PROJECTS II.1 : NANOSTRUCTURES FOR NANOELECTRONICS, PHOTONICS AND SENSORS

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Other key researchers: N. Papanikolaou, S. Gardelis

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Others: E. Michelakaki (MSc), H. Katsogridakis (diploma thesis), M. Karmpadaki (project administration)

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- EU IST I_3 ANNA, 1/12/2006 – 28/2/2011, Contract N^o: 026134
- FP7-IST-NoE NANOSIL, 1/1/2008-1/3/2011 - Contract N^o: 216171
- EU FP7 ENIAC JU Project SE2A, 1/1/2009-31/12/2011- Contract No 120009
- EU FP7 Network of Excellence NANOFUNCTION, 1/9/2010-1/9/2013 - Contract No 257375
- EU FP7 Coordination and Support Action NANO-TEC, 1/9/2010-18/2/2013 - Contract No 257964
- EU FP7 FET-Open TAILPHOX (N. Papanikolaou) 1/5/2009-31/4/2012 Contract No: 233883

Research orientation:

a) Si nanowires and nanodots fabrication, properties and applications

The activity on semiconductor nanostructures started within this research group at the early nineties. It has been conducted within different EU projects, and worldwide pioneering results include the following: Development of a fabrication technique of light emitting silicon nanowires using the top-down approach (1985), development of light emitting devices based on Si nanowires (1998), development of the growth and investigation of the properties of single and multiple two-dimensional arrays of Si nanocrystals (NCs) with controllable size, embedded in SiO_2 and development of Si NC memories.

Currently, the group focuses on the following activities:

- Two-dimensional arrays of Si nanocrystals embedded in SiO_2 for solar cell applications: Investigation of their electrical and optical properties
- SiNWs by metal-assisted chemical etching: synthesis, characterization and applications

b) Porous Si membranes

The group has important expertise and know-how, as well as different proprietary processes in the field of porous Si membranes. Existing processes include the fabrication of thick porous Si membranes locally on the Si substrate, porous Si free standing close-type membranes over cavity fabricated in a single electrochemical process and porous Si cantilevers and suspended membranes fabricated by electrochemistry. The porous material is composed of either randomly distributed pores or straight vertical pores. Applications developed within the group include thermal sensors, nanocooling devices and RF passive devices integrated on Si. Porous Si membranes are used as substrate for thermal or RF isolation from the Si substrate.

c) Porous anodic alumina on Si

Porous anodic alumina thin films on Si with highly ordered hexagonally arranged pores are fabricated by electrochemistry and used either as template for growing nanowires and other nanostructures within the pores or as masking material for Si nanopatterning. Porous anodic alumina is also used as a high-k dielectric material in memory devices and in metal-oxide-metal (MIM) capacitors.

d) High performance on-chip RF passives and memory devices using novel materials and technologies

Key results in 2010 within this activity are as follows:

- High performance RF and mm-wave transmission lines were fabricated on porous Si membranes. Porous Si provides excellent shielding to the lossy Si substrate. It is thus possible to fabricate on-chip passive devices on the Si wafer that show similar comparable characteristics with the best off-chip corresponding devices. Co-planar waveguides were fabricated and tested at frequencies up to 110GHz.
- Novel high performance MIM capacitors using porous alumina dielectric and exhibiting large capacitance density and low leakage current were also demonstrated.
- Charge trapping memory devices using porous anodic alumina dielectric on a thin anodic SiO_2 layer, both fabricated in a single electrochemical step, were also demonstrated and their charging properties investigated.
- Metal-insulator semiconductor (MIS) capacitors using silicon oxinitride (SiON) dielectric were also investigated by electrical measurements.

e) Plasmonics and Metamaterials

Metallic nanostructures can focus light in subwavelength volumes, creating local resonances. Such structures have many interesting applications in chemical and biological sensing, as well as imaging. Periodicity is also exploited to design materials with effectively magnetic behavior even in the visible spectrum. The design of metamaterials that could eventually show negative refraction is an active field of research with many potential applications in nanotechnology.

f) Dual photonic-phononic spectral gap material

The project is about developing new materials that can simultaneously tailor both optical and elastic waves. Such structures could be used for a new generation, reduced footprint, acousto-optic devices and active control of light with sound in submicron structures. This is an EU-funded European collaboration with other theoretical and experimental groups

SELECTED RESEARCH RESULTS IN 2010

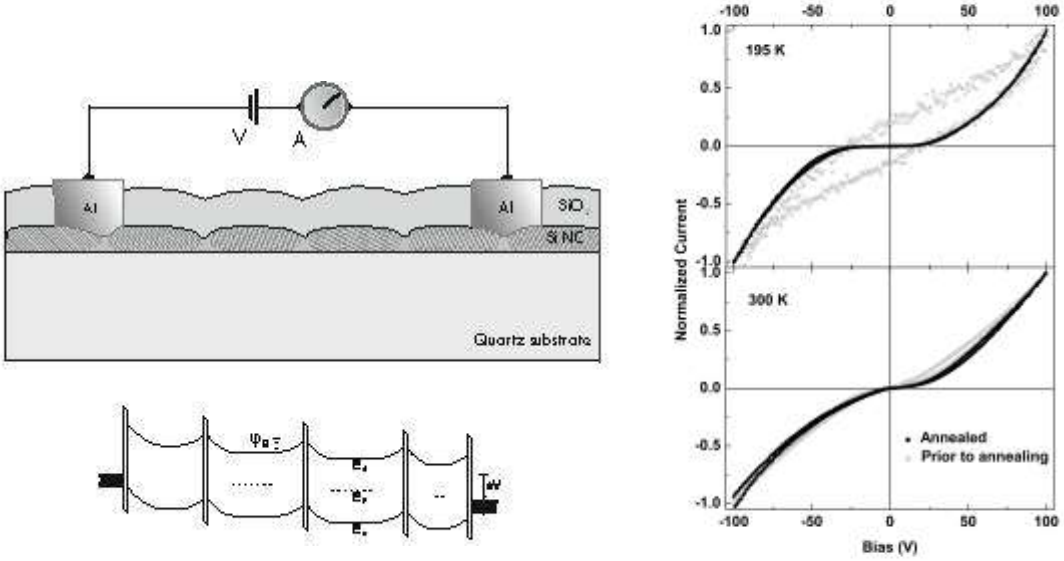
a. Lateral electrical transport, optical properties and photocurrent measurements of 2D arrays of Si NCs embedded in SiO_2

P. Manousiadis, S. Gardelis and A. G. Nassiopoulou

We investigated the lateral electronic transport, optical and photo-electric properties of two-dimensional (2D) arrays of oxidized silicon nanocrystals (Si NCs) of different sizes grown on quartz by low pressure chemical vapor deposition (LPCVD) and subsequent thermal oxidation. The films contained Si NCs with controlled sizes ranging from less than 2 nm up to 12 nm. The Si NCs within the films were separated with grain boundaries or silicon dioxide tunnel barriers. The electrical measurements showed that current in the films is mainly determined at low temperatures by tunneling, whereas at high temperatures by thermionic emission over the barriers. Charge traps at the interfaces of the Si NCs with the oxide or the grain boundaries caused considerable hysteresis in the current-voltage characteristics. Hydrogen passivation of the charge traps reduced the hysteresis effect and the activation energy of the thermionic emission, whereas the current-voltage characteristic after hydrogen passivation showed a superlinear shape, resulting from the collective effect of the Si NCs involved in the transport which were separated by tunnel barriers and had Coulomb gaps due to their small sizes. Activation energy corresponding to tunneling through the oxide tunnel barriers between the Si NCs was correlated with the charging energy of the Si NCs within the layers, i.e., the energy needed by the carriers to overcome the Coulomb gaps of the Si NCs in the current path.

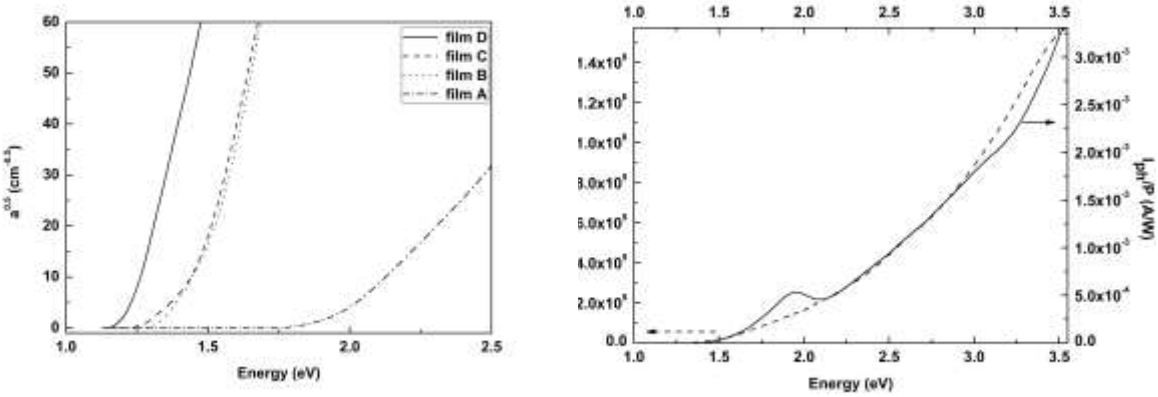
Absorption measurements showed a clear increase of Si NC energy bandgap with decreasing NC size due to quantum confinement. Also, higher absorption than bulk Si was observed in the visible and ultraviolet regions. Photocurrent and absorption spectra showed similar dependency on energy, confirming that photocurrent was due to carriers generated in the Si NCs within the films, when energy of illumination became higher than the energy bandgap of the Si NCs.

Light emission at room temperature was observed only in the film containing Si NCs smaller than 3nm. This film showed no measurable photocurrent. This effect was due to the strong localization of the photo-generated carriers within the Si NCs of these sizes which favored radiative recombination of the carriers and excluded photocurrent.



(a) (b)

Fig. a1 *(a) Schematic of the film and the two-terminal electrical measurements. Schematic of the energy band diagram of the films under bias. (b) Current-voltage (I-V) characteristics before and after hydrogen passivation.*



(a) (b)

Fig. a2 *(a) Upshift of the absorption edge with decreasing Si NC size. (b) Comparison between calculated and experimental results*

b. Si nanowires by metal-assisted chemical etching

V. Gianneta, H. Katsogridakis and A. G. Nassiopoulou

Si nanowires (SiNWs) are synthesized by the single-step metal-assisted chemical etching (MACE) technique in $AgNO_3$/HF aqueous chemical solution. The obtained SiNWs are of high crystalline quality, since they result from etching of the crystalline Si skeleton. The nanowire length is monitored by changing the immersion time of samples in the solution. SiNWs with length ranging from few μm up to several tens of μm can be obtained.

We investigated in detail the growth rate of NWs as a function of temperature (in the range of 20-50^{o}C) and found that it increases monotonically with temperature. An example of cross sectional scanning electron microscopy (SEM) images at three different temperatures are given n fig. b1. In fig. b2 we see a top view of the sample surface, which reveals that long SiNWs form bundles, attracted by capillary forces.

We also investigated the surface morphology of the SiNWs and found that it depends on their length. Short NWs are very smooth, while longer ones show a nanoporosity all along their surface.

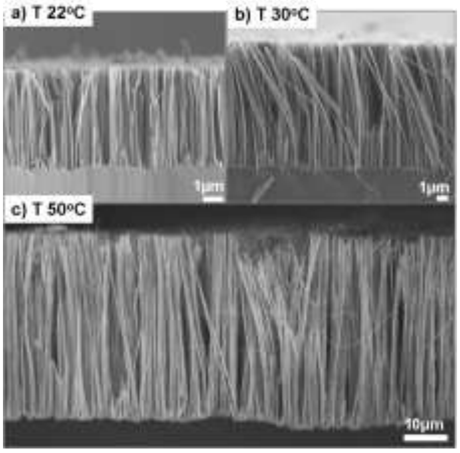


Fig. b1 *SEM images of Si nanowires formed via MACE technique at three different temperatures (a) 22, (b) 30 and (c) 50^{o}C. The etch rate of Si and thus the final nanowire length is achieved for the higher temperature of the three used.*

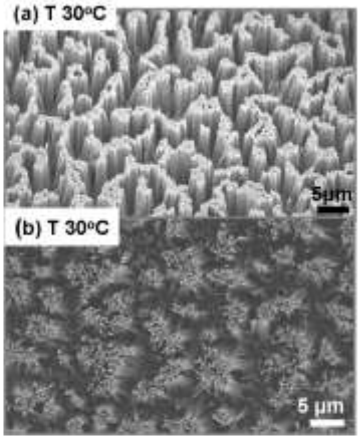


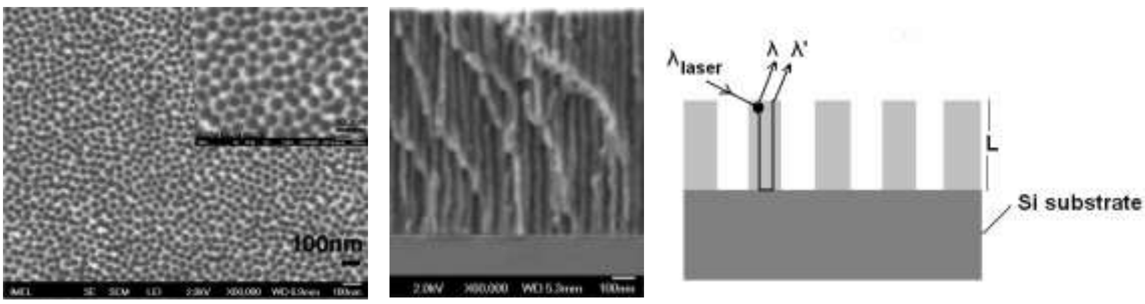
Fig. b2 *SEM images of a plane view of (a) shorter~8μm and (b) longer~18μm Si nanowires. We observed that in all cases the nanowires form bundles.*

This work was presented in Fourth International Conference on Micro-electronics, Nanotechnologies and MEMs which took place in Athens on 12-15 December 2010.

c. Photoluminescence–induced oscillations in porous anodic aluminum oxide grown on Si. A method to estimate porosity

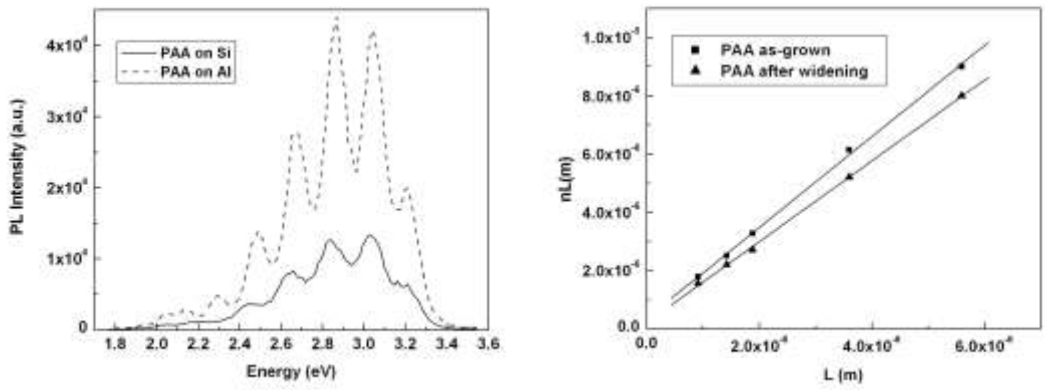
I. Leontis, A. G. Nassiopoulou and S. Gardelis

Porous anodic alumina (PAA) films grown directly on Si substrates show oscillations in their photoluminescence (PL) spectra. These oscillations are ascribed to PL-induced interferences within the Farby-Pérot optical cavity formed by the PAA film on Si, that involve the air/oxide and oxide/Si interfaces. The existence of the PL oscillations is indicative of the high quality of the interface of the PAA film with Si, which is both planar and smooth. Using these PL-induced oscillations we can develop a sensitive optical method of measuring the porosity of the PAA film if the film thickness is known. This method is based on the calculations of the effective refractive index of the PAA film derived from the PL-induced oscillations. This value of the estimated refractive index is introduced into the Bruggeman equation to derive the film porosity.



(a) **(b)** **(c)**

Fig. c1 *Plane view (a) and cross sectional (b) Scanning Electron Microscopy (SEM) images of 1μm thin film of porous anodic alumina obtained by two-step anodic oxidation of an Al film on Si in 0.5M sulfuric acid aqueous solution. (c) Schematic representation of the interference between emitted light λ and λ΄ in a PAA film of thickness L. The dot represents a luminescence center excited by the laser wavelength λ_{laser}.*



(a) (b)

Fig. c2 *(a) A comparison of PL-induced oscillations from a PAA film on Al substrate (dotted line) and on Si (continuous line). (b) Linear dependence of the optical length, nL on L for the as-grown PAA films and for the same films after pore widening. The slope of the linear fits is the effective refractive index, n_{eff} , of the PAA films.*

References:

"Photoluminescence-induced oscillations in porous anodic aluminum anodic oxide films grown on Si:Effect of the interface and porosity", S.Gardelis, A.G. Nassiopoulou, V. Gianneta, M. Theodoropoulou, Journal of Applied Physics 107, 113104 (2010)

"PL-induced ascollations from porous anodic alumina on Si", MSc thesis of I. Leontis, carried out at IMEL under the supervision of A. G. Nassiopoulou and defended at the University of Thessaloniki, 21 March 2011

d. Si microplate technology for on-chip local RF isolation

E. Hourdakis, P. Sarafis and A. G. Nassiopoulou
In collaboration with the group of Ph. Ferrari (IMEP-Minatec, Grenoble, France)

Co-planar wave (CPW) transmission lines were fabricated on porous Si microplates electrochemically developed on low loss substrates. The substrates used were p+ Si wafers of resistivity 0.001-0.005 Ωcm. The thickness of the porous Si microplate was 150 μm. The CPW lines were designed to have 2 different values of characteristic impedance, namely 50 and 145 Ω. The lines were characterized up to 40 GHz. De-embedding techniques were used to extract the values of the characteristic impedance, the quality factor and the attenuation constant. It was shown that attenuation lower than 0.3 dB/mm can be achieved at 40 GHz for both values of the characteristic impedance used. This value is several times better than commonly quoted values in the literature. Also a quality factor of 20 was demonstrated at 40 GHz. The experimental results were reproduced using simulations with the HFSS program. The CPW lines were then tested up to a frequency of 110 GHz also producing results that are better than the state-of-the-art performance of on-chip mm-wave passives.

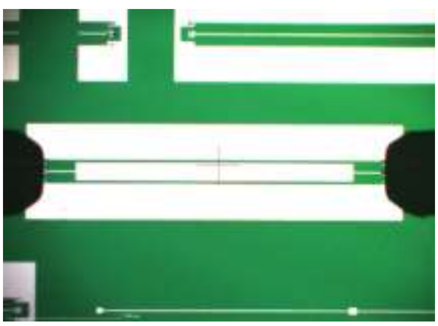


Fig. d1 *Photography of the 50 Ω CPW transmission line under test.*

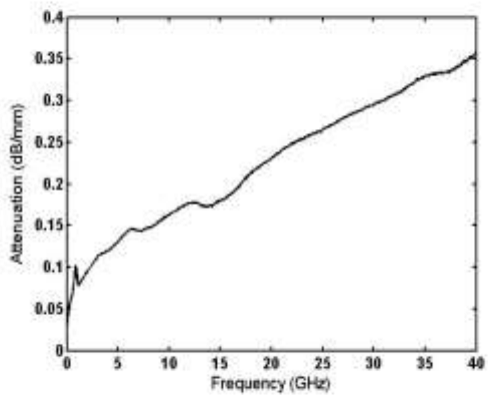


Fig. d2 *Attenuation of the 50 Ω CPW transmission line under test.*

e. Fabrication and characterization of high performance anodic alumina MIM capacitors

E. Hourdakis and A. G. Nassiopoulou

We fabricated and characterized Metal-Insulator-Metal (MIM) capacitors using as dielectric a thin porous anodic alumina (Al_2O_3) layer between two Al films. The Al_2O_3/Al stack was grown electrochemically by partly anodizing an Al film on Si, while a top Al film was then deposited on the aluminum oxide and patterned in order to define the capacitor area. The obtained MIM capacitors exhibit at the same time large capacitance density (above ~5 fF/μm^2), low leakage current density (below ~10^{-9}A/cm^2 at 2V) and good thermal stability of operation, demonstrated by an α coefficient that changes by less than 10% for temperature changes of the order of 100K. The temperature stability was further demonstrated by the low leakage current density (below ~7x10^{-9}A/cm^2) even at temperatures as high as 420K. These characteristics satisfy the ITRS requirements for MIM capacitors in the next years. Additional advantages of the demonstrated capacitors is the simplicity of fabrication, that reduces the cost, and the fact that the entire fabrication is CMOS compatible and room temperature which is very important since MIM capacitors are back-end devices.

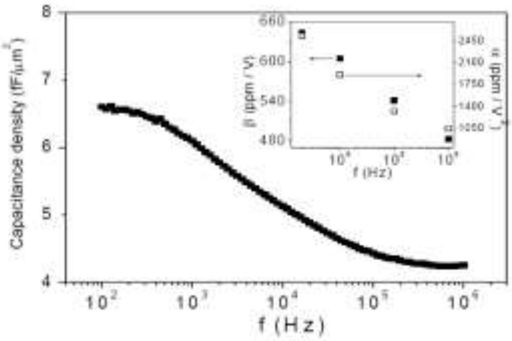


Fig. e1 *Variation of the capacitance as a function of frequency for the MIM capacitor at zero bias. The inset shows the variation of both α and β coefficients as a function of frequency (open squares represent α, solid ones represent β).*

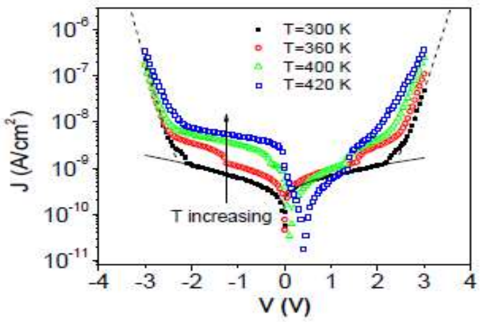


Fig. e2 *Current density (J) as a function of applied voltage (V) at different temperatures. The capacitor area was 300 μm by 300 μm. The solid lines represent fits of the data at 300 K using the Schottky conduction mechanism, while the dashed lines fits using the direct tunneling mechanism.*

Ref. E. Hourdakis and A.G. Nassiopoulou, *IEEE Transactions on Electron Devices* 57 (10), art. no. 5535075, pp. 2679-2683 (2010)
Also presented at: XXVI panhellenic conference on solid state physics and material science, Ioannina, Greece, September 26-29 2010

Using the same fabrication scheme as described above we fabricated and characterized MIM capacitors using barrier-type anodic alumina (Al_2O_3) as the dielectric instead of the porous anodic alumina previously used. The obtained capacitors exhibited large capacitance density (above 7 fF/μm^2) and very small leakage current for a voltage range between -2 V and 2 V (below the background noise of our measurement system). It was shown that there is a significant improvement in both the value of the capacitance density and the value of the non-linearity coefficient α compared to the porous alumina capacitors.

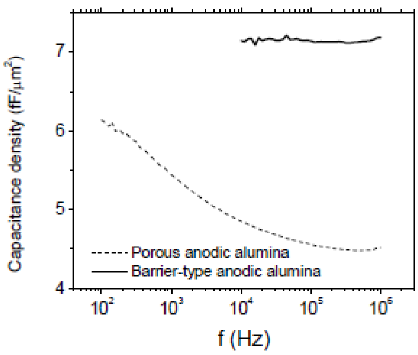


Fig. e3 *Capacitance density vs. frequency (f) for the barrier-type (black line) and the porous (dashed line) anodic alumina MIM capacitors.*

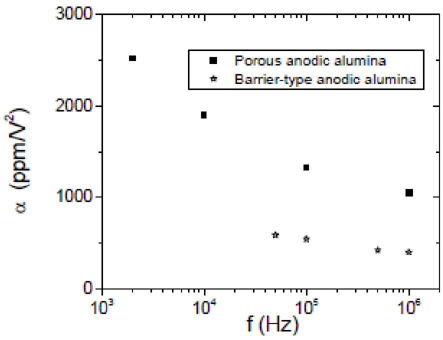


Fig. e4 *Non-linearity coefficient α vs. frequency (f) for the barrier-type (open stars) and the porous (black squares) anodic alumina MIM capacitors.*

Ref. E. Hourdakis and A.G. Nassiopoulou, *Microelectronics Engineering*, in press (submitted in 2010)
Also presented at: Micro&Nano 2010 conference, Athens, Greece, December 12-15 2010

f. Fabrication and characterization of charge trapping MOS memory structure using anodic alumina dielectric

E. Hourdakis and A. G. Nassiopoulou

A novel charge-trapping-type MOS memory structure using a high-k dielectric on a thin SiO_2 layer, both fabricated in a single electrochemical step, was demonstrated. The high-k dielectric was a porous anodic aluminum oxide layer (Al_2O_3, PAA) that played the combined role of the charging medium and the control oxide. The tunnel oxide was an electrochemical SiO_2 layer grown through the pores of the anodic alumina layer. It was demonstrated that this simple MOS structure shows comparable memory characteristics (charging/discharging, memory window and retention) with those of charge trapping type memories using high-k dielectrics in a complicated gate dielectric stack, fabricated using expensive equipment. It could be a solution towards a novel low cost charge trapping dielectric layer for memory devices.

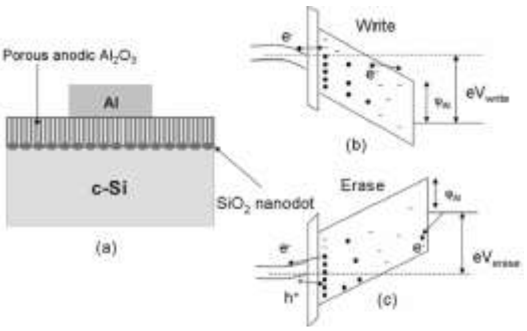


Fig. f1 *Schematic representation of the cross section of the MIS memory structure with anodic dielectric (porous anodic Al_2O_3 and undulated anodic SiO_2 layer underneath). (b), (c) Schematic representation of the write (b) and erase (c) memory operations.*

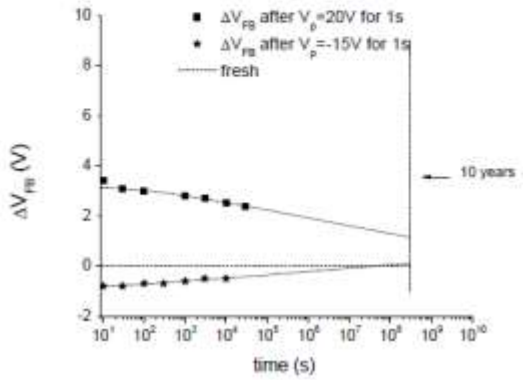


Fig. f2 *Retention characteristics ΔV_{FB} versus time) of the memory structure after charging at +20 V, 1s and -15 V, 1s.*

Ref. E. Hourdakis and A.G. Nassiopoulou, *Microelectronics Engineering*, in press (submitted in 2010)

g. Electrical properties of ultra thin SiON films

E. Hourdakis and A. G. Nassiopoulou
*In collaboration with partners of the EU project ANNA – see reference below**

We combined electrical and structural characterization with analytical and spectroscopic measurements in order to fully analyze oxynitride nanofilms that were produced in a mini batch type plasma nitridation reactor. We demonstrated that for the investigated samples the result of nitridation is different in the 2 nm thick SiO_2 films compared to the 5 nm thick films. In the first case, nitridation results in an increase in the initial film thickness with a consequent decrease in leakage current and an increase in equivalent oxide thickness (EOT), while in contrast, nitridation of the 5 nm thick SiO_2 films leads to a reduction of both the leakage current and EOT. Finally, we demonstrated that the applied nitridation process results in the desired nitrogen profile with high nitrogen concentration near the top surface or the middle of the SiON film and low nitrogen concentration near the SiON/Si interface, that leads to a relatively low density of interface states (~10^{11} states/cm^2) for non-annealed films.

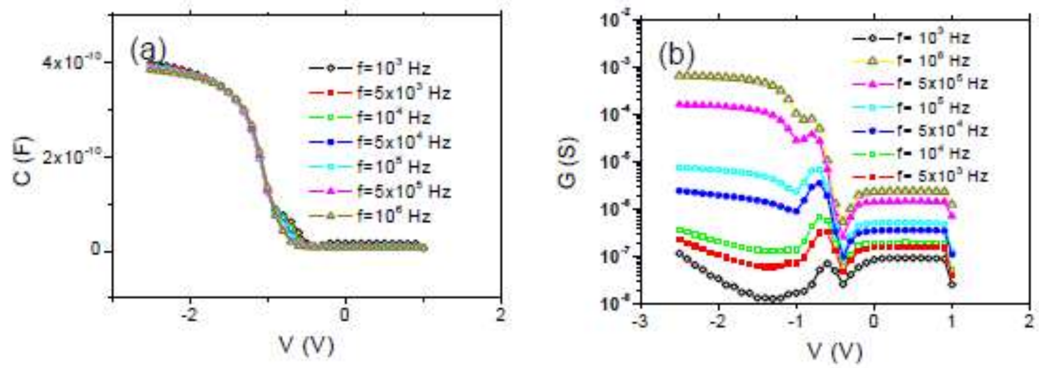


Fig. g1 *Capacitance (C) -Voltage (V) measurements, (a), and Conductance (G) –Voltage (V) measurements, (b), in the high frequency region for sample 03 (2 nm nominal thickness, 60 min plasma nitridation).*

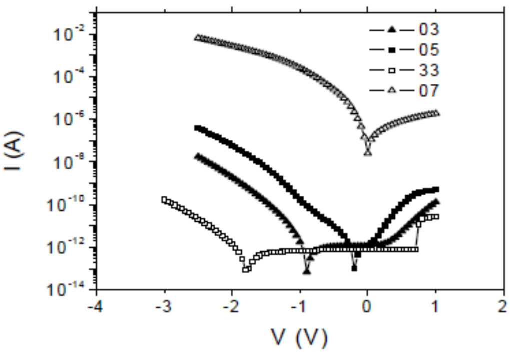


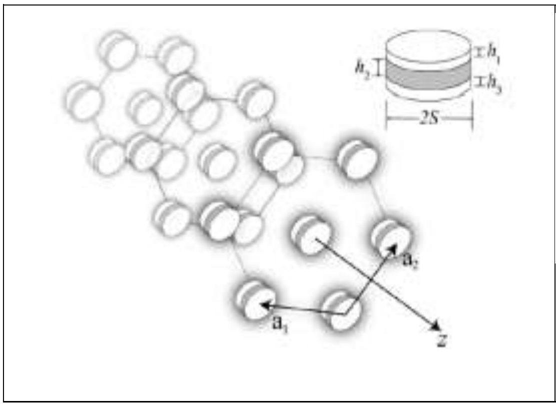
Fig. g2 *Leakage current (I) –Voltage (V) characteristics for all samples.*

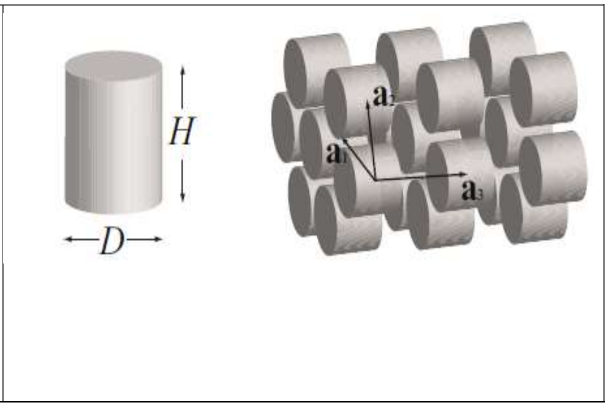
[*] Ref. E. Hourdakis, A. G. Nassiopoulou, A. Parisini, M. A. Reading, J. A. van den Berg, L. Sygellou, S. Ladas, P. Petrik, A. Nutsch, M. Wolf, and G. Roeder, *J. Vac. Sci. Technol. B* 29, 022201 (2011) (accepted in 2010, published in 2011)

h. Plasmonic metamaterials

N. Papanikolaou, Ch. Tserkezis, G. Gantzounis, N. Stefanou

In the last years, increasing amount of attention has been directed toward the assembly of metal nanoparticle building blocks into ordered structures for diverse applications that include, among others, (bio)sensing and optoelectronic devices. In some cases structure determines the material properties, and the term metamaterial is used. Unlike metamaterials based on metallic nanorods, split-ring resonators, or cut-wire pairs, which operate at a specific polarization mode of the electromagnetic (EM) field, metal–dielectric-metal nanosandwiches, due to their cylindrical symmetry, offer the possibility for designing polarization-insensitive metamaterials. Moreover the problem of assigning effective EM parameters to a heterogeneous medium is an important issue and various homogenization methods have been proposed. Usually one imposes the scattered wave from a planar slab of the heterogeneous medium in the far-field zone, to be the same with that scattered from a slab of a hypothetical homogeneous material. But this technique often leads to nonphysical material parameters as a result of forcing a homogeneous material to reproduce exactly the features of the wave field scattered by the actual heterogeneous medium. We used a homogenization method based on systematic full-electrodynamic complex-band-structure calculations, and deduce the effective permittivity tensor of a uniaxial photonic crystal consisting of consecutive hexagonal arrays of aligned metallic nanorods of finite length. The form of the obtained permittivity tensor over a relatively broad low-frequency region, where homogenization is applicable, suggests the occurrence of unconventional refractive behavior, namely, negative refraction and self-collimation. Moreover, in the frequency region where negative refraction occurs, a finite slab of the crystal possesses eigenmodes that form flat bands outside the light cone. These eigenmodes allow for transfer of the evanescent components of an incident wave field to the other side of the slab, thus enabling subwavelength imaging.





Schematic view of a layered metal/silica/ metal nanosadwich metamaterial.

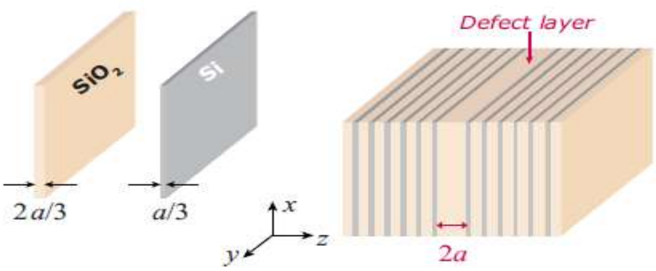
Arrays of metallic nanorods can be used for negative refraction and subwavength imaging.

i. Dual photonic-phononic spectral gap materials

N. Papanikolaou, E. Albanis, I. Psarobas, N. Stefanou

(In collaboration with European Project TAILPHOX partners)

Photonic crystals with submicron periodicity have band gaps in the visible and near infrared part of the spectrum promising applications in optical sensors and telecommunications. Phononic crystals on the other hand are mainly studied in more macroscopic length scales in the order of millimeter. Only very recently, elastic composites with submicron periodicity were demonstrated with acoustic band gaps in the gigahertz range. Tailoring both acoustic and optical properties on the same system can lead to applications which require better control of the acousto-optic interaction. Phoxonic crystals having dual spectral gaps for both photons and phonons could lead to promising applications. We have studied 3D metallodielectric crystals, 2D perforated Si slabs and Si pillars on a silica slab but also 1D multilayer structures, and predicted simultaneous band gaps for both light and sound at different frequencies in all geometries. Moreover by analyzing the acousto-optic interaction in 1D multilayers we demonstrate that the simultaneous light and sound localization in a phoXonic cavity leads to enhanced acousto-optic interaction and multiphonon emission-absorption processes.



A silicon-silica multilayer phoXonic cavity that is predicted to enhance the acousto-optic interaction on resonance.

PROJECT OUTPUT IN 2010

Publications in International Journals and Reviews

1. "High-density MIM capacitors with porous anodic alumina dielectric", Hourdakis, E., Nassiopoulou, A.G, IEEE Transactions on Electron Devices 57 (10), art. no. 5535075, pp. 2679-2683 (2010)
2. "Photoluminescence-induced oscillations in porous anodic aluminum oxide films grown on Si: Effect of the interface and porosity", Gardelis, S., Nassiopoulou, A.G., Gianneta, V., Theodoropoulou, M., Journal of Applied Physics 107 (11), art. no. 113104 (2010)
3. "Enhanced acousto-optic interactions in a one-dimensional phoxonic cavity", Psarobas, IE; Papanikolaou, N; Stefanou, N; et al. Phys. Rev. B, 82 (17): Art. No. 174303 (2010)
4. "Dual phononic and photonic band gaps in a periodic array of pillars deposited on a thin plate" El Hassouani, Y, Pennec, CLY, El Boudouti, EH, H. Larabi, A. Akjouj, O. Bou Matar, V. Laude, N. Papanikolaou, A. Martinez, and B. Djafari Rouhani Phys. Rev. B, 82 (15): Art. No. 155405 (2010)
5. "Effective optical parameters of thin-film and bulk metamaterials of metallodielectric nanosandwiches" Tserkezis, C; Stefanou, N; Papanikolaou, N, Opt. Commun., 283 (20): 4074-4077 (2010)
6. "Simultaneous existence of phononic and photonic band gaps in periodic crystal slabs" Pennec, Y; Rouhani, BD; El Boudouti, EH; C. Li, Y. El-Hassouani, J. Vasseur, N. Papanikolaou, S. Benchabane, V. Laude, and A. Martinez, Opt. Exp., 18 (13): 14301-14310 (2010)
7. "Absolute spectral gaps for infrared light and hypersound in three-dimensional metallodielectric phoxonic crystals", Papanikolaou, N; Psarobas, IE; Stefanou, N, Appl. Phys. Lett., 96 (23): Art. No. 231917 (2010)
8. 6. "Extraordinary refractive properties of photonic crystals of metallic nanorods", Tserkezis, C; Stefanou, N; Papanikolaou, N, J. Opt.. Soc. Am. B, 27 (12): 2620-2626 (2010)

Publications in Conference Proceedings

1. "Comparative studies of single- and double-nanocrystal layer NVM structures: Charge accumulation and retention", Turchanikov, V., Ievtukh, V., Nazarov, A., Lysenko, V., Theodoropoulou, M., Nassiopoulou, A.G., 2010 27th International Conference on Microelectronics, MIEL 2010 - Proceedings, art. no. 5490524, pp. 103-104 (2010)
2. "Plasmonic nanostructures and optical metamaterials: Studies by the layer-multiple-scattering method", Stefanou, N; Papanikolaou, N; Tserkezis, C, Physica B-Cond. Mat., 405 (14): 2967-2971 (2010)

Presentations in international conferences - invited lectures

1. "Nanostructures on Si by Electrochemistry and their Applications", A. G. Nassiopoulou **(invited talk)**, International Conference on Nanomaterials (ICN 2010), India, 27-29 April 2010
2. "Porous Si for Electronics and Sensors", A. G. Nassiopoulou **(Tutorial),** 7th International Conference on Porous Semiconductors Science and Technology – PSST 2010, Valencia, 14-19 March 2010
3. "On-chip heat sink devices using Copper-Filled Macroporous Si membranes and cavity underneath", F. Zacharatos and A. G. Nassiopoulou, 7th International Conference on Porous Semiconductors Science and Technology – PSST 2010, Valencia, 14-19 March 2010
4. "Photoluminescence from silicon nanocrystal ensembles: effect of exciton migration and role of surface vibration modes", A. G. Nassiopoulou **(invited talk)**, VCIAN Conference on Interactions Among Nanostructures 2010, Santorini, Greece, 21-25 June 2010
5. "Optimized porous Si RF microplate as a low-loss substrate for on-chip RF isolation", A. G. Nassiopoulou, F. Zacharatos and H. Contopanagos, 7th International Conference on Porous Semiconductors Science and Technology – PSST 2010, Valencia, 14-19 March 2010
6. "Colleration of light emission properties with exciton migration in silicon nanocrystal ensembles", S. Gardelis and A. G. Nassiopoulou, 7th International Conference on Porous Semiconductors Science and Technology – PSST 2010, Valencia, 14-19 March 2010
7. "European Nanoelectronics: The Initiatives and Networks of the Academic Community", A. G. Nassiopoulou, F. Balestra **(invited presentation)**, Sixth International Nanotechnology Conference on Communication and Cooperation, Grenoble, France, 17-20 May 2010
8. "Nanostructures on Si: Application in Electronics and Sensors", A. G. Nassiopoulou **(Invited Lecture)**, University of Cyprus, 16 February 2010
9. "Nanostructures on Si: Application in Electronics and Sensors", A. G. Nassiopoulou **(Invited Lecture)**, Cyprus Univ. of Technology , 17 February 2010
10. "Si nanocrystals for solar cell applications", A. G. Nassiopoulou, Workshop: Analytical Trends and Needs for Nanoelectronics, Berlin, November 8, 2010
11. "Electrodeposition of copper in mesoporous Silicon on p+ type wafer" (Poster Presentation), E. Michelakaki, Materials of the 7th International Conference - PSST 2010, Valencia, Spain 14-19 March 2010

12. “Si nanowires by metal assisted etching: Localization of the nanowires and study of the effect of surface pre-patterning on their morphology”, V. Gianneta, H. Katsogridakis and A. Nassiopoulou, Fourth International Conference on Micro-electronics, Nanotechnologies and MEMs Athens 12 – 15 December 2010
13. “Hexagonally ordered nanofeatures on Si by nanopatterning through porous anodic alumina”, H. Katsogridakis, V. Gianneta and A.G. Nassiopoulou, Fourth International Conference on Micro-electronics, Nanotechnologies and MEMs Athens 12 – 15 December 2010
14. “Lateral electronic transport, optical and photocurrent properties of 2D arrays of silicon nanocrystals in silicon dioxide”, S. Gardelis, P. Manousiadis, and A.G. Nassiopoulou, 4th International Conference on Micro-Nanoelectronics, Nanotechnologies & MEMs, NCSR Demokritos, Athens, 12 – 15 December 2010
15. “Light modulation in phoxonic nanocavities”, N. Papanikolaou, I.E. Psarobas, N. Stefanou, B. Djafari-Rouhani, B. Bonello, V. Laude. Micro and Nano Conference, Athens, December 2010. (Best oral presentation award)
16. “Design of waveguides in silicon phoxonic crystal slabs”, V. Laude, S. Benchabane, Y. Pennec, B. Djafari Rouhani, N. Papanikolaou, A. Martinez, Oral presentation at IEEE Ultrasonics, San Diego (U.S.A), October 2010
17. “Metallodielectric PhoXonic Nanostructures”, I. E. Psarobas, N. Papanikolaou, and N. Stefanou, O12 (proceedings p. 35) XXVI Panhellenic Conference on Solid State Physics & Materials Science, Ioannina (Greece), September 26-29, 2010.
18. “PhoXonic band gaps and waveguiding in nanostructured silicon slabs”, E. Almpanis, G. Gantzounis, N. Papanikolaou, and N. Stefanou, O13 (proceedings p. 37) XXVI Panhellenic Conference on Solid State Physics & Materials Science, Ioannina (Greece), September 26-29, 2010.
19. “Slow Phonons and Photons in Periodic Crystal Slabs and Strip Waveguides”, C. Li, Y. El Hassouani, Y. Pennec, B. Djafari Rouhani, E.H. El Boudouti, N. Papanikolaou, S. Benchabane, V. Laude, J. M. Escalante, A. Martinez, poster P06, Proceeding pp. 154, in 9th International Conference on Photonic and Electromagnetic Crystal Structures (PECS-IX 2010), 26-30 September, Granada (Spain)
20. “Band Gaps and Waveguiding in Phoxonic Silicon Crystal Slabs.” Y. Pennec, B. Djafari Rouhani, E.H. El Boudouti, C. Li, Y. El Hassouani, J.O. Vasseur, N. Papanikolaou, S. Benchabane, V. Laude, A. Martinez, Phonons 2010 in Taiwan, 19-23 April 2010.
21. “Multiple scattering calculations for photons and phonons in nanostructures”, G. Gantzounis, N. Papanikolaou, N. Stefanou. Workshop on: "Nano-particles, nanostructures and near field omputation", Bremen, Germany, 11-12 March 2010.
22. “Confined photons and phonons in nanopatterned silicon films.” N. Papanikolaou, E. Almpanis, and N. Stefanou. Second Mediterranean Conference on Nano-Photonics, Medinano, Athens, Greece 26-27 Oct 2009.
23. “Collective plasmon modes and negative refraction in metallodielectric nanostructures”,C. Tserkezis, N. Stefanou, and N. Papanikolaou, 4th Young Scientist Meeting on Metamaterials, Feb. (2010) Valencia, Spain, (Best paper award).

Greek Conferences and Lectures

1. "Nanotechnology at the Service of the Society", A. G. Nassiopoulou, **Invited lecture**, Popular University of Athens, June 2010
2. “High performance MIM capacitor for RF using anodic alumina dielectric”, E. Hourdakis, Micro&Nano2010 Conference, Athens, Greece, December 12-15 2010
3. “Porous anodic alumina based MIM capacitors for RF applications”, E. Hourdakis and A. G. Nassiopoulou, XXVI Panhellenic Conference on Solid State Physics and Material Science, Ioannina, Greece, September 26-29 2010
4. “Growth and Properties of Porous Anodic Alumina Thin Films on Si”, V. Gianneta and A. G. Nassiopoulou, XXVI Panhellenic Conference on Solid State Physics and Materials Science, Ioannina September 26 - 29 2010
5. “Exciton migration in light emitting silicon nanocrystal ensembles and its effect on light emission”, S. Gardelis and A.G. Nassiopoulou, XXVI Panhellenic Conference on Solid State Physics and Materials Science, 26-29 September, 2010, University of Ioannina, Ioannina, Greece (oral presentation by S. Gardelis)
6. “Electronic transport in nanocrystalline silicon films: Observation of Coulomb blockade effects”, P. Manousiadis, S.Gardelis and A.G. Nassiopoulou, XXVI Panhellenic Conference on Solid State Physics and Materials Science, 26-29 September, 2010, University of Ioannina, Ioannina, Greece (poster presentation by P. Manousiadis)
7. "Electronic devices and sensors by Electrochemistry:, A. G. Nassiopoulou, Summer School organized by NCSR “DEMOKRITOS”, July 2010, Athens, Greece
8. “Optoelectronics and Applications”, S. Gardelis, Summer School organized by NCSR “DEMOKRITOS”, July 2010, Athens, Greece
9. “Microelectronic Materials and Device Technology”, S. Gardelis, 6th Summer School “Methods in Micro-Nanotechnology and Nanobiotechnology, September 13-17, 2010, Athens, Greece

MSc and diploma theses

1. MSc thesis of E. Linarakis under the supervision of A. G. Nassiopoulou on: “Si nanopatterning using electron beam lithography”, defended at the University of Athens, Department of Informatics in September 2010

Courses taught

1. Lectures on “Silicon processing for Nanoelectronics” by A. G. Nassiopoulou within: a) the MSc program on Microelectronics organized by the Department of Informatics of the University of Athens, in cooperation with the Institute of Microelectronics of NCSR Demokritos and b) the MSc program on “Microsystems and Nanoelectronics” organized by the National Technical University of Athens with the participation of the Institute of Microelectronics of NCSR Demokritos
2. Lectures on “Micromechanics and Sensors”, by the S. Gardelis within the MSc program organized by the Department of Informatics, University of Athens, in cooperation with the Institute of Microelectronics of NCSR “Demokritos”