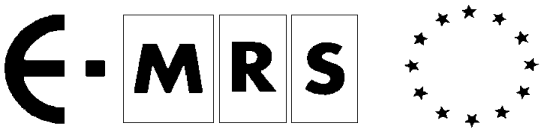

EUROPEAN
MATERIALS RESEARCH SOCIETY

Strasbourg (France)

E-MRS IUMRS ICEM 2006 Spring Meeting

Nice, France - May 29 – June 2, 2006

SYMPOSIUM L

Characterization of High-k Dielectric Materials

Symposium Organizers:

Jarek Dabrowski, IHP, Frankfurt (Oder), Germany

Paul Hurley, Tyndall National Institute, Cork, Ireland

Junichi Murato, University of Tohoku, Japan

Eicke R. Weber, University of California, Berkeley, USA

Symposium Support

Papers to be published in Materials Science in Semiconductor Processing

Poster Session 4b : Physical and Electrical Properties

Tuesday, May 30, 2006
16:30 - 18:30

L 4b 01 STRUCTURAL AND ELECTRONIC PROPERTIES OF ZIRCONIA PHASES :
R. Terki, G. Bertrand, H. Aourag and C. Coddet. Laboratoire d'Etudes et de Recherches sur les Matériaux, les Procédés et les Surfaces, Université de Technologie de Belfort-Montbéliard, Site de Sévenans, 90010 Belfort, France

L 4b 02 Spectroscopic ellipsometry characterization of ZrO2 thin films by nitrogen assisted reactive magnetron sputtering
L.Q.Zhu(a), Q.Fang(a,b), G.He(a), M.Liu(a), X.X.Xu(a), L.D.Zhang(a) a: Key Laboratory of Materials Physics, Anhui Key Laboratory of Nanomaterials and Nanostructure, Institute of Solid State Physics, Chinese Academy of Science, P.O.Box 1129, Hefei 230031, P.R.China b: London Centre for Nanotechnology and Electronic & Electrical Engineering, University College London, Torrington Place, London WCIE 7JE, UK

L 4b 03 Microstructure of High-k HfAlxO2-x Thin Films and Control of Leakage Current by High Concentration Ozone Oxidation
A. P. Huang and Paul K. Chu * Department of Physics and Materials Science, City University of Hong Kong Tat Chee Avenue, Kowloon, Hong Kong

L 4b 04 ELECTRICAL PROPERTIES OF Al2O3-HfTiO GATE DIELECTRIC STACKS WITH LESS THAN 0.8 NM EQUIVALENT OXIDE THICKNESS
V. Mikhelashvili and G. Eisenstein, Department of Electrical Engineering, Technion-Israel Institute of Technology, Haifa 3200, Israel

L 4b 05 Suppressed Interlayer and Dielectric Properties of Carbon-Doped High-k ZrO2 Thin Films
A. P. Huang and Paul K. Chu * Department of Physics and Materials Science, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong

L 4b 06 Conduction mechanisms and trapping in sputtered HfO2 films
L Wang, D Liu, J Robertson, Engineering Dept, Cambridge University, Cambridge CB2 1PZ, UK

L 4b 07 EPR characterization of defects in monoclinic powders of ZrO2 and HfO2
R.C. Barklie and S. Wright School of Physics, Trinity College, Dublin 2, Ireland.

L 4b 08 Low-Temperature Conductance Measurements of Surface States in HfO2-Si Structures with Different Gate Materials
Yu.Gomenyuk1, A.Nazarov1, Ya.Vovk1, Yi Lu2, Octavian Buiu2, Steve Hall2, J.K. Efavi3 and M.C. Lemme3 1 Institute of Semiconductor Physics, NASU, 41, pr. Nauky, 03028 Kiev, Ukraine 2 Department of Electrical Engineering and Electronics, Brownlow Hill, University of Liverpool, Liverpool, L69 3GJ, UK 3 Advanced Microelectronic Center Aachen (AMICA), AMO GmbH, Huyskensweg 25, 52074 Aachen

L 4b 09 Interfacial Reactions between High-k Praseodymium Aluminate and TiN
G. Lippert, J. Dabrowski, I. Costina, G. Lupina, V. Melnik, L. Oberbeck*, U. Schroeder*, Ch. Wenger, P. Zaumseil, and H.-J. Muessig IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany, *Infineon Technologies AG, 01099 Dresden, Germany

L 4b 10 Electrical and interfacial characteristics of nanolaminate (Al2O3/ZrO2/Al2O3) gate stack on fully-depleted SiGe-on-insulator
Zengfeng Di (a), Miao Zhang, Weili Liu, Qinwo Shen, Suhua Luo (a), Zhitang Song, Chenglu Lin The Research Center of Semiconductor Functional Film Engineering Technology & State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology (SIMIT), Chinese Academy of Sciences (CAS), Shanghai 200050, People's Republic of China Anping Huang, and Paul K. Chu (b) Department of Physics and Material Science, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, China (a) Also affiliated with Department of Physics & Materials Science, City University of Hong Kong, Hong Kong, China (b) Corresponding author

L 4b 11 The effect of quenching media on the surface heat transfer coefficient of electronic materials
Seunghwan Ma, and Youngman Kim, Hanyang University, Korea

L 4b 12 Point defects in dielectrics based on Pr oxides
J. Dabrowski, IHP, Im Technologiepark 25, 15-236 Frankfurt(Oder), Germany

L 4a 00 15:30 **Title : Precise determination of metal effective work function and fixed oxide charge in MOS capacitors with high-k dielectric**
(view full abstract)

L 4a 00 15:45 **Title : The effect of oxygen in Ru gate electrode on effective work function of Ru/ HfO2 stack structure**
(view full abstract)

L 4b poster 00 16:15 **Title : STRUCTURAL AND ELECTRONIC PROPERTIES OF ZIRCONIA PHASES :**
(view full abstract)

L 4b poster 00 16:15 **Title : Spectroscopic ellipsometry characterization of ZrO2 thin films by nitrogen assisted reactive magnetron sputtering**
(view full abstract)

L 4b poster 00 16:15 **Title : Microstructure of High-k HfAlxO2-x Thin Films and Control of Leakage Current by High Concentration Ozone Oxidation**
Paul Chu, A. P. Huang and Paul K. Chu * Department of Physics and Materials Science, City University of Hong Kong Tat Chee Avenue, Kowloon, Hong Kong
Resume : The high integrated circuit density and performance demanded by the microelectronics industry requires thin gate dielectric layers. The use of SiO2 thin films as the gate oxide dielectric is quickly reaching a limitation due to the rapid increase in the tunneling current causing unsustainably large energy consumption and poor device reliability. A promising alternative is to use a gate insulator with a higher relative dielectric constant k (high-k) than silicon dioxide (3.9). Recently, many metal oxides, such as TiO2, Ta2O5, ZrO2 and HfO2 have been proposed as candidates for high-k materials. Unfortunately, a transition metal oxide with a higher permittivity tends to have a narrow bandgap, which leads to a large leakage current. In addition, most high-k materials are thermodynamically unstable at elevated temperatures when they are in contact with Si. Therefore, it is necessary to align the energy bandgap and improve the thermal stability of these high-k materials for the application in ultra large-scale integrated (ULSI) circuits. Al2O3, which has good thermal stability and a large bandgap, is a suitable dopant in high-k materials such as HfO2 and ZrO2. In this work, HfAlxO2-x samples were prepared by oxidation of Hf films evaporated on silicon substrate followed by Al ion implantation in high concentration (3%) ozone at low temperature. The 5 nm thick Hf films were fabricated by electron beam evaporation at high base vacuum (2×10-8 torr) without intentional heating. After metal deposition, the samples were implanted with Al ions and then transferred to a conventional oxidation furnace filled with a high concentration of ozone produced by microwave. Oxidation was performed at 150 °C for 5 min under 1 atm oxygen pressure and then the samples were treated by rapid thermal annealing (RTA) at 1000oC for 30 s. The microstructure and interfacial layer between HfAlxO2-x and the silicon substrate can be effectively controlled and the leakage current density is also substantially reduced. Our results show direct evidence that high concentration ozone oxidation is an effective method to improve the properties of HfAlxO2-x thin films.
(close full abstract)

L 4b poster 00 16:15 **Title : ELECTRICAL PROPERTIES OF Al2O3-HfTiO GATE DIELECTRIC STACKS WITH LESS THAN 0.8 NM EQUIVALENT OXIDE THICKNESS**
(view full abstract)

L 4b poster 00 16:15 **Title : Suppressed Interlayer and Dielectric Properties of Carbon-Doped High-k ZrO2 Thin Films**
Paul Chu, A. P. Huang and Paul K. Chu * Department of Physics and Materials Science, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong
Resume : Zirconia (ZrO2) is a promising high-k material in dynamic random access memories (DRAM) and gate oxide in field effect

transistors (FET) because of its high permittivity and good thermodynamic stability in contact with silicon. However, ZrO2 crystallizes at temperatures below 400oC seriously limiting applications of the materials in ultra large-scale integrated (ULSI) circuits from a storage point of view. In this work, carbon-doped ZrO2 thin films were fabricated on n-type Si (100) wafers by hybrid cathodic arc deposition involving oxygen and ethane gases in the presence of substrate biasing. The interfacial and dielectric properties of the materials were investigated. Incorporation of C into the ZrO2 structure increases the crystallization temperature, and the microstructure of the carbonized ZrO2 thin films is improved based on X-ray diffraction and atomic force microscopy characterization. In particular, formation of interfacial silicates between the ZrO2 thin film and Si substrate is well suppressed according to the results of FTIR and HRTEM. The suppression is believed to stem from carbonization in conjunction with substrate biasing which can increase the number of bombarding ions as well as the ion impact energy thereby improving the interfacial properties. An Au/ZrO2/Si/Al capacitor structure was fabricated and the electrical characteristics were measured. The hysteresis of the carbon-doped ZrO2 thin films is reduced significantly and a negligible flatband shift is also observed. At the same time, there is no degradation in the dielectric constant and the leakage current density is significant reduced. Our study suggests that a hybrid cathodic arc deposition process conducted in the presence of ethane in conjunction with substrate biasing is an effective method to improve the properties of high-k ZrO2 thin films and may accelerate the development of alternative high-k dielectric thin films in advanced microelectronic devices and structures.
(close full abstract)

L 4b poster 00 16:15 **Title : Conduction mechanisms and trapping in sputtered HfO2 films**
(view full abstract)

L 4b poster 00 16:15 **Title : EPR characterization of defects in monoclinic powders of ZrO2 and HfO2**
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L 4b poster 00 16:15 **Title : Low-Temperature Conductance Measurements of Surface States in HfO2-Si Structures with Different Gate Materials**
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L 4b poster 00 16:15 **Title : Interfacial Reactions between High-k Praseodymium Aluminate and TiN**
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L 4b poster 00 16:15 **Title : Electrical and interfacial characteristics of nanolaminate (Al2O3/ZrO2/Al2O3) gate stack on fully-depleted SiGe-on-insulator**

Zengfeng dizengfeng, Zengfeng Di (a), Miao Zhang, Weili Liu, Qinwo Shen, Suhua Luo (a), Zhitang Song, Chenglu Lin The Research Center of Semiconductor Functional Film Engineering Technology & State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology (SIMIT), Chinese Academy of Sciences (CAS), Shanghai 200050, People's Republic of China Anping Huang, and Paul K. Chu (b) Department of Physics and Material Science, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, China (a) Also affiliated with Department of Physics & Materials Science, City University of Hong Kong, Hong Kong, China (b) Corresponding author: Prof. Paul K Chu Telephone: 852-27887724 Fax: 852-27889549 or 852-27887830 Electronic mail: paul.chu@cityu.edu.hk

Resume : The structural and electrical characteristics of a novel nanolaminate Al2O3/ZrO2/Al2O3 high-k gate stack together with the interfacial layer formed on SiGe-on-insulator substrate have been investigated. A clear layered Al2O3 (2.5 nm) / ZrO2 (4.5 nm) / Al2O3 (2.5 nm) structure and an interfacial layer (2.5 nm) are observed by