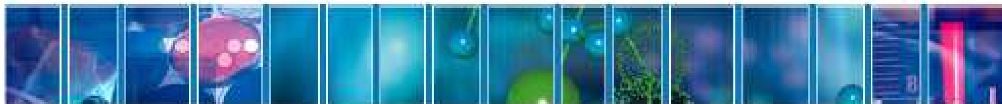

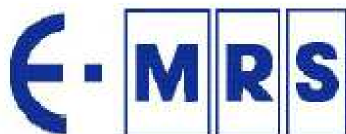

2012 Spring Meeting

May 14 – 18
Strasbourg, France

PROGRAMME

CONFERENCE SYMPOSIA

MATERIALS FOR ENERGY

A Advanced Silicon Materials Research for Electronic and Photovoltaic Applications III
B Thin Film Chalcogenide Photovoltaic Materials
C Solid State Ionics: Mass and Charge Transport across and along Interfaces of Functional Materials
D Unconventional Thermoelectrics: from new materials to energy conversion devices
E Actinide compounds and properties
F Solid proton conductors (In honor of Prof. G. Alberti)

BIO / ORGANIC / POLYMERIC MATERIALS

G Functional Biomaterials
H Organic and Hybrid Materials for Flexible Electronics: Properties and Applications
I Biological applications for organic electronic devices
J DNA Directed Programmable Self-assembly of Nanoparticles into Meta Materials for energy and other applications
K Surface modifications of carbon-related materials II

MATERIALS FOR ELECTRONIC / PHOTONIC / PLASMONIC

L Novel Functional Materials and Nanostructures for innovative non-volatile memory devices
→ M More than Moore: Novel materials approaches for functionalized Silicon based Microelectronics
N Control of light at the nanoscale: materials, techniques and applications
O Applied Nanoplasmonics: Nanoplasmonic Functional Materials and Devices

ADVANCED MATERIALS AND NANO MATERIALS

P Advanced Hybrid Materials II: design and applications
Q Novel materials and fabrication methods for new emerging devices
R Science and technology of nanotubes, graphene and 2D layered materials
S Novel materials for hetereogeneous catalysis
T Physics and Applications of Novel gain materials based on Nitrogen and Bismuth Containing III-V Compounds
U Carbon- or Nitrogen-Containing Nanostructured Thin Films

METHODS AND ANALYSIS

V Laser materials processing for micro and nano applications
W Current Trends in Optical and X-Ray Metrology of Advanced Materials for Nanoscale Devices III
X Quantitative Microscopy of Energy Materials
Y Advanced materials and characterization techniques for solar cells

Affiliations : 1Institute of Materials Science, NCSR DEMOKRITOS, GR-15310 Athens, Greece; 2PSE Division, KAUST, Thuwal 23955-6900, Saudi Arabia
Resume : Forming a good Ge/dielectric interface is important to improve the electron mobility of Ge-metal-oxide-semiconductor field-effect transistor. A thin yttrium germanate layer can improve the interfacial properties of Ge/GeO2. We employ electronic structure calculations to investigate the effect of oxygen vacancies in yttrium-doped GeO2 and the yttrium germanates Y2Ge2O7 and Y2GeO5. The calculated densities of states indicate that dangling bonds (from the vacancies) introduce in-gap states, but the system remains insulating.

add to my program (close full abstract)

16:00 **Improved electrical properties of atomic layer deposited multilayer gate dielectrics in different arrangement for Germanium MOS devices**

Authors : a) Ming-Ho Lin, a) Chih-Chiao Chen, a) Chun-Kai Lan, a) Jyun-Yi Wu, b) Che-Hao Chang
Affiliations : a) Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan, Republic of China ; b) Taiwan Semiconductor Manufacturing Company, Hsinchu Taiwan, Republic of China
Resume : In the literatures, it shows that the rare earth oxides have strong reaction with Germanium (Ge) substrate, which results to the spontaneous formation of stable interfacial layer. In addition, we know that larger energy band gap (Eg) ~8.8 eV of Al2O3 and larger κ value ~60 of TiO2 are good characteristics in high-κ gate oxide used for metal-oxide-semiconductor (MOS) devices. In this article, La2O3-Al2O3-TiO2 high-κ multilayer gate dielectrics were successfully grown on p-type Ge (100) substrate by remote plasma atomic layer deposition (RPALD). Electrical properties of the films, including C-V and I-V relations, were measured by Keithley 4200. It shows many different electrical characteristics, including C-V behavior, leakage current density, and interface-state density between the devices which the stacking films are in different arrangement. Among them, the intermediate layer and the contact layer with substrate are the most important issues for device characteristics. Appropriate high-κ oxide can effectively improve the performance of the device and take advantage of the each stacking film. Furthermore we also investigate the physical properties of the films by X-ray Photoelectron Spectroscopy (XPS), auger electron spectroscopy (AES) and transmission electron microscopy (TEM) to realize the mechanism of multilayer gate dielectrics for Ge MOS devices.

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→ 16:00 **Controlling the properties of layered self-organized Ge clusters in a silica matrix**

Authors : S. R. C. Pinto1, M. Roldan2, Maja Buljan3, S. Bernstorff4, A. Chahboun5, N.P. Barradas6, E. Alves6, S I.Molina2,M. Varela7, S.J. Pennycook7, M. M.D. Ramos1, M. J. M. Gomes1,
Affiliations : 1 University of Minho, Centre of Physics and Physics Department, Braga, 4710-057, Portugal; 2 Departamento de Ciencia de los Materiales e Ing. Metalúrgica y Q. I., Universidad de Cádiz, Cádiz, Spain; 3 Institut Ruđer Bošković Institute, Bijenička 54, HR-10000, Croatia; 4 Sincrotrone Trieste, SS 14 km163, 5, 34012 Basovizza, Italy; 5 FST Tanger, Physics Department, BP 416 Tanger, Morocco; 6 University of Lisbon, Physics Department and ICEMS, 1749-016 Lisboa, Portugal;7Oak Ridge National Laboratory, Oak Ridge TN 37831 USA.
Resume : Si and Ge nanocrystals (NCs) embedded in a dielectric matrix, such as SiO2, have attracted great interest for many relevant technological applications. There are many studies about Ge NCs embedded in a single layer of SiO2 [1]. However, there are only a few published results about Ge NCs embedded in SiO2 multilayers [2]. Using a multilayered superlattice approach one can achieve a higher density and more uniform size and spatial distributions of NCs, which is very important for the collective behavior effects. In this work we investigate the structural properties of Ge quantum dot (QD) lattices formed in amorphous silica matrix by magnetron sputtering deposition of (Ge+SiO2)/SiO2 multilayers. We demonstrate the dependencies of QD shape, size, separation and spatial arrangement on Ge-rich (Ge+SiO2) layer thickness. We show that the formed QDs are elongated perpendicular to the multilayer surface (vertical direction). The vertical size of the QDs and their separation in the vertical direction can be tuned by changing the Ge-rich layer. The mean values of the QDs lateral size and their lateral separation are not affected by the thickness of the Ge-rich layer. However, the thickness of Ge-rich layer significantly affects the regularity in QD ordering. In addition, we investigate the dependence of the

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Controlling the properties of layered self-organized Ge clusters in a silica matrix

S. R. C. Pinto[1], M.A. Roldan[2], Maja Buljan[3], S. Bernstorff[4], A. Chahboun[5], N.P. Barradas[6], E. Alves[6], S I.Molina[2], M. Varela[7], S.J. Pennycook[7], M. M.D. Ramos[1], M. J. M. Gomes[1]

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Contact author: chahboun@fisica.uminho.pt

INTRODUCTION

Si and Ge nanocrystals (NCs) embedded in dielectric matrices, such as SiO_2, have attracted a great interest for many relevant technological applications. There are many studies about Ge NCs embedded in a single layer of SiO_2 [1]. However, there are only few published results about Ge NCs embedded in SiO_2 multilayers [2]. Using a multilayered superlattice approach one can achieve a higher density and more uniform size and spatial distributions of NCs, which is very important for the collective behavior effects.

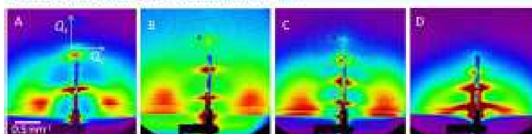
In this work we investigate the structural properties of Ge quantum dot (QD) lattices in amorphous silica matrix, prepared by low-temperature magnetron sputtering deposition of $(Ge+SiO_2)/SiO_2$ multilayers. We demonstrate the dependencies of QD shape, size, separation and arrangement type on the Ge-rich $(Ge+SiO_2)$ layer thickness. The size of the QDs and their separation along the growth direction can be tuned by changing the Ge-rich layer thickness. The average values of the QDs lateral sizes and their lateral separation are not affected by the thickness of the Ge-rich layer. However, the thickness of Ge-rich layer significantly affects the QD ordering. In addition, we investigate the dependence of the multilayer average atomic composition and QD crystalline quality on the deposition parameters, which are important for future device applications [3].

RESULTS AND DISCUSSION

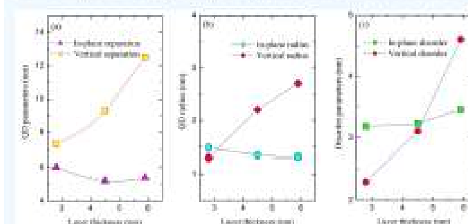
TABLE: Layer thickness of the multilayers, controlled by the deposition time. Dot parameters found from GISAXS analysis

Sample name	Layer thickness-nominal (nm)		Dot parameters-GISAXS (nm)			
	SiO_2 + Ge	SiO_2	R_L	R_V	a_0	c_0
A	2±1	6±1	1.5±0.2	1.3±0.2	6.0±0.5	7.3±0.1
B	5±1	6±1	1.4±0.2	1.7±0.2	5.2±0.5	9.3±0.1
C	6±1	7±1	1.3±0.3	2.6±0.4	5.4±0.7	12.5±0.2
D	9±1	6±1	1.8±0.5	2.5±0.9	7.1±0.9	14.5±0.2

The structural properties of the multilayers, the ordering and size of the Ge clusters were studied by the GISAXS technique. The strong intensity peaks indicate the formation of a well-ordered structure of Ge clusters. The Ge clusters are ordered in plane (within the layers) and also in vertical direction (within different layers). However, the position of the peaks and their intensity structure depend strongly on the deposition conditions

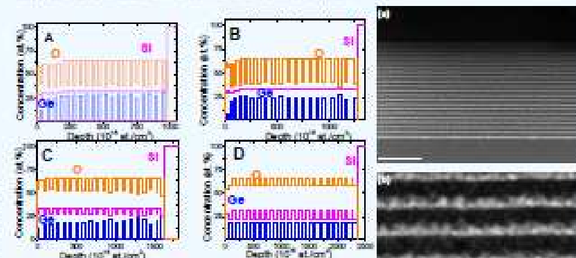


GISAXS maps of multilayer samples deposited under different conditions

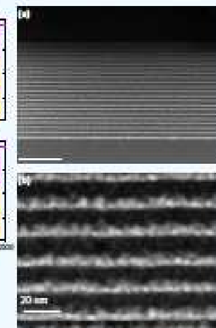


Dependence of quantum dots lattice parameters (a) QD radius (b) and QD disorder (c) on the $Ge+SiO_2$ layer thickness, obtained using the paracrystal model.

The thicknesses of the layers and their atomic composition were determined by RBS technique. The results confirm the formation of a multilayer structure and the increasing of the layer thicknesses with the deposition time. HAADF image shows the distribution of nanoparticles and the formation of well-defined layers.

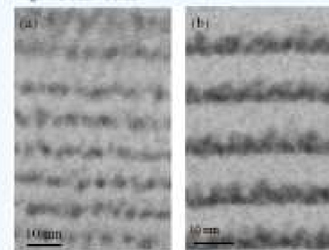


Concentration of different elements (Si, O and Ge) in function of the depth for multilayers samples with different thicknesses.



Low Mag HAADF image (a)and HAADF image for sample D (b)

Increasing the Ge-rich layer thickness the self assembly mechanism works less efficiently. This is due to the increase of the surface roughness with the increase of the QD vertical radius.



STEM images of films A (a) and D (b)

The QD vertical radius and the roughness of the interface of the $Ge+SiO_2/SiO_2$ layers is significantly higher for film D. For the case of self-assembled growth in thinner layers (film A) the self-assembly mechanism causes improvement of both in-plane and vertical ordering.

CONCLUSIONS

➢ It is possible to tune the properties of the Ge QDs (size, shape, lateral and vertical distances) through the deposition conditions.

➢ Increasing the layer thickness of Ge-rich layers the quality of the QDs self-assembly decreases.

➢ The size of the QDs along the growth direction gets larger by increasing the $Ge+SiO_2$ layer thickness, since the SiO_2 layer acts as physical barrier by stopping the GeO diffusion.

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[1] W. K. Choi, et al., Appl. Phys. Lett. **89**, 113126 (2006);
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[3] S. R. C. Pinto, et al, J. Appl. Phys. **111**, 074316 (2012)

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