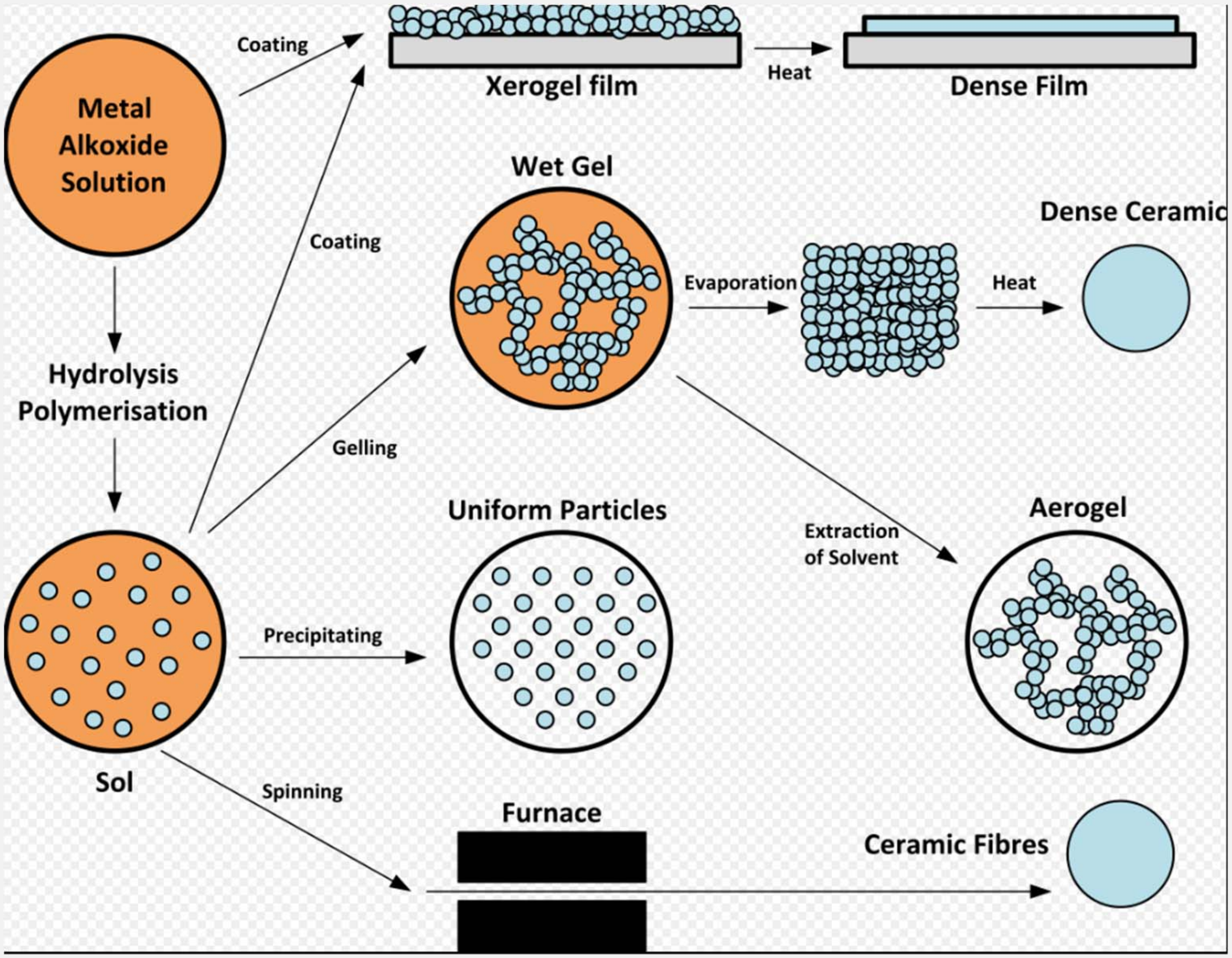


Fig. 2. High frequency (1 MHz) C-V plot of a MOS capacitor having as-deposited ALD HfO2 film deposited on Si-OH terminated silicon (p-type) and Al gate, annealed in N_2 at 250ºC

Sol-Gel Technology for Functional Films



C.J. Brinkler and G.W. Scherer, " Physics and Chemistry of Sol-Gel Processing" 1990

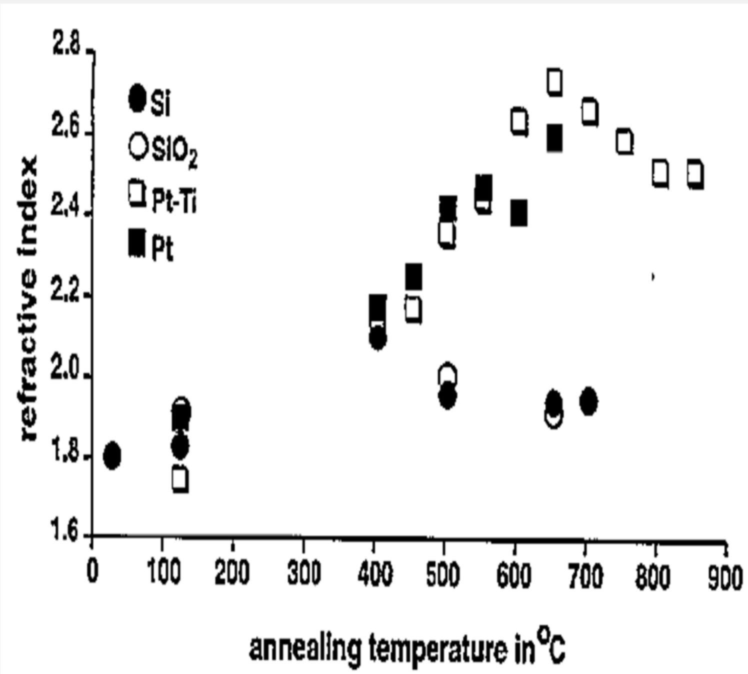
Characterization of sol-gel PZT films on Pt-coated substrates

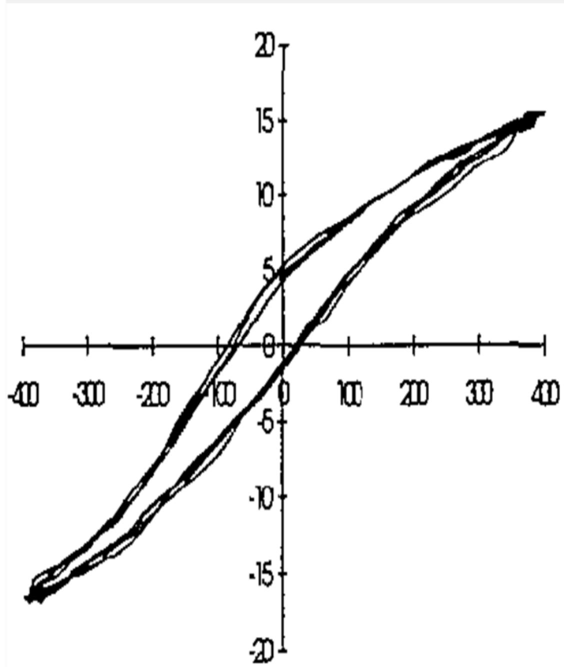
J G E Gardeniers†, A Smith† and C Cobianu‡
J. Micromech. Microeng. 5 (1995) 153–155.

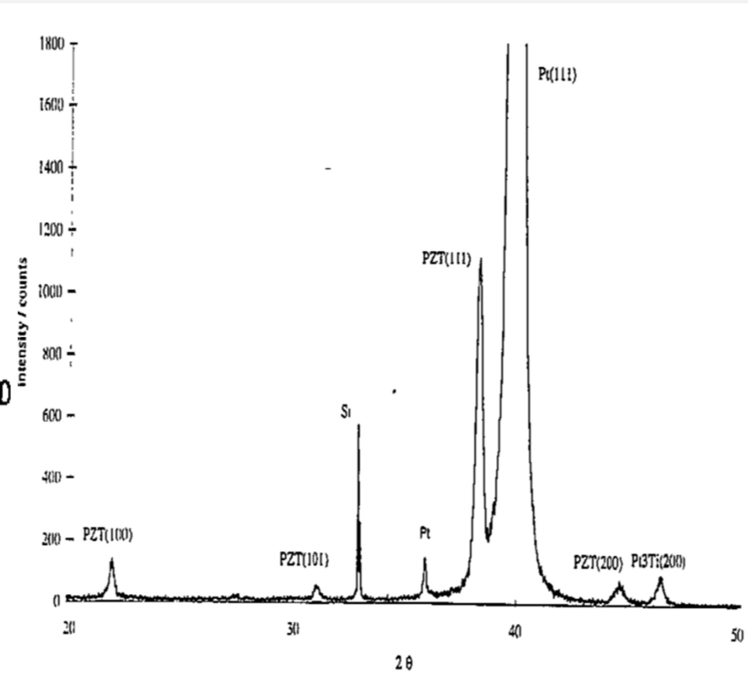
TEMPUS Project -1993

† Micromechanical Transducers, MESA Research Institute, PO Box 217, NL-7500 AE Enschede, The Netherlands
‡ Institute of Microtechnology, PO Box 38-160 Bucharest 72225, Romania

Abstract. A conventional sol-gel process was used to spin-cast PZT films on oxidized Si wafers coated with sputtered Pt layers. After annealing at 550 °C–800 °C, the resulting perovskite-type PZT films showed different textures and surface morphologies, depending on whether or not a Ti adhesion layer was used. If a Ti layer was present, Ti diffusion into and through the Pt film leads to a compound Pt_3Ti, which facilitates crystallization of the perovskite PZT phase; without Ti, crystallization is more difficult and occurs via the growth of dendritic crystallites. Several optical and electrical properties of the PZT films have been measured; the first results indicate high dielectric constants ($\epsilon \simeq 480$) and acceptable ferroelectric behaviour.







Characterisation of sol-gel PZT films on Pt-coated substrates 14 1995

JGE Gardeniers, A Smith, C Cobianu

Journal of micromechanics and microengineering 5 (2), 153

Tin dioxide sol–gel derived thin films deposited on porous silicon

Cornel Cobianu [a,*], Cristian Savaniu [a], Octavian Buiu [a], Dan Dascalu [a], Maria Zaharescu [b], Constanta Parlog [b], Albert van den Berg [c], Bela Pecz [d]

[a] *Institute of Microtechnology, P.O. Box 27-17, R-77550 Bucharest, Romania*
[b] *Institute of Physical-Chemistry of the Romanian Academy, Splaiul Independentei 202, Bucharest, Romania*
[c] *MESA Research Institute, University of Twente, Faculty of Electrical Engineering, P.O. Box 217, 7500 AE Enschede, The Netherlands*
[d] *Research Institute of Technical Physics (RITP), P.O. Box 76, H-1325 Budapest, Hungary*

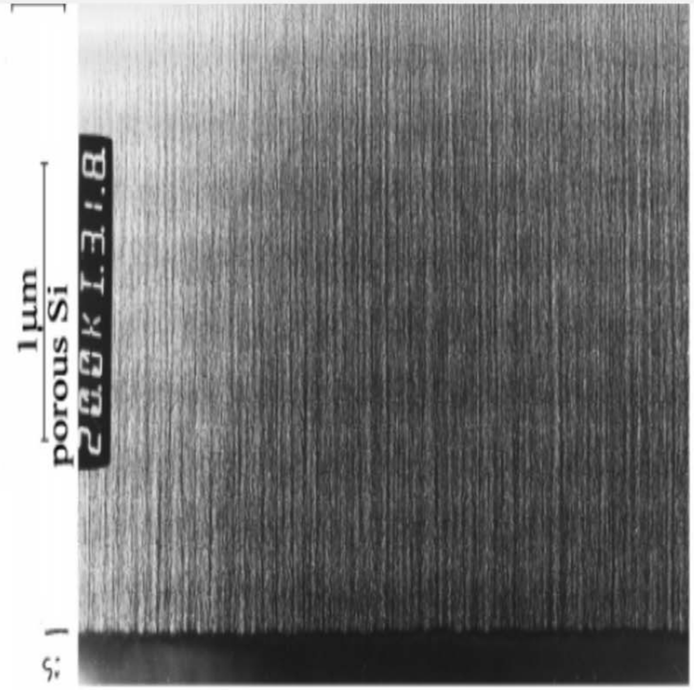
Accepted 28 May 1997

Sensors and Actuators B 43 (1997) 114–120

EU-COPERNICUS, "PORSIS" Project

Abstract

Undoped and Sb-doped SnO_2 sol–gel derived thin films have been prepared for the first time from tin (IV) ethoxide precursor and $SbCl_3$ in order to be utilised for gas sensing applications where porous silicon is used as a substrate. Transparent, crack-free and adherent layers were obtained on different types of substrates (Si, SiO_2/Si). The evolution of the Sn–O chemical bonds in the SnO_2 during film consolidation treatments was monitored by infrared spectroscopy. By energy dispersive X-ray spectroscopy performed on the cross section of the porosified silicon coupled with transmission electron microscopy, the penetration of the SnO_2 sol–gel derived films in the nanometric pores of the porous silicon has been experimentally proved. © 1997 Elsevier Science S.A.



g. 2. XTEM image of the porous silicon after SnO_2 film sol–gel position. The thickness of the PS is about 2.2 µm.

Tin dioxide sol–gel derived thin films deposited on porous silicon
C Cobianu, C Savaniu, O Buiu, D Dascalu, M Zaharescu, C Parlog, ...
Sensors and Actuators B: Chemical 43 (1-3), 114-120

52 1997

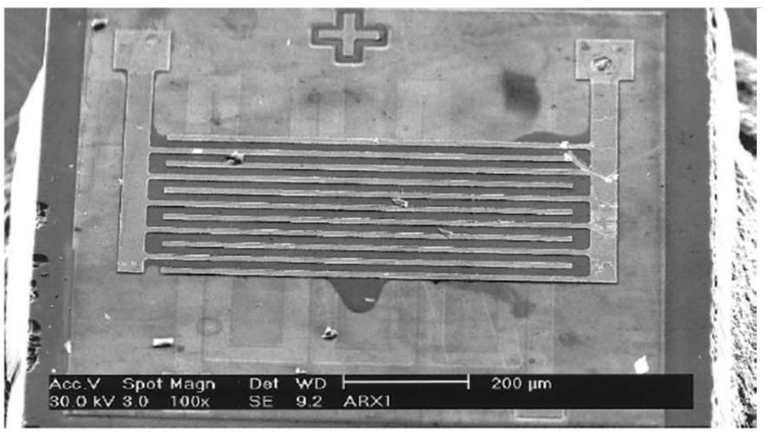
A SnO_2 microsensor device for sub-ppm NO_2 detection

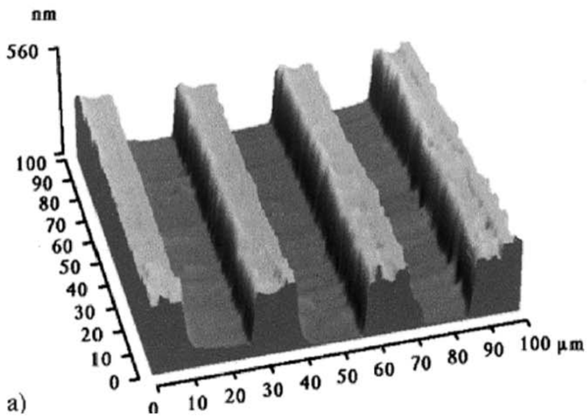
C. Cobianu [a], C. Savaniu [a], A. Arnautu [a], R. Iorgulescu [a], D. Dascalu [a], G. Leo [b], M. Mazzer [b], R. Rella, P. Siciliano [b,*], S. Capone [c], L. Vasanelli [c]

Sensors and Actuators B 58 (1999) 552–555

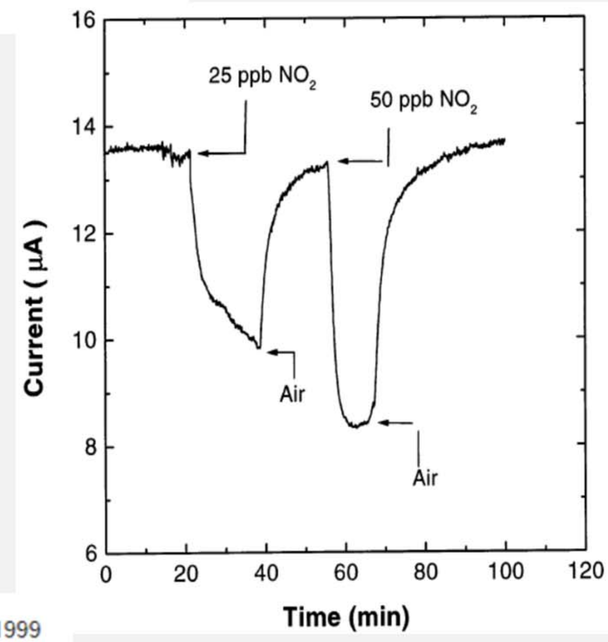
[a] *National Institute of Microtechnology, PO Box 38–160, 72225 Bucharest, Romania*
[b] *IME-CNR, Materiali per l'Elettronica, Campus Universitario, Via Arnesano, 73100 Lecce, Italy*
[c] *INFM, Università di Lecce, Via Arnesano, 73100 Lecce, Italy*

Gas sensors based on SnO_2 films deposited by sol-gel on a Si substrate have been fabricated, characterised and tested. The results of structural characterisation and the sensing tests have shown the validity of this technological approach, which is a very promising step towards the full integration of the gas sensors in VLSI Si technology.





a)



SnO_2 sol–gel derived thin films for integrated gas sensors

Sensors and Actuators B 77 (2001) 496–502

Cornel Cobianu[a,b,*], Cristian Savaniu[b], Pietro Siciliano[c], Simonetta Capone[d]
Mikko Utriainen[e], Lauri Niinisto[e]

[a]*Department of Systems Science and Automation, Electrical Engineering Faculty, University "Valahia" of Targoviste, P.O. Box 27-17, 777550 Bucharest, Romania*
[b]*Institute of Microtechnology Bucharest, P.O. Box 38-160, RO 72225 Bucharest, Romania*
[c]*Istituto per lo Studio di Nuovi materiali per L'Elettronica-IME-CNR, Lecce, Via Arnesano 73100, Lecce, Italy*
[d]*INFM University of Lecce, Via Arnesano 73100, Lecce, Italy*
Laboratory of Inorganic and Analytical Chemistry, Helsinki University of Technology, P.O. Box 6100, FIN-02015, Espoo, Finland

In this paper, we present for the first time the compatibility of sol–gel method for SnO_2 thin film preparation with the silicon technology or integrated gas sensor microfabrication. An integrated circuit (IC) compatible test structure of medium power consumption equipped vith boron-doped silicon heater and Au/W metallization is developed. The acid composition of the (liquid) sol phase, the thermal budget of ensing layer structuring, selective wet etching of SnO_2 sensing film, thickness uniformity and step coverage of SnO_2 sol–gel films are fitted vith the requirement of above test structure where metal layer is deposited before SnO_2 film. Nanometric grain sizes of undoped and antimony doped polycrystalline SnO_2 films are obtained, as revealed by XRD investigations. The AFM measurements of SnO_2 thin films deposited on existing Au/W metallization shown the excellent step coverage and morphology of SnO_2 films used for gas sensing applications. Low temperature gas sensing properties of our SnO_2 sol–gel derived thin films in reducing (CH_4, CH_3COOH) and oxidizing NO_2) are preliminary reported by using our integrated test structure.

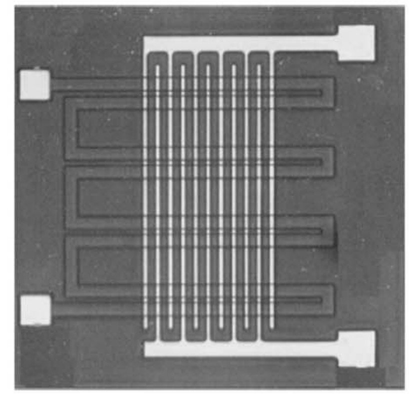
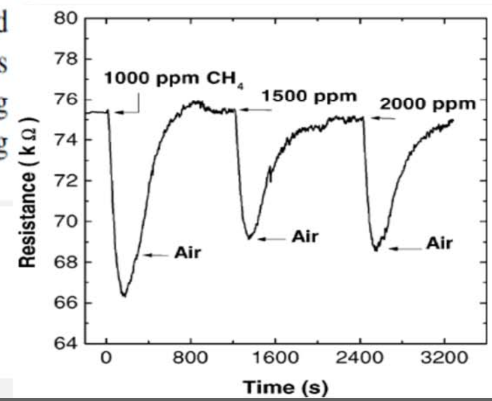
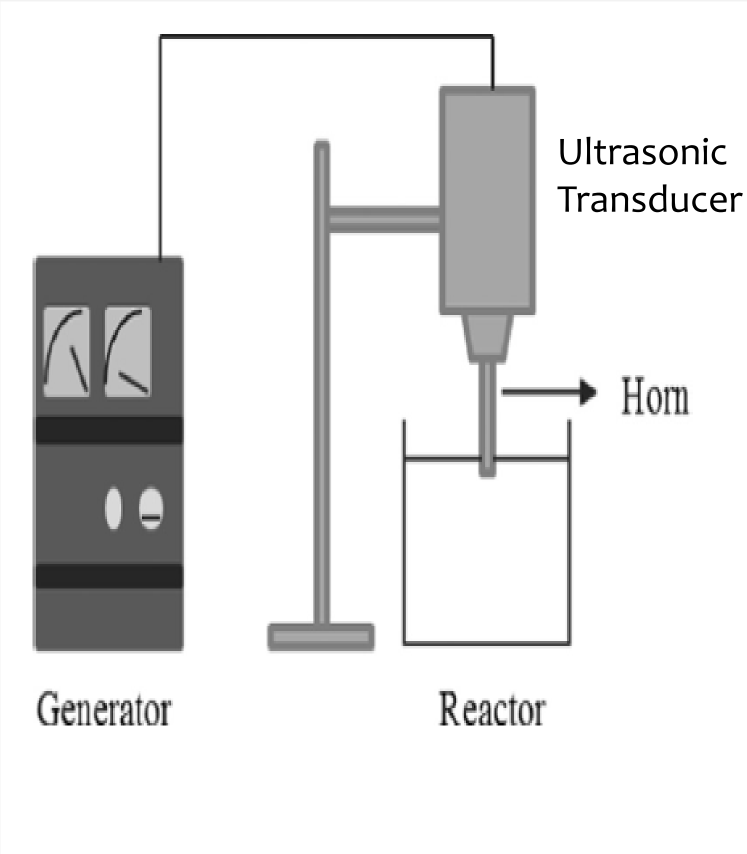


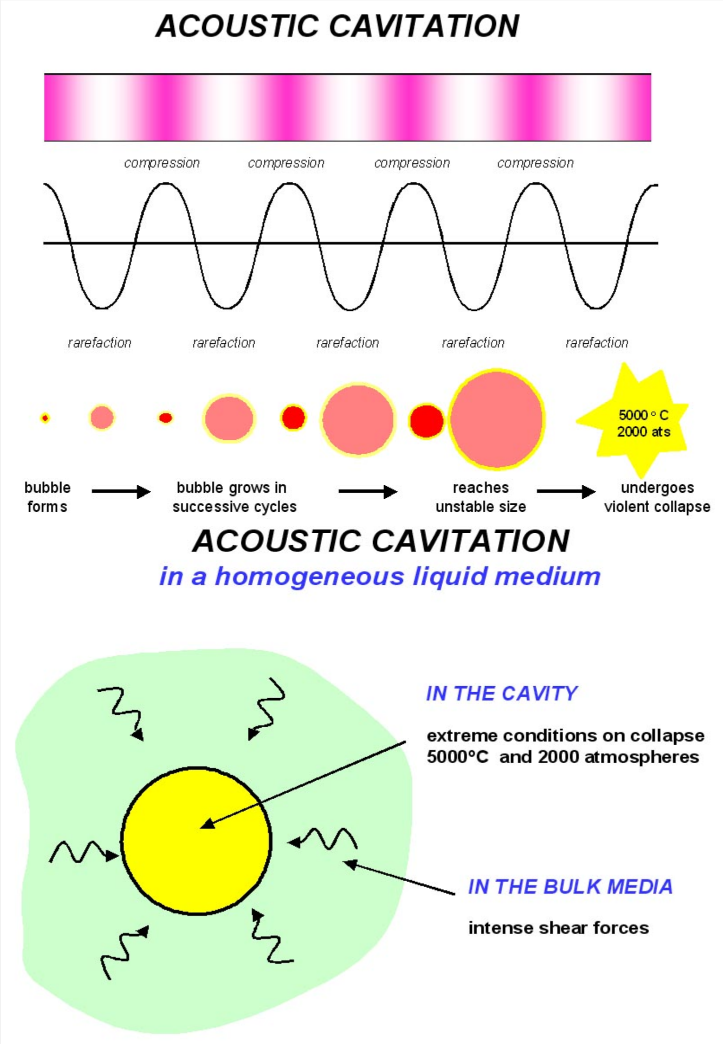
Fig. 1. Top view of the SnO_2 gas sensor lay-out. Meandered heater with two W/Au contacts and W/Au sensor electrodes can be identified from this picture.



Functional films prepared by Sonochemistry

Basics of sonochemistry





(12) **United States Patent**
Cobianu et al.

(10) **Patent No.:** **US 9,604,191 B2**
(45) **Date of Patent:** **Mar. 28, 2017**

METHOD AND SYSTEM FOR FLAMMABLE GAS DETECTION COMPRISING A SONICATED NANOSTRUCTURED METAL OXIDE

Applicant: **HONEYWELL INTERNATIONAL INC.**, Morristown, NJ (US)

Inventors: **Cornel P. Cobianu**, Bucharest (RO); **Bogdan-Catalin Serban**, Bucharest (RO); **Alisa Stratulat**, Bucharest (RO); **Viorel Georgel Dumitru**, Prahova (RO); **Mihai Brezeanu**, Bucharest (RO); **Octavian Buiu**, Bucharest (RO)

Assignee: **Honeywell International Inc.**, Morris Plains, NJ (US)

(57) **ABSTRACT**

The present disclosure relates to a nanostructured palladium-based flammable gas detector synthesized using sonochemistry. The nanostructured palladium-based flammable gas detectors may use nanostructured sensing materials to allow reduction of power consumption, where the nanostructures reduce power consumption due to their large specific area and increased porosity. The nanostructures may increase the number of active sensing sites, allowing the surface energy to be high enough for sensing reactions to occur without requiring significant external thermal energy,

Low Power Resistive Oxygen Sensor Based on Sonochemical $SrTi_{0.6}Fe_{0.4}O_{2.8}$ (STFO40)

Alisa Stratulat [1], Bogdan-Catalin Serban [1,*], Andrea de Luca [2], Viorel Avramescu [1], Cornel Cobianu [1], Mihai Brezeanu [1], Octavian Buiu [1], Lucian Diamandescu [3], Marcel Feder [3] Syed Zeeshan Ali [4] and Florin Udrea [2,4]

Sensors **2015**, *15*, 17495-17506; doi:10.3390/s150717495

[1] Honeywell Romania SRL, Sensors and Wireless Laboratory Bucharest (SWLB), Bucharest 020339, Romania; E-Mails: alisa.stratulat@honeywell.com (A.S.); viorel.avramescu@honeywell.com (V.A.); cornel.cobianu@honeywell.com (C.C.); mihai.brezeanu@honeywell.com (M.B.); octavian.buiu@honeywell.com (O.B.)

[2] Centre for Advanced Photonics and Electronics (CAPE), University of Cambridge, Cambridge CB3 0FA, UK; E-Mails: ad597@cam.ac.uk (A.L.); fu@eng.cam.ac.uk (F.U.)

[3] National Institute of Materials Physics, Bucharest-Magurele, P.O. Box. MG-7, Magurele 77125, Romania; E-Mails: diamand@infim.ro (L.D.); mfeder@infim.ro (M.F.)

[4] Cambridge CMOS Sensors Ltd., Cambridge CB4 0DL, UK; E-Mail: zeeshan.ali@ccmoss.com

EU-FP-7 "SOI-HITS" project, rewarded for technology innovation on entire FP-7 program, in December 2015 at Berlin

Low Power Resistive Oxygen Sensor Based on Sonochemical $SrTi_{0.6}Fe_{0.4}O_{2.8}$ (STFO40)

Alisa Stratulat [1], Bogdan-Catalin Serban [1,*], Andrea de Luca [2], Viorel Avramescu [1], Cornel Cobianu [1], Mihai Brezeanu [1], Octavian Buiu [1], Lucian Diamandescu [3], Marcel Feder [3] Syed Zeeshan Ali [4] and Florin Udrea [2,4]

Abstract: The current paper reports on a sonochemical synthesis method for manufacturing nanostructured (typical grain size of 50 nm) $SrTi_{0.6}Fe_{0.4}O_{2.8}$ (Sono-STFO40) powder. This powder is characterized using X ray-diffraction (XRD), Mössbauer spectroscopy and Scanning Electron Microscopy (SEM), and results are compared with commercially available $SrTi_{0.4}Fe_{0.6}O_{2.8}$ (STFO60) powder. In order to manufacture resistive oxygen sensors, both Sono-STFO40 and STFO60 are deposited, by dip-pen nanolithography (DPN) method, on an SOI (Silicon-on-Insulator) micro-hotplate, employing a tungsten heater embedded within a dielectric membrane. Oxygen detection tests are performed in both dry (RH = 0%) and humid (RH = 60%) nitrogen atmosphere, varying oxygen concentrations between 1% and 16% (v/v), at a constant heater temperature of 650 °C. The oxygen sensor, based on the Sono-STFO40 sensing layer, shows good sensitivity, low power consumption (80 mW), and short response time (25 s). These performance are comparable to those exhibited by state-of-the-art O_2 sensors based on STFO60, thus proving Sono-STFO40 to be a material suitable for oxygen detection in harsh environments.

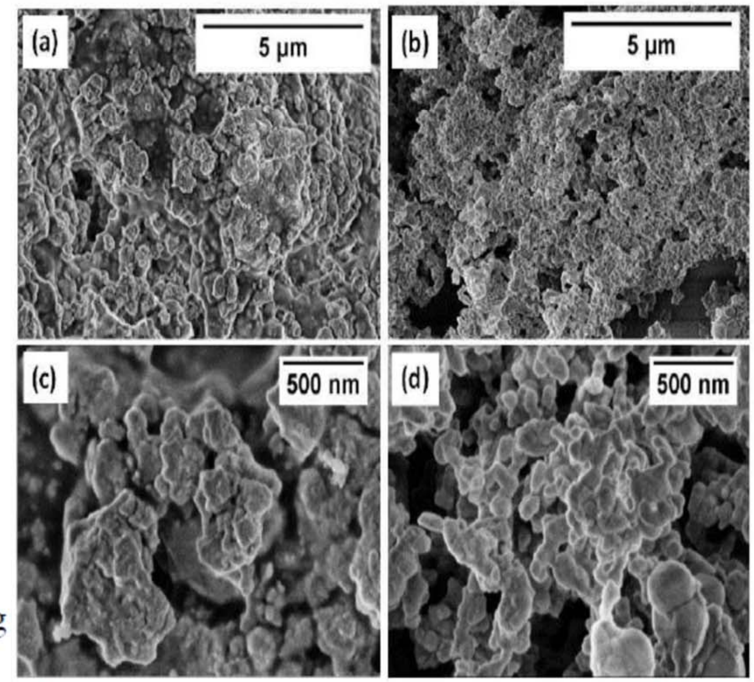


Figure 5. SEM micrographs of (**a**) commercial STFO60 (10 kX); (**b**) Sono-STFO40 (10 kX); (**c**) commercial STFO60 (50 kX); (**d**) Sono-STFO40 (50 kX).

Low Power Resistive Oxygen Sensor Based on Sonochemical $SrTi_{0.6}Fe_{0.4}O_{2.8}$ (STFO40)

Alisa Stratulat [1], Bogdan-Catalin Serban [1,*], Andrea de Luca [2], Viorel Avramescu [1], Cornel Cobianu [1], Mihai Brezeanu [1], Octavian Buiu [1], Lucian Diamandescu [3], Marcel Feder [3] Syed Zeeshan Ali [4] and Florin Udrea [2,4]

Sensors **2015**, *15*, 17495-17506; doi:10.3390/s150717495

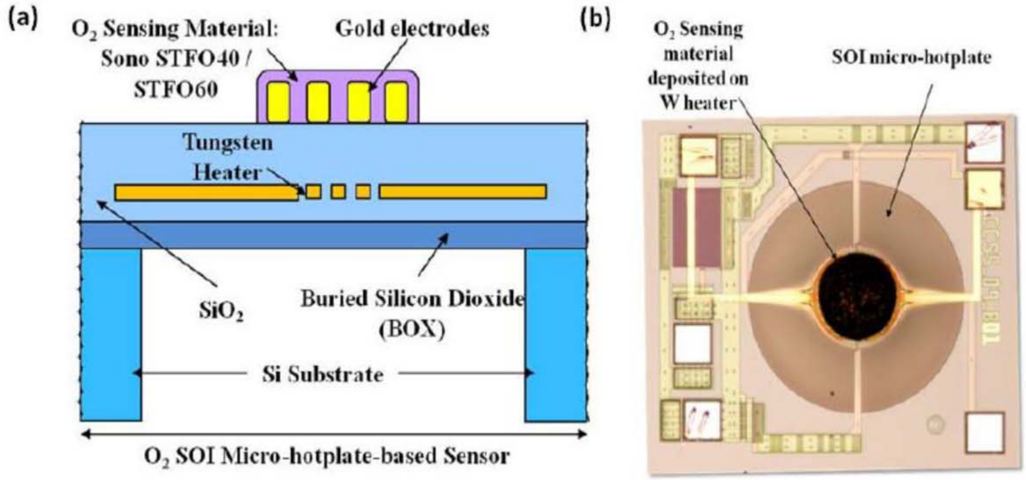


Figure 1. (**a**) O_2 resistive sensor structure employing a CMOS-compatible SOI micro-hotplate as substrate and Sono-STFO40 as sensing layer; (**b**) Top-view of the manufactured O_2 resistive sensor.

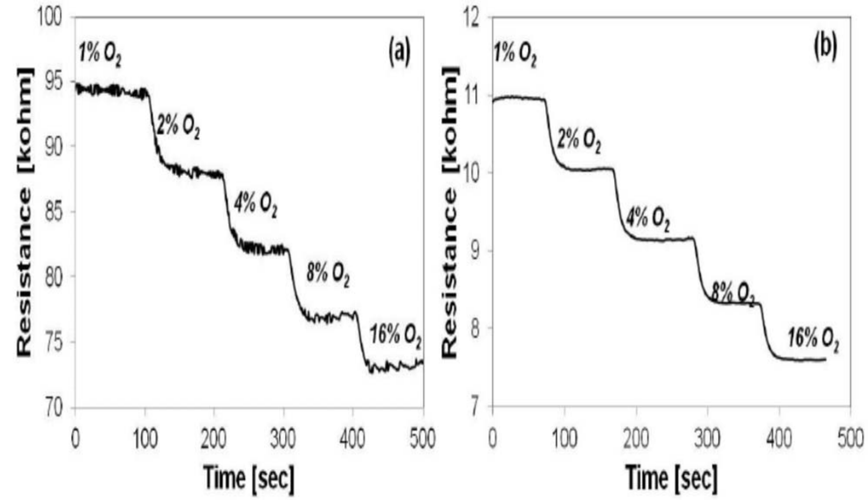


Figure 6. Oxygen sensor response in dry nitrogen atmosphere (1%–16% O_2) for: (**a**) Sono-STFO40 and (**b**) STFO60.

Industrial Research

(19) **United States**

(12) **Patent Application Publication**

Cobianu et al.

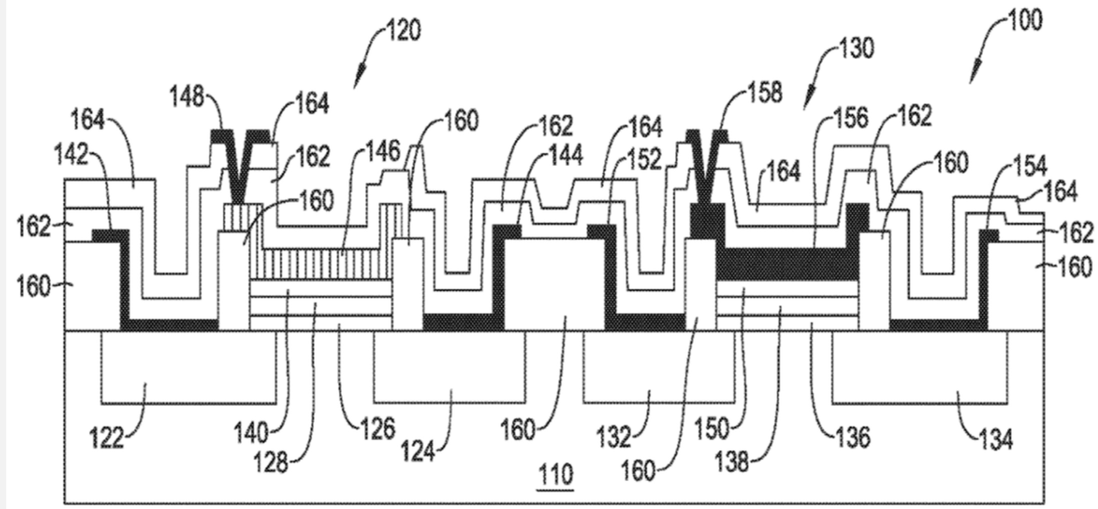
(10) **Pub. No.: US 2017/0328855 A1**

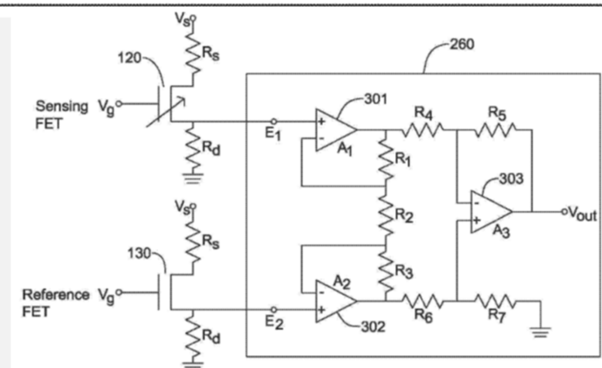
(43) **Pub. Date: Nov. 16, 2017**

FET BASED HUMIDITY SENSOR WITH BARRIER LAYER PROTECTING GATE DIELECTRIC

Applicant: **Honeywell International Inc.**, Morris Plains, NJ (US)

Inventors: **Cornel Cobianu**, Bucharest (RO); **Alisa Stratulat**, Bucharest (RO); **Bogdan Serban**, Bucharest (RO); **Octavian Buiu**, Bucharest (RO); **Cazimir Gabriel Bostan**, Bucharest (RO); **Mihai Brezeanu**, Bucharest (RO); **Stefan Dan Costea**, Bucharest (RO); **Richard Davis**, Plano, TX (US)





Quartz –MEMS Technology : Differential Pressure and Temperature Sensors

(12) **United States Patent**
Cobianu et al.

(10) **Patent No.: US 7,243,547 B2**
(45) **Date of Patent: Jul. 17, 2007**

(54) **MEMS SAW SENSOR**

(75) Inventors: **Cornel P. Cobianu**, Bucharest (RO); **Ioan Pavelescu**, Bucharest (RO); **James D. Cook**, Freeport, IL (US)

(73) Assignee: **Honeywell International Inc.**, Morristown, NJ (US)

Devices and methods for acoustically measuring temperature and pressure are disclosed. An illustrative SAW sensor can include an electrode structure that transmits and receives surface acoustic waves along a SAW delay line, a temperature sensor for measuring temperature along a first direction of the SAW delay line, and a pressure sensor for measuring pressure along a second direction of the SAW delay line. The SAW sensor can include an antenna that wirelessly transmits and receives RF signals to and from an electrical interrogator unit that can be used to power the SAW sensor.

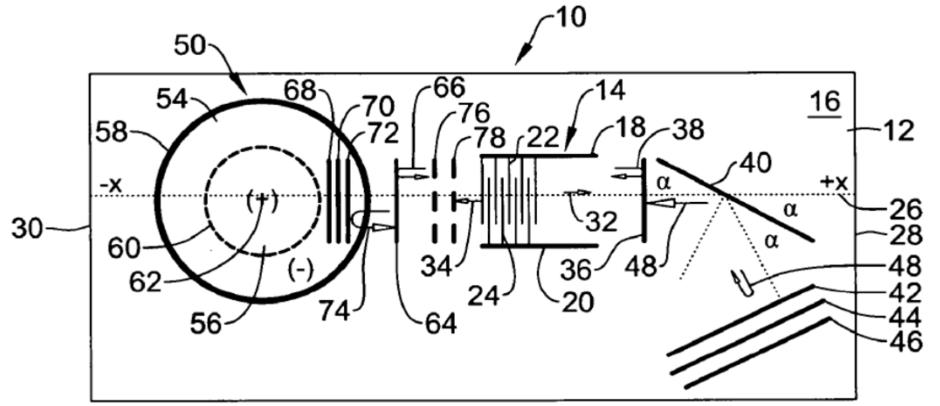


Figure 1

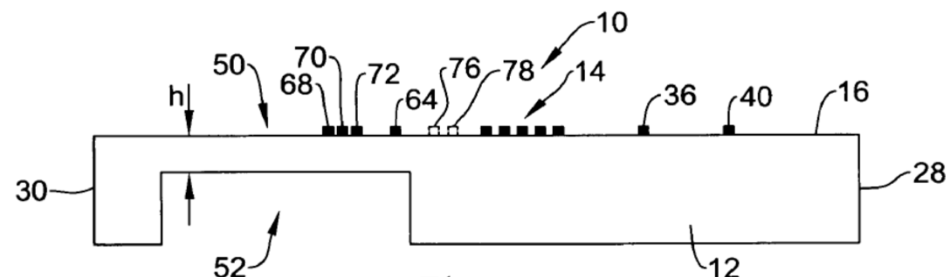


Figure 2

Low cost differential pressure sensor on plastic package

(12) **United States Patent**
Cobianu et al.

(10) **Patent No.: US 7,318,351 B2**
(45) **Date of Patent: Jan. 15, 2008**

(54) **PRESSURE SENSOR**

(75) Inventors: **Cornel P. Cobianu**, Bucharest (RO); **Stephen R. Shiffer**, Xenia, OH (US); **Bogdan Catalin Serban**, Bucharest (RO); **Alistair D. Bradley**, Edinburgh (GB); **Mihai N. Mihaila**, Bucharest (RO)

(73) Assignee: **Honeywell International Inc.**, Morristown, NJ (US)

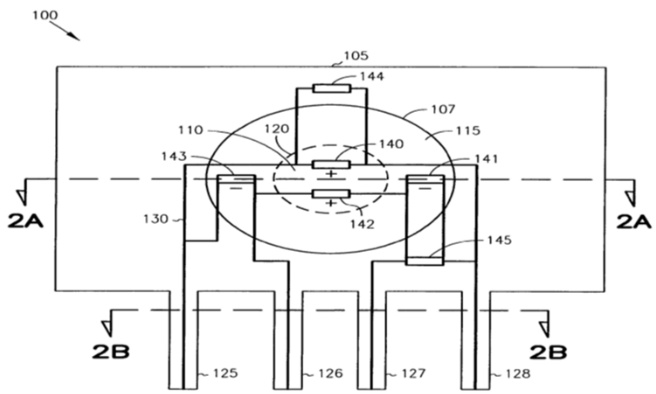


FIG. 1

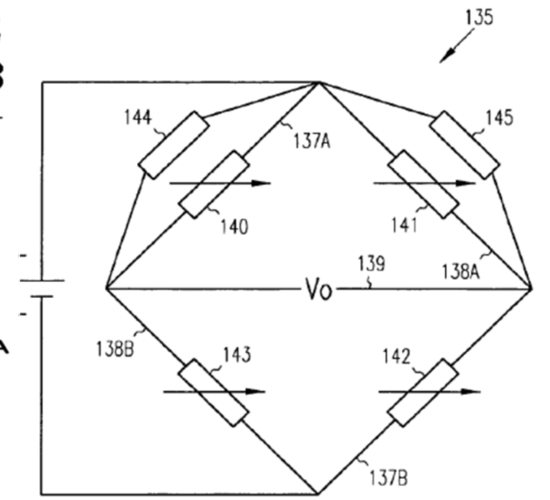


FIG. 3

A pressure sensor is constructed of a plastic package. The plastic package incorporates in the same material a sensing diaphragm including tensile and compression regions. Deposited on the diaphragm are metal electrodes and a polymer film having piezoresistive properties. The electrodes and/or the polymer film are directly printed onto the plastic package without the use of a mask.

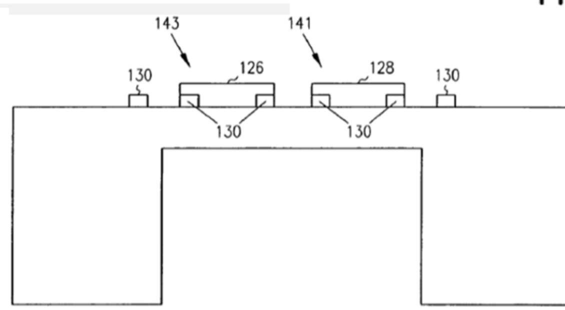


FIG. 2A

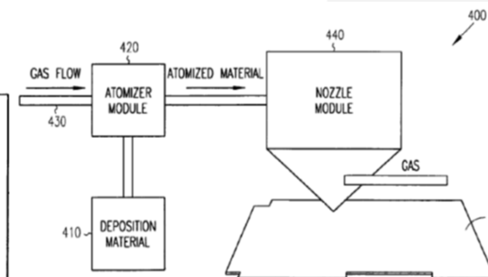


FIG. 4

Lead-free Electrochemical O_2 sensors

(12) **United States Patent**
Cobianu et al.

(10) **Patent No.:** **US 9,557,289 B2**
(45) **Date of Patent:** **Jan. 31, 2017**

(54) **LEAD-FREE ELECTROCHEMICAL GALVANIC OXYGEN SENSOR**

(75) Inventors: **Cornel Cobianu**, Bucharest (RO); **Bogdan-Catalin Serban**, Bucharest (RO); **Bryan Stewart Hobbs**, West Sussex (GB)

(73) Assignee: **Life Safety Distribution AG**, Hegnau (CH)

(57) **ABSTRACT**

A lead-free, self-corrosion-free electrochemical galvanic oxygen sensor is provided. The preferred sensor includes a container, the container including a lead-free anode, an alkali electrolyte, a carbon platinized with platinum cathode and a nickel wire current collector, wherein the container further includes a diffusion barrier that causes the sensor to operate in the limiting current region.

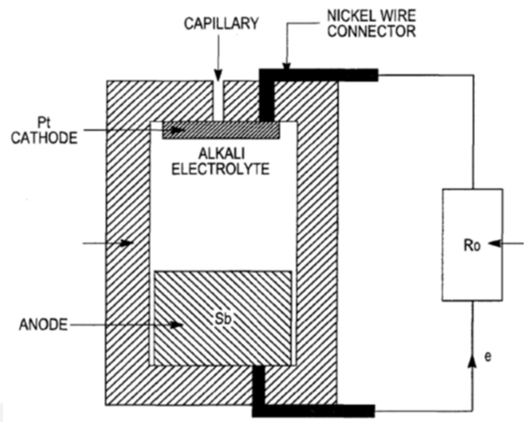
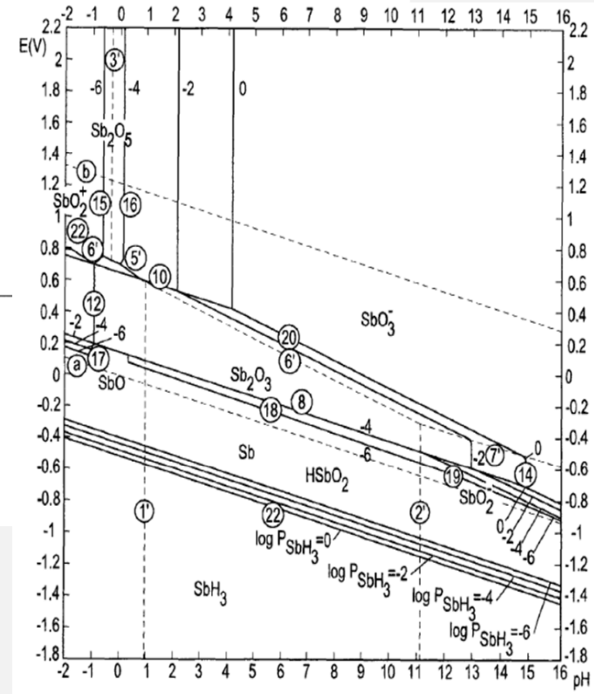


FIG. 1



POTENTIAL-pH EQUILIBRIUM DIAGRAM FOR THE SYSTEM ANTIMONY-WATER, AT 25°C

(12) **United States Patent**
Cobianu et al.

(10) **Patent No.: US 9,518,856 B2**
(45) **Date of Patent: Dec. 13, 2016**

THREADED COUPLING DEVICE WITH NOZZLE FOR GWR MEASUREMENTS IN NON-METALLIC TANKS

(72) Inventors: **Cornel Cobianu**, Bucharest (RO); **Ion Georgescu**, Bucharest (RO); **Stuart James Heath**, Surrey (CA); **Michael Kon Yew Hughes**, Vancouver (CA); **Frank Martin Haran**, North Vancouver (CA)

(73) Assignee: **Honeywell International Inc.**, Morristown, NJ (US)

(57) **ABSTRACT**

A coupling device for coupling a threaded feed-through of a process connection to provide a launcher for a non-metallic storage tank. The storage tank includes a tank aperture in its top surface. The coupling device includes a foil nozzle including an inner upper metal foil surface that includes a threaded aperture for securing the feed-through thereto, and a first and second lower metal foil surface on respective sides of the upper metal foil surface. The foil nozzle also includes a first and a second foil level transition region disposed between the respective sides of the inner upper metal foil surface and the first and second lower metal foil surface. The foil nozzle can be configured in a cylindrical, horn, or a corrugated horn shape.

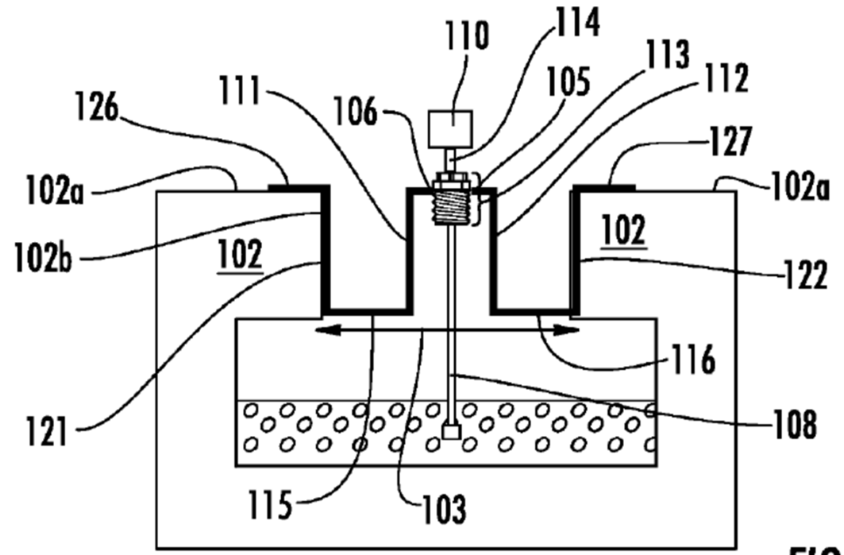


FIG. 1

Nanosensor technology

United States Patent
Cobianu

(10) **Patent No.:** **US 8,980,666 B2**
(45) **Date of Patent:** **Mar. 17, 2015**

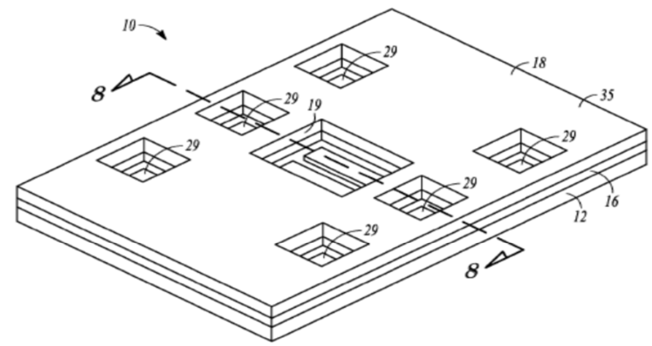
METHOD OF FABRICATING SENSORS HAVING FUNCTIONALIZED RESONATING BEAMS

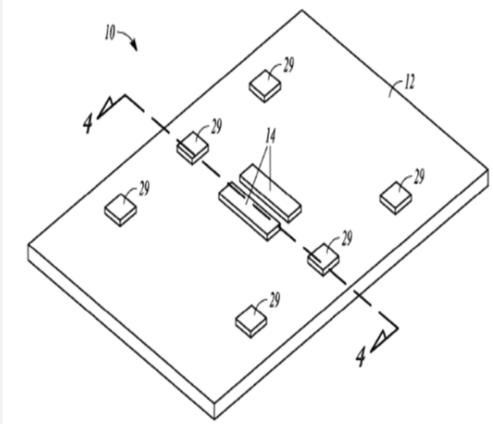
Inventor: **Cornel P. Cobianu**, Bucharest (RO)

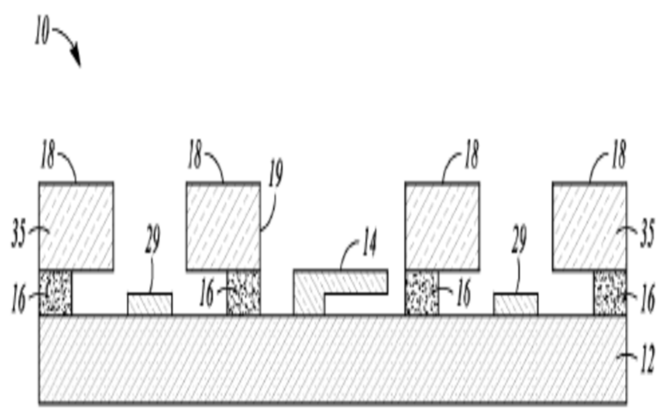
Assignee: **Honeywell Romania s.r.l.** (RO)

(57) **ABSTRACT**

Some embodiments relate to method of fabricating a sensor. The method includes providing a substrate wafer that includes a suspended beam; adding an adhesive layer to the substrate wafer such that the adhesive layer covers portions of the substrate without covering the suspended beam; positioning a cover wafer onto the adhesive layer such that the suspend beam is exposed to ambient air through openings in the cover wafer; and functionalizing the suspended beam by contacting the suspended beam with materials through the opening in the cover wafer.







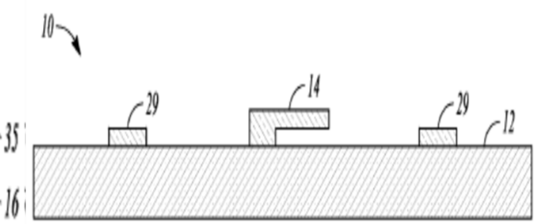


FIG. 4

Research performed within EU-FP-7 NEMSIC Project , Coordinator Prof. Adrian Ionescu, EPFL

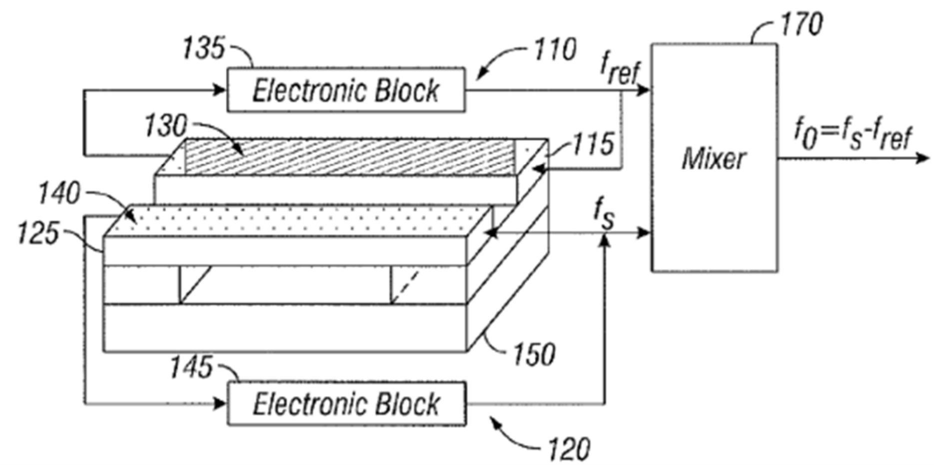
(12) **United States Patent**
Cobianu et al.

(10) **Patent No.: US 8,479,560 B2**
(45) **Date of Patent: Jul. 9, 2013**

(54) **DIFFERENTIAL RESONANT SENSOR APPARATUS AND METHOD FOR DETECTING RELATIVE HUMIDITY**

(75) Inventors: **Cornel Cobianu**, Bucharest (RO); **Bogdan Serban**, Bucharest (RO); **Mihai N. Mihaila**, Bucharest (RO)

(73) Assignee: **Honeywell International Inc.**, Morristown, NJ (US)



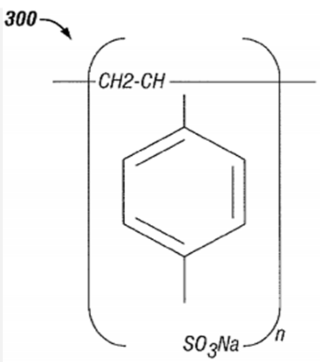


FIG. 3

Sensing layer
Sulfonated Polystyrene

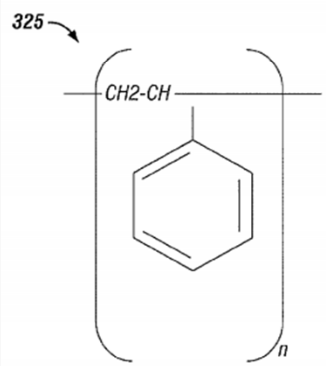


FIG. 4

Reference layer
Polystyrene

United States Patent
Serban et al.

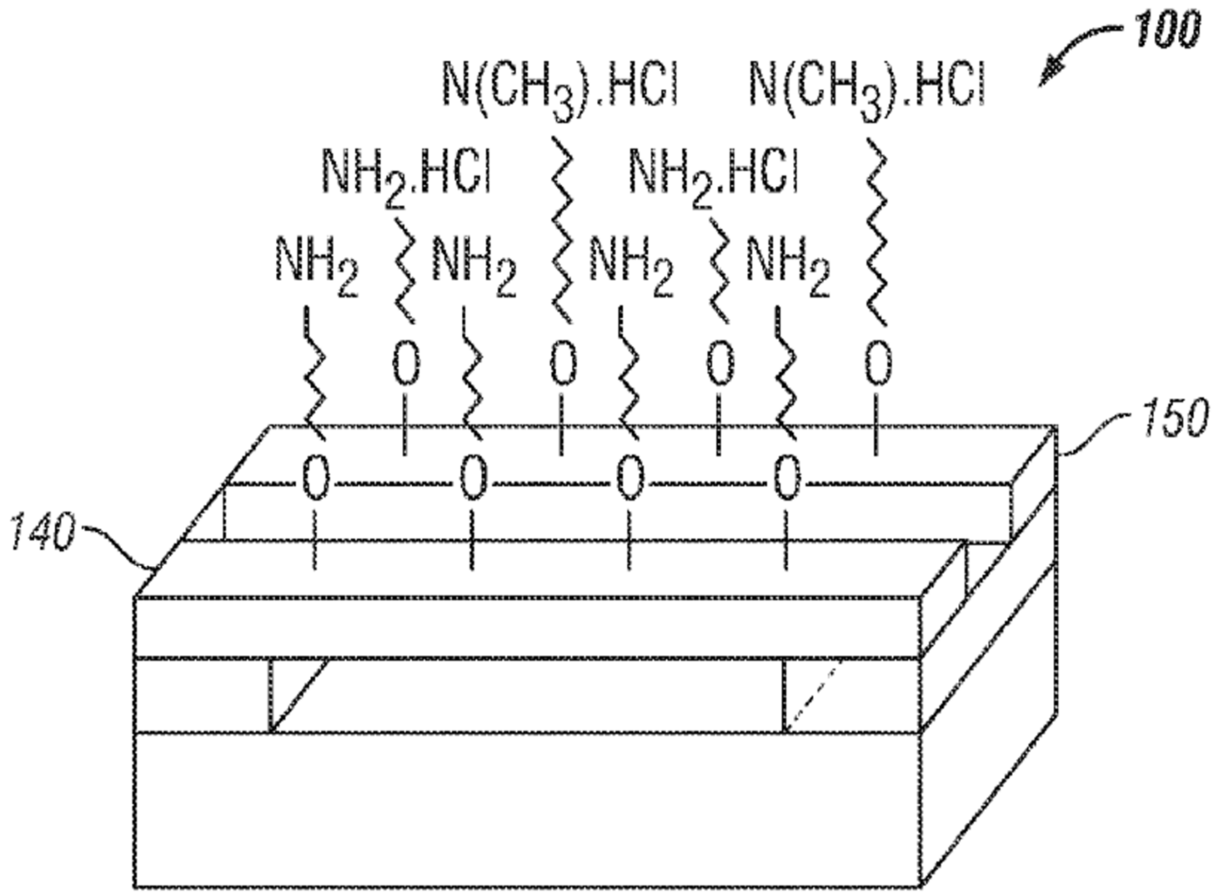
(10) **Patent No.: US 8,230,720 B2**
(45) **Date of Patent: Jul. 31, 2012**

FUNCTIONALIZED MONOLAYERS FOR CARBON DIOXIDE DETECTION BY A RESONANT NANOSENSOR

Inventors: **Bogdan-Catalin Serban**, Bucharest (RO); **Cornel Cobianu**, Bucharest (RO); **Mihai N. Mihaila**, Bucharest (RO); **Viorel-Georgel Dumitru**, Ploiesti (RO)

Assignee: **Honeywell International Inc.**, Morristown, NJ (US)

A resonant nanosensor apparatus associated with a functionalized monolayer for detecting carbon dioxide and a method of forming the same. A wafer including a sensing vibrating beam and a reference vibrating beam may be functionalized with a functional group in order to form a sensing self monolayer. The sensing self assembled monolayer may be configured by bridging oxygen or carbon atoms covalently bonded with respect to the vibrating beams. A liquid solution of hydrochloric acid may then be applied to the sensing self assembled monolayer at the surface of the reference beam by a direct printing process to obtain a reference monolayer. The liquid solution of HCl transforms the functional groups responsible for the carbon dioxide detection into protonated groups, which do not react with carbon dioxide, but possess visco-elastic properties similar to that of the sensing monolayer.



Conclusions

W. Edwards Deming:

"Learning is not compulsory... neither is survival".
It is not necessary to change, survival is not compulsory
" In God we trust. All the other must bring data"

Einstein :

"Life is like riding a bicycle. To keep your balance you must keep moving"
"Make things as simple as possible, but not simpler"
"Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution."

Thank you for your attention !