

Project I. 2

LITHOGRAPHY and PLASMA PROCESSES for ELECTRONICS, MICROFLUIDICS, and SURFACE Nano-ENGINEERING

Project leader: E. Gogolides

Key researchers: E. Gogolides, A. Tserepi

Collaborating researchers: K. Misiakos, I. Raptis, P. Argitis, C. Tsamis, S. Chatzandroulis

Permanent Researcher: V. Constantoudis

Researchers on Contract: G. Patsis, G. Kokkoris

PhD candidates: P. Bayiati, N. Vourdas, M. Vlachopoulou, G. Boulousis, K. Tsougeni,
A. Malainou

MSc Students: D. Kotziambasis, A. Panagiotopoulos, K. Kontakis

Engineer: K. Kontakis

External collaborators: A. Boudouvis and M. Kalantzopoulou (NTUA, Greece), N. Hadjichristidis and E. Iatrou (UoA, Greece), S. Garbis and A. Vlahou (IIBEA, Greece), S. Kakabakos and P. Petrou (IRRP, NCSR-Demokritos, Greece), G. Kaltsas (TEI Athens Greece), K. Beltsios (U. Ioannina, Greece), E. Gizeli and K. Mitsakakis (Univ. of Crete-FORTH, Greece) C. Cardinaud (U. Nantes, France), I. Rangelow and B. Volland (Univ. Ilmenau Germany), M. Cooke and A. Goodyear (Oxford Instruments Plasma Technology, UK), S. Daniels (DCU, Ireland), A. Erdmann (Fraunhofer, Germany), S. Tedesco (CEA-LETI, France)

Objectives:

Our mission is to use lithography and plasma processing as enabling technologies for electronics, MEMs, microfluidics and lab-on-a-chip fabrication and modification. We are also developing new multiscale (continuum, Monte Carlo and Molecular Dynamics) simulation tools for these processes, while we are extending our tools to device simulation:

- For nano-electronics our work focuses on Line Edge Roughness (LER) metrology, lithography process simulation and effects of LER on transistor operation (see section A).
- For MEMS fabrication a positive tone easily strippable SU8 process was developed for metallization via lift-off (see section A).
- For microfluidics we use soft lithography, Deep Plasma Etching, and plasma assisted bonding to fabricate PDMS, PMMA (and other organic polymer) based microfluidic devices, we fabricate capillary electrophoresis, and chromatography devices, we develop open microfluidics using electrowetting actuation. Finally we also demonstrate novel plasma based micro array technologies (see section B).
- For nano-Engineering of Surfaces, we have developed promising nano manufacturing processes for nano-texturing of polymers, and modifying their optical, wetting, and biological behaviour. We can now fabricate superhydrophilic, superhydrophobic, antireflective, and highly protein absorbing smart polymer surfaces (see section C).
- We have also developed the components of a total multi scale plasma simulator, comprising gas phase kinetics, surface kinetics, profile evolution, and stochastic etching simulation for nano-scale effect description (see section D)

Funding:

- EU IST IP More Moore, Contract No 507754, 1/1/2004-31/3/2007
- IEU NMP NoE Nano2Life, Contract No 500057, 1/2/2004-31/1/2008
- EU NMP2 STREP Nanoplasma, Contract No 016424 , 1/4/2006-31/3/2009
- GSRT, PENED 03 ED 202, 1/12/2005-31/11/2008
- DHMOEREUNA-2005, 1/1/2007-30/6/2008
- MNE2008, 1/7/2007-30/6/2010
- MD3, IT 214948, 1/12/2007-30/11/2009

RESEARCH RESULTS

A. Micro & Nanopatterning: Micro and Nano Lithography and Line Edge Roughness (LER, LWR)

a₁ Impact of LWR on transistor performance: Effects of fractal dimension of LWR on transistor threshold voltage, using simple analytic transistor equations and model functions

V. Constantoudis

Line Edge or Line Width Roughness (LER and LWR) is currently considered as one of the main challenges in the further advancement of lithography to sub-50nm resist patterning. The most commonly used LWR metric, rms value R_q , suffers from the deficiency of being dependent on the line length L included in the measurement process. Our group has suggested that this problem can be overcome by the introduction of a three parameter model for LWR characterization including a) the rms value for infinite (very large) line length $R_q(L \rightarrow \infty)$, b) the correlation length ξ and c) the roughness exponent α or fractal dimension d_f . These parameters determine the dependence of the rms on the line length L , i.e. the curve $R_q(L)$, and thus the relationship between the LWR of resist lines (estimated for large L) and the Gate Length Roughness defined for small L which affects transistor performance. In previous years, we investigated the impact of rms value and correlation length on transistor performance. This year, we focused on the effects of fractal dimension of LWR by using model self affine lines. It has been found that larger values of fractal dimension (smaller roughness exponents α) lead to a reduction of threshold voltage deviation (Fig. I.2.1).

a₂ Impact of LWR on transistor performance: Use of state of the art transistor models

G. Patsis

The incorporation of LER effects on device performance was done using VHDL-AMS description of nMOS transistor incorporating quantum mechanical and polydepletion effects as they are described in MM11 MOSFET model by Philips (Fig. I.2.2). VHDL-AMS offers a programming platform that easily incorporates behavioral as well as detailed modeling of device physics, necessary for accurate description of future device generations, including quantum mechanical effects, and variability.

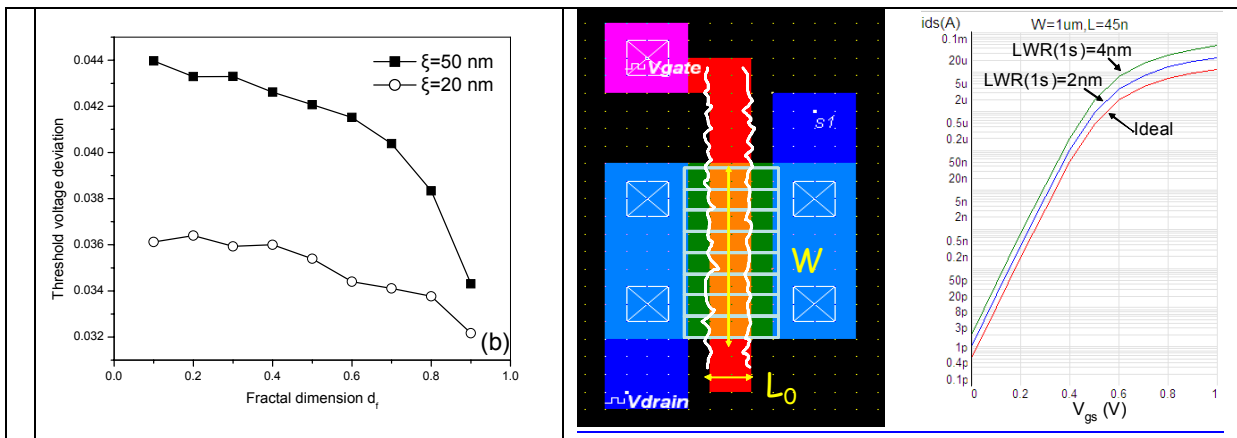


Fig. I.2.1: Effect of Fractal dimension on Threshold voltage variation of the transistor, using simple analytic transistor equations, and model fractal edges

Fig. I.2.2: The Philips MM11 MOSFET model is extended to incorporate gate length variability. This is introduced by "dividing" the device width into sub-units following a Gaussian gate length distribution, with appropriate line-width roughness. The combined model is used to determine source-drain current in terms of gate line-width roughness. The model is implemented in VHDL-AMS in order to be used for circuit simulation

a₃ *Simulation of lithography for LER reduction and design layout corrections*
G. Patsis, G. Kokkoris, V. Constantoudis, D. Drigiannakis, I. Raptis, E. Gogolides

We try to understand how lithographic material and processing, affect LER, and device operation. Stochastic Monte Carlo techniques are used with a quasi-static dissolution algorithm to simulate dissolution of polymer lattice based on the concept of critical ionization. Etching is simulated applying an isotropic deformation on a numerically obtained line edge. Two-dimensional simulations have shown that molecular resists have lower LER (see Project I.1 molecular resists) compared to conventional low MW resists. LER is also minimized with low acid diffusion range, and low secondary electron blur. Etching can be used to remove high frequency components of resist edges LER. The simulation was extended all the way to device operation, as discussed in task (A2) above. Combined CD and LER simulation on critical places of a design in terms of exposure, material and processes are important aspects for the quality of the devices. The current methodology could deliver CD and LER metrology on a realistic layout (Fig. I.2.3), rather than model resist lines. Thus, it becomes possible to perform design optimization in terms of both CD and LER, while today usually only CD is considered (Fig.I.2.4).

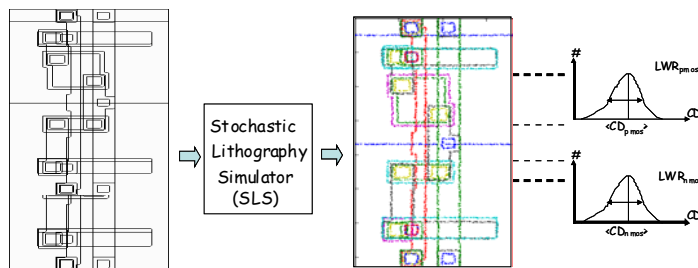


Fig. I.2.3: Drawn layout of CMOS inverter, simulated layout with the proposed methodology, and determination of the transistor gate length distributions

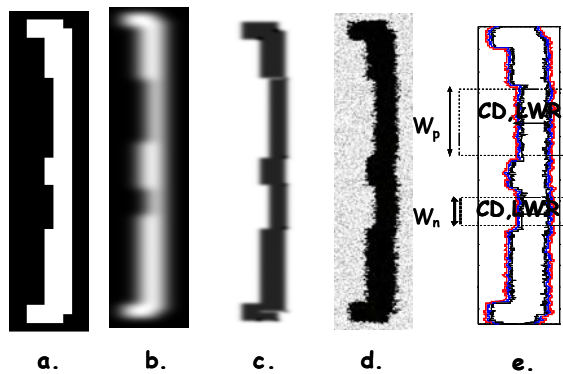


Fig. I.2.4: (a) Drawn layout of gate mask, (b) E-beam energy deposition (Monte Carlo simulation results), (c) Translated into PAG ionization probability, (d) After PEB and dissolution for (CPAG=20%, DF=0.8, Diffusion range, DR=4nm), (e) After etching for two etching times t1 (blue) and t2 (red). Black line corresponds to (d)

a₄ *Dry development of SU8: A positive tone process for microsystem fabrication*
D. Kontziampasis, E. Gogolides

A positive tone liquid-phase silylation process for epoxydized photoresists (such as EPON® SU-8) was proposed for microstructure fabrication and lift-off metallization. In the proposed process the development is done not with solvents but with the use of oxygen plasma. Silylation and dry development were used for 15 μm , 22 μm and 35 μm thick films. Stripping was easily achieved after plasma development using acetone and ultrasonics (within 30s) while this was not possible for several minutes for the crosslinked polymer. Metallization on a silicon substrate was achieved with the proposed process using 125 and 250 nm metal thickness.

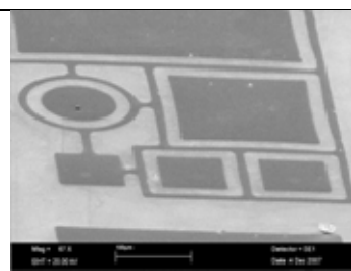
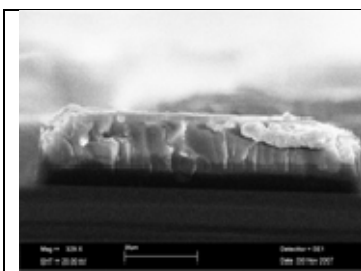


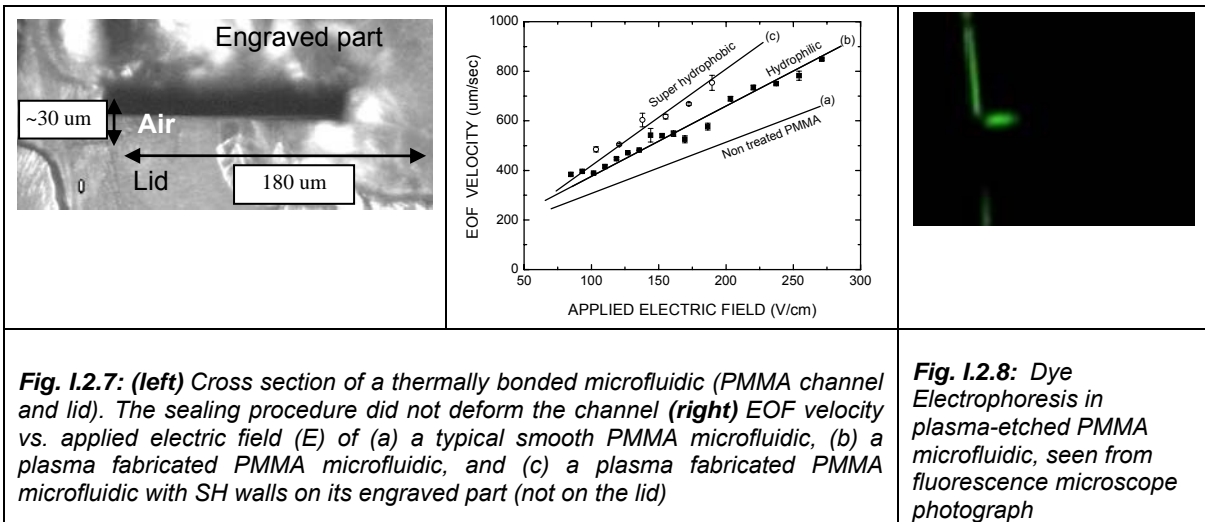
Fig. I.2.5: Cross-section of a pattern created by silylation and dry development. Notice the difference in contrast in the upper part of the pattern, showing the silylation depth

Fig. I.2.6: Metal pattern created with lift-off process after silylation and dry development. Metal thickness is 250 nm

B. Microfluidics fabrication and actuation using lithography and plasma processes
(see also project III.3)

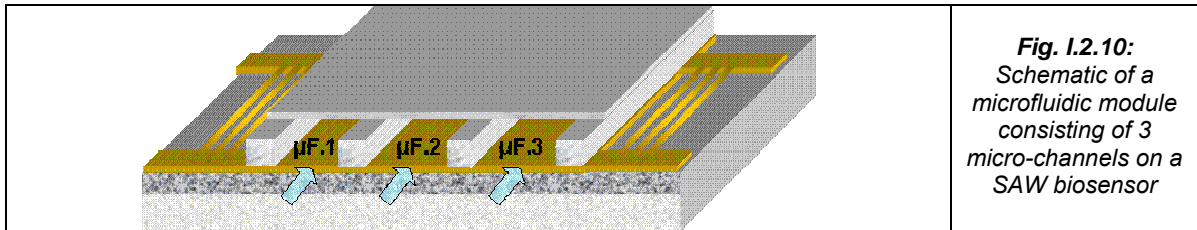
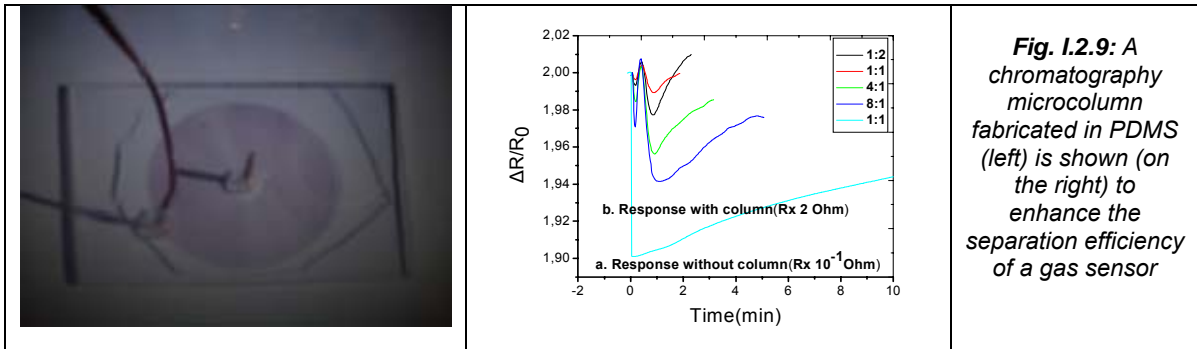
b₁ Plasma etching for fabrication of PMMA Microfluidic devices
N. Vourdas, K. Kontakis, K. Tsougeni, E. Gogolides

This year we worked on the fabrication and electrokinetic characterization of poly-methyl methacrylate (PMMA) microfluidics by deep O₂ plasma etching, utilizing a photosensitive poly(dimethyl siloxane) (PDMS) as a resist (in situ mask). The mass production amenability, the high throughput without the use of mold, the dry character along with the flexibility to control surface properties towards specific demands are some of the advantages of this method. Intense ion bombardment ensures high etch rates (~1.5 μm/min) and anisotropy. A PMMA lid was thermally bonded to the plasma fabricated microchannel. Surface roughness and hydrophilization are some unique features induced by plasma processing, affecting the electrokinetic performance of the microfluidic and resulting in relatively high electro-osmotic flow (EOF) mobilities of $2.83 \cdot 10^{-4} \text{ cm}^2/\text{V}\cdot\text{sec}$. Teflon-like coating deposition on the engraved part modified the surface into a super-hydrophobic and resulted in even higher EOF mobility ($3.89 \cdot 10^{-4} \text{ cm}^2/\text{V}\cdot\text{sec}$), thus proposing an alternative means in microfluidic surface modification and EOF control. Demonstration of on chip electrophoresis was done (Fig. I.2.8)



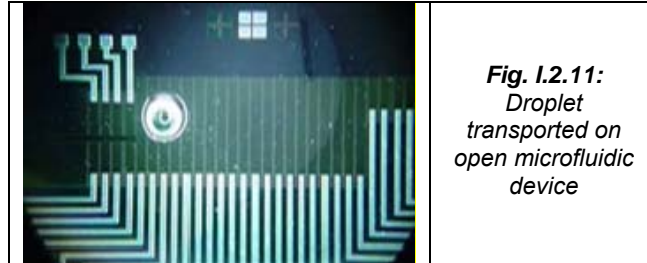
b₂ Fabrication of microfluidic devices based on soft lithography
A. Malainou, M. Vlachopoulou, and A. Tserepi

We have adopted the process of replica molding (soft lithography) using SU(8) for mold fabrication and rapid prototyping of PDMS-based microfluidic devices, as well as we have developed bonding processes (see Annual Report 2006) where permanent sealing of micro-channels is required. We have used these processes to fabricate two types of devices, shown below: a gas chromatography microcolumn and microfluidic modules integrated on a SAW biosensor. The micro-column (Fig. I.2.9) used in combination with a gas sensor (hybrid system) is shown to enhance the separation efficiency of the sensor. Here, mixtures of xylene/benzene are used in the chromatography microsystem and are sufficiently separated (in collaboration with Dr. S. Chatzandroulis). The microfluidic modules integrated on a biosensor (Fig. I.2.10) consist of many identical micro-channels which placed on the biosensor surface divide it in rather equal parts, thus allowing parallel analysis of multiple biological samples (in collaboration with E. Gizeli, K. Mitsakakis, Univ. of Crete-FORTH).



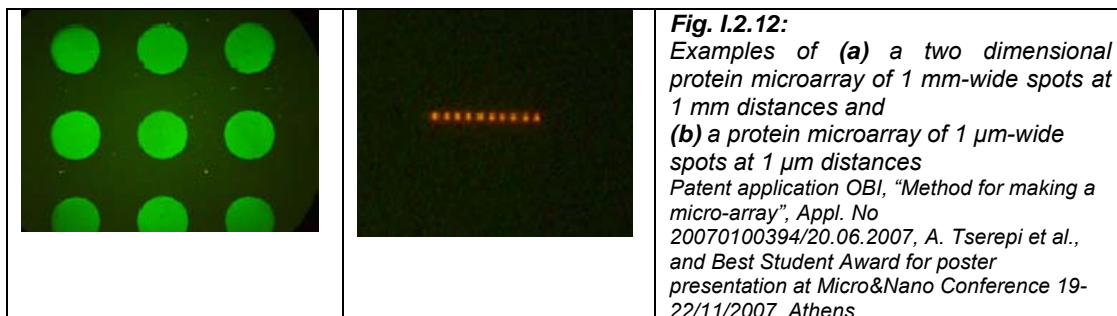
b₃ Electrowetting-based actuation in microfluidics through the use of hydrophobic plasma-deposited fluorocarbon films
P. Bayiati, A. Tserepi, K. Misiakos, D. Goustouridis

Optimized plasma-deposited fluorocarbon films are used in this work as the hydrophobic top layer of a droplet-based microfluidic device, where droplet actuation and transport is achieved via electrowetting. We have demonstrated electrowetting-based droplet transport on an open microfluidic device, fabricated using hydrophobic/dielectric fluorocarbon films deposited on a series of micro-electrodes, sequentially activated (Fig. 1.2.11).



b₄ Method for fabrication of protein microarrays through selective plasma-induced fluorocarbon deposition
P. Bayiati, A. Malainou, A. Tserepi, P. S. Petrou, S.E. Kakabakos

Microarrays have recently become an invaluable tool for large-scale and high-throughput bioanalytical applications, used for basic research, diagnostics and drug discovery. We have developed a simple and fast process for fabricating protein microarrays by selective protein adsorption on hydrophilic SiO₂ or Si₃N₄ patterns versus hydrophobic fluorocarbon-covered Si substrates exposed to fluorocarbon plasmas. We have demonstrated protein arrays of highly regular spots with increased signal to noise ratio (Fig. 1.2.12a), very small spot size (0.75 μm) and high spot density (Fig. 1.2.12b).



C. Plasma nanostructuring-nanotexturing of polymer surfaces: Optical, Wetting, and Bio applications, and periodic structure formation

c₁ *Design and Control of Surface Wetting and Antireflective properties of PMMA (organic polymer) and PDMS (inorganic polymer) by plasma processing*
N. Vourdas, M. Vlachopoulou, A. Tserepi, E. Gogolides

Transparent and anti-reflective coatings are of great interest, for applications such as photodiodes, solar cells, displays and lens industry, and smart panels / windows. We have shown that SF₆ plasma etching of PDMS results in periodic columnar-like high aspect ratio structures (see Annual Report 2005). In addition plasma processing was employed to create nanostructures and control the wetting properties of poly(methyl methacrylate) PMMA surfaces from Superhydrophilic to Superhydrophobic (see Annual Report 2006). This year, superhydrophobic (SH) yet optically transparent and antireflective surfaces were fabricated by means of highly anisotropic Oxygen plasma processing and plasma-enhanced fluorocarbon deposition on PMMA. It is also revealed that SF₆ treated PDMS surfaces for plasma durations between 1 and 3 minutes, can be used as transparent and anti-reflective coatings. After 4 minutes SF₆ plasma treatment, transmittance at 600nm decreases to 88%, while reflectance decreases to 3.5% and below.

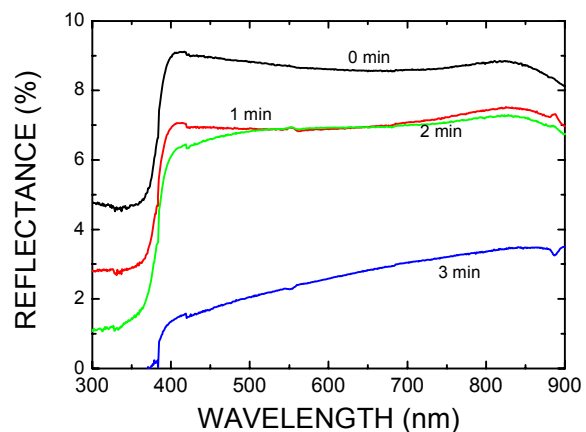


Fig. 1.2.13: (a) Photograph of the Institute of Microelectronics logo (*imel*) below two PMMA substrates, demonstrating the milky-like appearance of a 10 min-processed PMMA (placed over “*im*”) contrary to the optical transparency and reduced reflectivity of a 1 min-processed PMMA (placed over “*el*”) **(b)** Reflection spectra of PMMA substrates before and after 1, 2 and 3 min of Oxygen plasma processing. Until 2 min the surface is simultaneously optically transparent

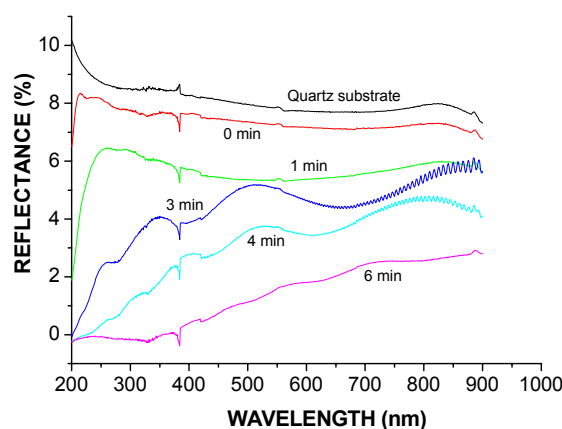
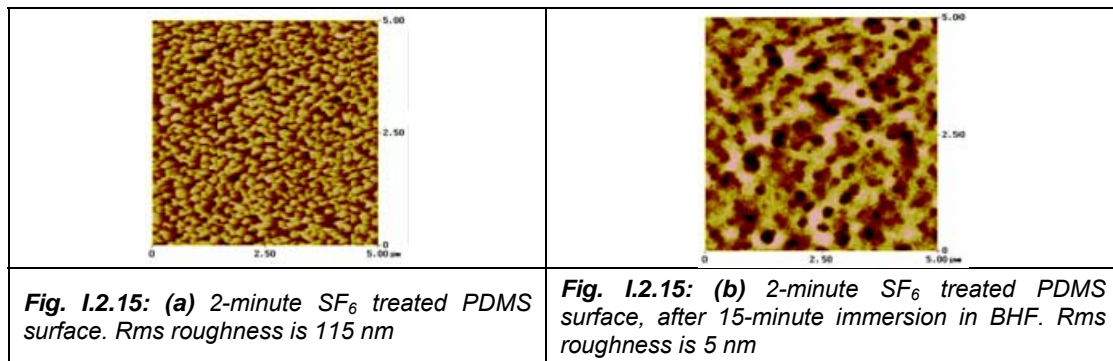


Fig. 1.2.14: Reflection spectra of untreated PDMS surface and treated in SF₆ plasma for 1, 3, 4 and 6 minutes

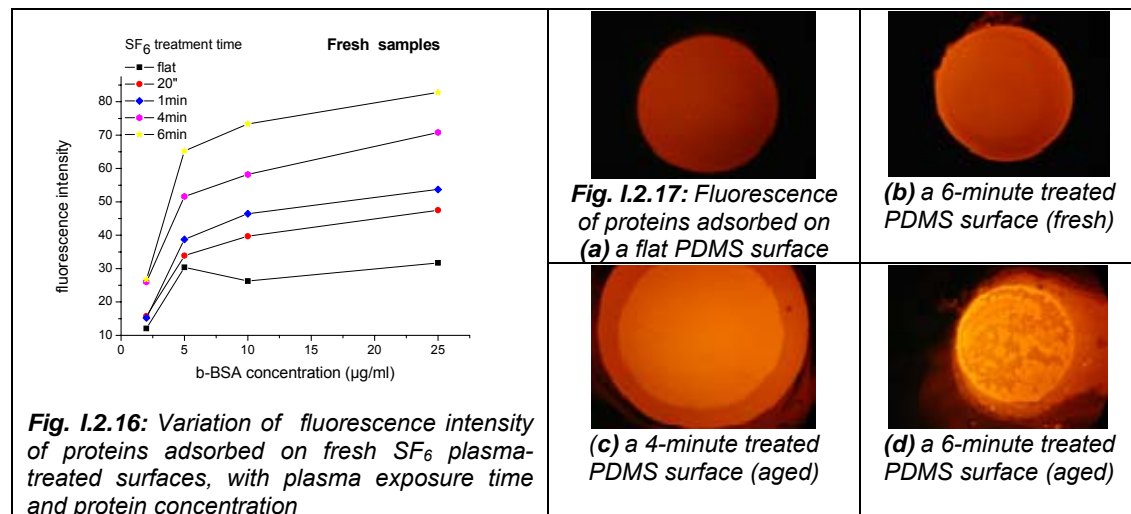
In addition, this year we also achieved the control and reduction of SF₆ plasma-induced PDMS surface roughness, by wet etching of treated PDMS surfaces in BHF. 2-minute treated PDMS surfaces (115 nm initial rms) show significant reduction in roughness (5nm rms) after 15-minute immersion in BHF (evolution of topography is shown in Fig. 1.2.15 (a) and (b), respectively). The

effect of roughness reduction in BHF is also simulated by isotropic etching of PDMS in BHF (collaboration with Dr. G. Kokkoris).



c₂ Plasma Nanotexturing of PDMS for increased Protein adsorption
M. Vlachopoulou, A. Tserepi, E. Gogolides

Plasma nano-textured PDMS surfaces (see C1 above) were also investigated as platforms for protein adsorption. Fresh and aged plasma-treated PDMS surfaces, for various plasma treatment durations, are used, and their hydrophobicity evolution is simultaneously studied. An increase in protein adsorption, more than 100%, is observed on 6-min treated PDMS nano-columnar surfaces, compared to flat untreated PDMS surfaces, mainly due to increased surface area, as shown in Fig. I.2.16. Larger fluorescence values are observed for aged samples compared to fresh ones, while best spot morphology is obtained either for fresh samples, even for long SF₆ treatment time or for aged samples, but for short SF₆ treatment time.



c₃ Plasma-based PDMS Nanotexturing: Oriented Spontaneously Formed Nanostructures on PDMS Films and Stamps
K. Tsougeni, G. Boulousis, E. Gogolides, A. Tserepi

We also proposed a plasma-based methodology to fabricate oriented spontaneously formed nanostructures on PDMS films and stamps. Oxygen plasma treatment of PDMS produces spontaneously-formed wavy structures with high nano-scale amplitude and with periodicity of a few 100's nm as revealed by Atomic Force Microscopy (AFM). We present two plasma based methods for the fabrication of such oriented nano-structures on PDMS films and stamps. Fig. I.2.18(a) shows a 3D AFM image of a thin PDMS film after exposure to O₂ plasma for 10 min through a stencil mask placed on top of the surface. Fig. I.2.18(b) shows AFM images of oriented nano-structures with periodicities ranging from 1150 to 170 nm formed on the top of a stamp bearing equally spaced lines A with dimensions (i) A = 35 µm, (ii) A = 20 µm and (iii) A = 5 µm. This simple oxygen plasma treatment to orient spontaneously formed nanostructures,

with wavelength in the sub-micrometer range, may be used to print, for example, fine patterns of biologically active molecules onto surfaces with high spatial frequency.

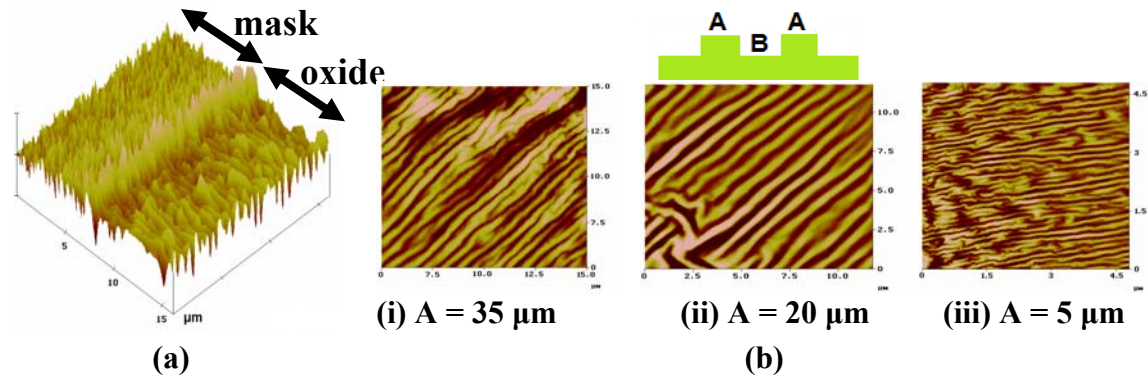


Fig. 1.2.18: (a) AFM 3D view image of a PDMS film after 10 min treatment in O₂ plasma through a stencil mask on top of the surface

Fig. 1.2.18: (b) AFM 2D images of a PDMS stamp after exposure to O₂ plasma for 10 min: structures formed on the top of the stamp.

(i) A = 35 μm, (ii) A = 20 μm and (iii) A = 5 μm

D. Simulation of micro and nano-structuring evolution from plasma processes: Towards a complete multi scale plasma process simulator

d₁ Simulation of plasma (gas phase) and surface kinetics during plasma etching
G. Kokkoris, A. Panagiotopoulos, E. Gogolides

Control of plasma reactors in real time, as well as fast simulation of nanostructure profile evolution and surface nanotexturing with plasma processes demand the use of fast 'global' or '0-dimensional' models. Such models use average plasma variables ignoring their spatial variation (these are the so-called well stirred tank reactors in chemical engineering). A zero dimensional (Global) plasma chemistry code has been developed for 3 gases, namely O₂, SF₆, C₄F₈ applicable for high Density plasma reactors. Surface models have also been developed for calculation of the etching rates of SiO₂ etching in C₄F₈ / fluorocarbon plasmas:

- Si in SF₆ plasmas or Si in the gas chopping process using alternating SF₆/C₄F₈ plasmas
- Organic polymer (PMMA) etching AND silicon containing polymer etching (silsequioxane type). This model enables simulation of bilayer lithographic processes using silicon-containing resists (an application useful for microelectronics, microsystems and microfluidic channel fabrication).

The plasma and surface kinetics codes have been coupled to permit calculation of etch rates versus reactor parameters. A schematic of the interface of the zero dimensional code is shown below. This module will be coupled to the profile evolution simulator presented in annual reports for years 2006, 2005, 2004

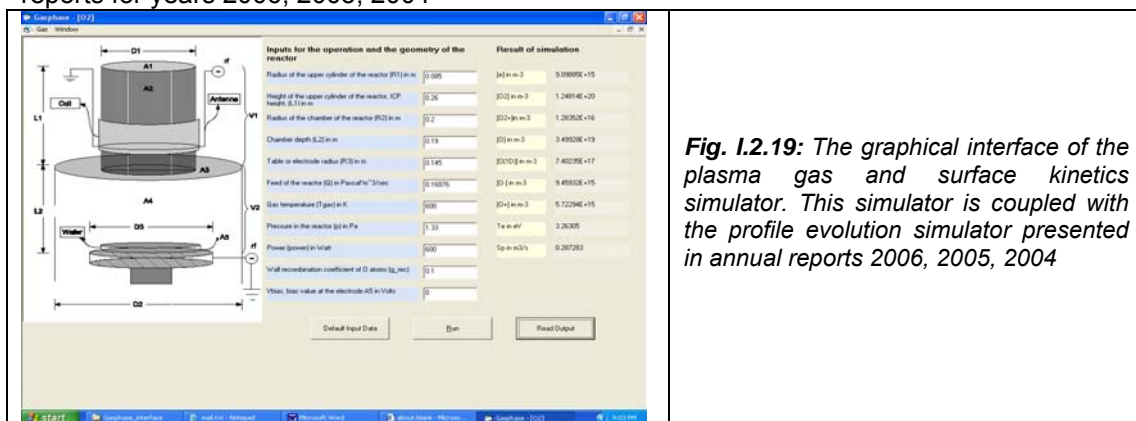
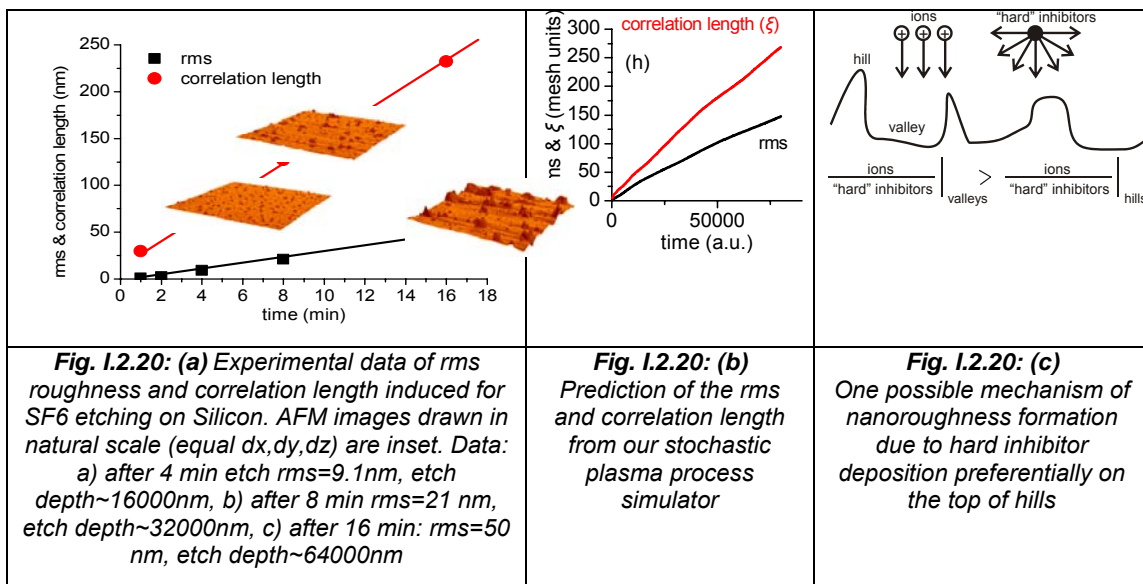


Fig. 1.2.19: The graphical interface of the plasma gas and surface kinetics simulator. This simulator is coupled with the profile evolution simulator presented in annual reports 2006, 2005, 2004

d₂ Stochastic simulation of roughness evolution of homogeneous and composite materials during plasma etching

V. Constantoudis, G. Kokkoris, G. Boulousis, E. Gogolides

Mechanisms of roughness formation on homogeneous and composite materials are being investigated. Our work targets both, Silicon based and organic materials to line up with the results presented in the previous section. The nanoroughness formation and evolution during fluorine-based plasma etching of Si surfaces was investigated this year both experimentally and theoretically. Dual nanoscale morphology, as well as, almost linear increase of both root mean square roughness and correlation length versus etching time was observed in the experiment. The effect of etch inhibitors from the plasma environment is modeled. Two kinds of etch inhibitors can explain and predict the nanoroughness formation and evolution. Key factors in the nanoroughness formation is the angular distribution of etch inhibitors versus that of ions and their sticking probability compared to that of reactive neutral species.



PROJECT OUTPUT in 2007

Publications in International Journals and Reviews

1. "Tunable poly(dimethylsiloxane) topography in O₂ or Ar plasmas for controlling surface wetting properties and their ageing", Tsougeni K, Tserepi A, Boulousis G, V. Constantoudis, E. Gogolides, (2007) JPN J Applied Physics 1 46 (2): 744-750.
2. "Electrowetting on plasma-deposited fluorocarbon hydrophobic films for biofluid transport in Microfluidics", Bayiati P., Tserepi A., Petrou P.S., Kakabakos S.E., Misiakos K., Gogolides E., (2007) Journal of Applied Physics, 101 (10), art. no. 103306.
3. "Control of nanotexture and wetting properties of polydimethylsiloxane from very hydrophobic to super-hydrophobic by plasma processing", Tsougeni K., Tserepi A., Boulousis G., Constantoudis V., Gogolides E., (2007) Plasma Processes and Polymers, 4 (4), pp. 398-405.
4. "Photosensitive poly(dimethylsiloxane) materials for microfluidic applications", Tsougeni K., Tserepi A., Gogolides E., (2007) Microelectronic Engineering, 84 (5-8), pp. 1104-1108.
5. "Nanostructuring of PDMS surfaces: Dependence on casting solvents", Vlachopoulou M.-E., Tserepi A., Beltsios K., Boulousis G., Gogolides E., (2007) Microelectr. Engineering, 84 (5-8), pp. 1476-1479.
6. "Biofluid transport on hydrophobic plasma-deposited fluorocarbon films", Bayiati P., Tserepi A., Petrou P.S., Misiakos K., Kakabakos S.E., Gogolides E., Cardinaud C., (2007) Microelectronic Engineering, 84 (5-8), pp. 1677-1680.
7. "Stochastic simulation studies of molecular resists", Drygiannakis D., Patsis G.P., Raptis I., Niakoula D., Vidali V., Couladouros E., Argitis P., Gogolides E., (2007) Microelectronic Engineering, 84 (5-8), pp. 1062-1065.
8. "Nanotextured super-hydrophobic transparent poly(methyl methacrylate) surfaces using high-density plasma processing", Vourdas N., Tserepi A., Gogolides E., (2007) Nanotechnology, 18 (12), art. no. 125304.
9. "Fermi acceleration in the randomized driven Lorentz gas and the Fermi-Ulam model", Karlis A.K., Papachristou P.K., Diakonou F.K., Constantoudis V., Schmelcher P., (2007) Physical Review E - Statistical, Nonlinear, and Soft Matter Physics, 76 (1), art. no. 016214.
10. "Optical characterization of Si-rich silicon nitride films prepared by low pressure chemical vapor deposition", Vamvakas V.E., Vourdas N., Gardelis S., (2007) Microelectronics Reliability, 47 (4-5 SPEC. ISS.), pp. 794-797.
11. "Simulation of materials and processing effects on photoresist line-edge roughness", G. P. Patsis, M. D. Nijkerk, L. H. Leunissen, and E. Gogolides, International Journal of Computational Science and Engineering (Special Issue on Computational Methods and Techniques for Nanoscale Technology Computer Aided Design) Vol. 2, 3-4, 134-143 (2007).
12. "Effects of lithography nonuniformity on device electrical behavior. Simple stochastic modeling of material and process effect on device performance", G. P. Patsis, V. Constantoudis, and E. Gogolides, J. Computational Electronics 5, 341 (2007).
13. "Stochastic simulation of material and process effects on the patterning of complex layouts", N. Tsikrikas, D. Drygiannakis, G. P. Patsis, I. Raptis, S. Stavroulakis, E. Voyiatzis, Jap. J. Appl. Phys. 46 (9 B), 6191 (2007)
14. "Dual nanoscale roughness on plasma-etched Si surfaces: role of etch inhibitors", G. Kokkoris, V. Constantoudis, P. Angelikopoulos, G. Boulousis, and E. Gogolides, Phys. Rev. B 76, 193405 (2007)
15. "Roughness formation during plasma etching of composite materials: a kinetic Monte Carlo approach", Zakka, E., Constantoudis, V., Gogolides, E., IEEE Transaction on Plasma Science, vol. 35 (5) Page(s): 1359-1369, 2007
16. "Novel microfluidic flow sensor based on a microchannel capped by porous silicon", Pagonis, D.N., Petropoulos, A., Kaltsas, G., Nassiopoulou, A.G., Tserepi, A., Physica Status Solidi (A) Applications and Materials 204 (5), pp. 1474-1479

Publications in International Conference Proceedings

1. "Correlation length and the problem of line width roughness", V. Constantoudis, G.P. Patsis, E. Gogolides, Proceedings of SPIE Vol. #6518, 6518_57, 65181N pp. 1-10, San Jose, California, February 25 – March 2, (2007)
2. "Simulation of the combined effects of polymer size, acid diffusion length and EUV secondary electron blur on resist line-edge roughness (poster)", D. Drygiannakis, M. D. Nijkerk, G. P. Patsis, G. Kokkoris, I. Raptis, L. H. A. Leunissen, E. Gogolides, Proceedings of SPIE Vol. #6519, 6519_36, 65193T pp. 1-12, San Jose, California, February 25 – March 2, 2007
3. "Stochastic simulation of material and process effects on the patterning of complex layouts with e-beam and EUV lithography (poster)", N. Tsikrikas, D. Drygiannakis, G. P. Patsis, G. Kokkoris, I. Raptis, E. Gogolides, Proceedings of SPIE Vol. #6518, 6518_115, 651836 pp. 1-10, San Jose, California, February 25 – March 2, 2007
4. "Plasma processing in fabricating nano-textured, super-hydrophobic polymeric coatings", N. Vourdas, M.-E. Vlachopoulou, A. Tserepi, E. Gogolides, Proceedings of EURO-INTERFINISH 2007, Athens, Greece, 18-19 October 2007, O24 - pp165-170
5. "Protein patterning through selective fluorocarbon plasma-induced deposition on silicon", P. Bayiati, A. Tserepi, P. S. Petrou, S. E. Kakabakos, E. Matrozos, E. Gogolides, Proceedings of 11th

Publications in Greek Conference Proceedings

1. "Plasma processes in fabrication of nano-textured, super-hydrophobic polymeric surfaces", N. Vourdas, M.-E. Vlachopoulou, A. Tserepi, E. Gogolides, Proceedings of 6th Panhellenic Conference on Chemical Engineering (full paper), Athens, 31 May-2 June 2007, pp. 225-228
2. "Nanoroughness on plasma etched Si and polymer surfaces : theory, experiment and applications", M.-E. Vlachopoulou, N. Vourdas, G. Kokkoris, V. Constantoudis, G. Mpoulousis, A. Tserepi, E. Gogolides, Proceedings of XXIII Hellenic Conference On Solid State Physics 2007, Athens, Greece, 23-26 September 2007, pp. 55-56
3. "Stochastic simulation of the solution of photosensitive materials with applications in microelectronics (poster)", D. Drygiannakis, G. P. Patsis, I. Raptis, A.G. Boudouvis, Proceedings of XXIII Hellenic Conference On Solid State Physics (2007), Athens, Greece, 23-26 September 2007
4. "Simulation, pattern matching and metrology in electron beam lithography (poster)", N. Tsirikas, G. P. Patsis, I. Raptis, Proceedings of XXIII Hellenic Conference On Solid State Physics (2007), Athens, Greece, 23-26 September 2007, pp. 25-26

Conference Participation

- MNE 2007
- AVS 2007
- SPIE 2007
- 3rd International Conference on Micro-Nanoelectronics, Nanotechnology & MEMs
- EURO-INTERFINISH 2007 - "Nanotechnology and Innovative Coatings"
- The 11th International Conference on Miniaturized Systems for Chemistry and Life Sciences (μ TAS 2007 Conference)
- IMA 2007
- PESM 2007
- XXIII Panhellenic Conference on Solid State Physics and Material Science 2007
- Micro&Nano2007

Ph. D thesis

1. "Oxygen plasma etching, surface modification and nanotexturing of PMMA: Study of mechanisms and applications in PMMA microfluidic devices", Nikolaos Vourdas, Chemical Engineer, MSc, PhD, Thesis advisor-supervisor: Evangelos Gogolides, Other co-advisors: Angeliki Tserepi, Andreas Boudouvis, Dept. Chem. Eng., National Tech. Univ. Athens

M. Sc thesis

1. "Silylation and Oxygen Plasma Development of Epoxidized Photoresists (SU8) for micromachining and other applications", Dimitrios Kontziambasis, Materials Engineer, MSc, Thesis Advisor-Supervisor: Evangelos Gogolides, Masters Programme in Microelectronics

Laboratory Training

During the advanced summer school "Methods in Micro-Nano Technology and Nanobiotechnology", June 25 - July 6, 2007 we taught the following labs:

"Microfluidics with soft lithography" Fabrication of microfluidic devices on plastic substrates by soft lithographic techniques (A. Tserepi, M. Vlachopoulou)

"Microfluidics with Plasma Etching" Fabrication of plastic microfluidic Devices by Lithography and deep polymer plasma etching techniques (E. Gogolides, N. Vourdas, K. Kontakis)

See video on Tel Aviv University Site:

http://video.tau.ac.il/Lectures/nano/Nano2Life/Summer_Schools/Democritos/2007/

New patent applications

1. "Method for making a micro-array", A. Tserepi, E. Gogolides, P. Petrou, S. Kakambakos, P. Bayiati, E. Matrozos, Patent application OBI, Appl. No 20070100394/20.06.2007
2. "Bonding method", K. Misiakos, A. Tserepi, M.-E. Vlachopoulou, PCT/GR07/000047 (Filing date: 14/09/2007)

Organization of Conferences, Workshops and Project meetings

3rd Nano2life Summer School "Methods in Micro-Nano Technology and Nanobiotechnology", June 25th- July 6th 2007, <http://imel.demokritos.gr/SummerSchool2007/index.htm>

Participation in NCSR "Demokritos" summer school, July 9th – 20th 2007

- N. Vourdas, "Control of polymer surface properties by means of plasma processing"
- A. Tserepi, "Microfluidic systems: fabrication technology and applications in Life Sciences"
- V. Constantoudis, "Introduction in fractal geometry and its applications in Microelectronics"

Purchase of new equipment

- Microfluidics Lab on a chip kit by Micronit
- Capillary Electrophoresis on chip kit by Micronit
- High Voltage Generator for Electrophoresis by HVS488-3000D by LabSmith

Products for possible licensing or other development

- Software for LER measurement and characterization from SEM images. Demo available on our web site <http://www.imel.demokritos.gr/software.html>
- Software for nanolithography simulation and LER prediction based on Monte Carlo methods. Demo in Preparation
- Software for topography evolution simulation during plasma processing. Demo released and tested in graduate class for Micro and Nano Fabrication for Electronics and MEMS

Awards

P. Bayiati, *Best Student Award* for poster presentation ("Hydrophobic plasma-deposited fluorocarbon films as a means for biofluid transport and selective adsorption of biomolecules on lab-on-a-chip devices") at *Micro&Nano 2007 Int. Conference* 18-21/11/2007, Athens