Project I. 2: LITHOGRAPHY and PLASMA PROCESSES

Project leader: Dr E. Gogolides

Key researchers: Dr E. Gogolides, Dr A. Tserepi

Collaborating researchers: Dr K. Misiakos, Dr P. Argitis, Dr I. Raptis

Post-doctorals: Dr G. Patsis, Dr V. Constantoudis, Dr G. Kokkoris

PhD candidates: P. Bayiati, N. Vourdas

External collaborators: Prof. A. Boudouvis (NTUA), Dr P. Leunissen (IMEC), Prof. Th. Christopoulos (U. Patras), Y. Wang, J. Roberts (INTEL), Dr S. Kakabakos (IRRP, NCSR-Demokritos), Dr P. Petrou (IRRP, NCSR-Demokritos)

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Research orientation:

Our work in nanolithography focused on metrology and simulation of Line Edge Roughness, a side effect of the nanoscale era, which has deleterious effects on transistor operation. We have developed a protocol and software for LER measurement from SEM images. In addition, we are improving a stochastic nanolithography simulator to design processes with minimal LER. This work is in strong collaboration with IMEC and INTEL.

Microfluidics fabrication and actuation has consumed significant effort. A platform technology based on soft lithography has been complemented with sealing processes used for fabrication of microfluidic devices. We are also proposing an alternative technology for microfluidics patterned on polymeric substrates using plasma etching and plasma functionalisation. First results have been achieved on plexiglass. Selective plasma deposition of polymers has been used to create open channel microfluidics actuated with electrowetting. We demonstrated movement of protein solutions without protein loss on the surface.

Nanotexturing of polymers with plasmas has produced impressive results for PDMS where nanocolumns were created and superhydrophobicity was demonstrated. A patent was filed and applications on Microfluidics are being designed. Nanotexturing and nanoroughness creation from plasmas is being probed with Monte Carlo simulations.

Finally, topography evolution during plasma etching was investigated for deep silicon etching using our Integrated Plasma Topography Evolution Simulator in order to achieve very high aspect ratios and propose parameter ramping strategies. This work is significant for MEMS fabrication.

Main results in 2005

The main results obtained in 2005 within the different tasks of the project are given below.

Task 1 Nanopatterning: Metrology and simulation of Line Edge Roughness (LER)

a. Simulation of lithography for LER reduction G. Patsis, E. Gogolides

Resolution and line edge roughness are related to the used polymer chain size. They can further be strongly affected by acid diffusion and processing. It is thus essential to guide appropriate material design choices using simulations taking into account all relevant processing steps. Stochastic Monte Carlo techniques are used with a quasi-static dissolution algorithm to simulate dissolution of polymer lattice based on the concept of critical ionisation. Etching is simulated by applying an isotropic deformation on a numerically obtained line edge.LER decreases with decreasing polymerization length when acid diffusion is small. Otherwise, acid diffusion tends to result in lower LER for longer polymers. LER can be reduced during pattering. For shorter diffusion length the decrease in LER is initially much larger. The reduction in LER is related to the spatial frequency components of the resist.



of the dissolution of a thin polymer layer and LER formation (a) unexposed (left) and exposed (right) polymer chain lattice (b) the same lattice as in (a) after exposed polymer dissolution (c)magnification of the edge to observe roughness.

b. Metrological software for LER analysis V. Constantoudis, G. Patsis, E. Gogolides

A software has been developed for the analysis of SEM images during the years 2003-04. During 2005 the software has been expanded and standardized to become a tool for LER measurement and comparison of various lithographic materials. Software demos are in use at IMEC, INTEL and other research centers and companies. The protocol for LER/LWR resist comparison consists of the following steps:

1. Acquisition of top-down CD-SEM images of the resist line patterns to be analyzed.

2. Application of an off line image analysis algorithm with noise smoothing filter and extraction of the line edges of the images (see the top-left image of the output fig.).

3. Estimation of the height-height correlation function HHCF (top-right figure) and the three curves $\sigma_{LWR}(L)$, $CD_{variation}(L)$ (down-left), $rms_{sigma}(L)$ (down-right) from the obtained line



and morphologies averaged over all available resist lines and SEM images.

4.Calculation of the LWR descriptors used for resist comparison: a) the line length independent value of the line σ_{LWR} (inf) calculated bv the



relationship $\sigma_{LWR}^{2}(inf) = \sigma_{LWR}^{2}(L) + CD_{variation}^{2}(L)$, b) correlation length ξ after which the line looks flat or the sigma correlation length L_s after which the σ_{LWR} does not depend strongly on the length of the measurement box, and c) roughness exponent α which gives the relative importance of high frequency fluctuations on LWR and thus determines how fast the sigma drops off as the measured length decreases.

Task 2 Microfluidics fabrication and actuation using plasma processes

a. Plasma etching for fabrication of PMMA Microfluidic devices N. Vourdas, E. Gogolides



Fig. 1.2.3: Microfluidic channel made on PMMA by means of direct plasma etching. Patterning and surface properties control are performed simultaneously. The fabrication of microfluidic devices with features of 10-1000µm size are of great importance in many fields of analytical science, where a small quantity of sample is available, enhanced resolution and sensitivity in separation is needed and increased functional integration is desired (medical, chemical and biochemical analysis, microchemistry etc). Even though the first microfluidic devices were fabricated on silicon and glass, the need for easy fabrication, low cost and disposability has recently shifted the attention on polymeric materials.

We demonstrated an alternative method for fabrication of microfluidic devices based on direct O₂ plasma etching of polymers -PMMA in particular- using a photosensitive silicon-containing polymeric mask (poly-dimethylsiloxane-PDMS). Both patterning and surface properties control is attained simultaneously according to specific analysis requirements.

b. Plasma deposited films for electrowetting-based actuation in microfluidics P. Bayiati, A. Tserepi, K. Misiakos



This work focuses on the plasma deposition of fluorocarbon films on electrodes, in order to obtain surfaces that can be varied from hydrophobic to hydrophilic with voltage application (electrowetting). Such films can be used for biological fluid transport in microfluidic devices actuated by voltage application (fig. 1.2.4).

Fluorocarbon films with appropriate surface properties (small hysteresis) were deposited in fluorocarbon plasmas (C_4F_8). Composite films (plasma-deposited fluorocarbon films on Si₃N₄ films) were mainly used for the improvement of the dielectric properties of the stack-structure and its use in reversible electrowetting (fig. I.2.5). Electrowetting experiments were conducted using protein solutions for investigating the conditions under which transport of protein solutions is feasible. Furthermore, an open microfluidic device was fabricated and protein solution transport was demonstrated on devices under appropriate conditions.



Fig. I.2.5: Reversible electrowetting using protein solutions on composite (plasma-FC deposited on Si_3N_4) materials.

c. Fabrication technologies for microfluidic devices based on soft lithography M. Vlachopoulou, P. Bey, A. Tserepi, K. Misiakos

The process of replica molding (soft lithography) based on the lithography of SU(8) for the fabrication of the mold has been adopted for the rapid prototyping of PDMS-based microfluidic devices. The lithography of SU(8) has been used for the fabrication of dual-height structures in SU(8) such as those shown in fig. I.2.6 and thus it offers the capability for simultaneous fabrication of both open and closed channels in PDMS (fig. 1.2.7). For fabrication of closed microchannels on PDMS, sealing procedures have been developed for non-irreversible and/or irreversible sealing with materials such as PDMS, glass, plexiglass, and Polystyrene. Microfluidic devices have been fabricated, with the addition of interfaces with external tubing for inlet and outlet of the reagents, such as the one shown in fig. I.2.8. A microfluidic module is shown in the picture, with a red dye flowing through it for demonstration purposes. A similar microfluidic module is used for bio-spotting when placed on an optoelectronic bio-sensor (see PIII-2).



Fig. I.2.6: A dual-height structure fabricated by double photolithography of SU(8). Structures 30 and 60 µm high are shown.

Fig. 1.2.7: 30 and 60-µm deep structures fabricated by replica molding of PDMS (using as a mold an SU(8) structure similar to that in fig. 1.2.6).



Fig. I.2.8: A microfluidic device in PDMS supported on plexiglass and bearing two microchannels indicated by the red dye flowing through.



Task 3 Plasma nanostructuring-nanotexturing of polymers

a. Design and Control of Surface Wetting properties of PDMS by plasma processing M. Vlahopoulou, K. Tsougeni, A. Tserepi, E. Gogolides

Poly-dimethyl siloxane (PDMS) is a material widely used in soft lithography techniques for the fabrication of soft stamps, molds, and as a structural material for microfluidic devices. In all of these applications, control of the surface topography and the resulting wetting properties is greatly desired, as it can potentially affect the functionality of the structure/device.

In our work, the effect of O_2 and SF_6 plasma treatments on (commercial elastomer Sylguard 184) PDMS surfaces is investigated due to the use of the former for the activation of PDMS surfaces before channel sealing in microfluidic device fabrication, while the use of the latter for plasma-based patterning of PDMS devices. Both treatments were found to significantly affect the surface topography of PDMS (in addition to its surface chemistry).

In specific, surface undulations were observed after O_2 plasma treatments (fig. 1.2.9), of random orientation but with periodicity of rms in the nanoscale and wavelength in the range 200-600 nm, depending on treatment duration. After ion-induced dominated treatments in SF₆ plasmas, columnar-like structures (fig. 1.2.10 and 1.2.11) appear on the PDMS surface, with pillar diameter in the order of 100 nm and with height increasing linearly with the duration of plasma processing. In both cases, when FC deposition on the modified PDMS surface follows plasma treatment, increased water contact angles (140°-150°) were observed (fig. 1.2.12). Water contact angles on surfaces of topography similar to those shown in fig. 1.2.9 indicate Wenzel type surfaces characterized by high hysteresis, while contact angles on surfaces of topography similar to that shown in fig. 1.2.10, 1.2.11 indicate surfaces in the Cassie-Baxter regime (minimal hysteresis, and thus of minimal friction against droplet motion).



Fig. 1.2.9: AFM top view image of a PDMS surface after (a) 4 and (b) 10 min treatment in O_2 plasma. Roughness analysis gave an rms value of (a) 46 nm and a periodicity of 324 nm and in (b) an rms value of 28 nm and a periodicity of 461 nm



Fig. I.2.10: SEM image of a tilted PDMS surface after 6 min treatment in SF₆ plasmas



Fig. I.2.11: Top-down AFM image of a PDMS surface after 2 min treatment in SF₆ plasmas



Fig. I.2.12: Enhanced contact angle (150°) on a plasma-treated PDMS surface

Task 4 Simulation of micro and nano-structuring evolution from plasma processes

a. Deep silicon etching

G. Kokkoris, P. Papasimakis, E. Gogolides, A. Tserepi

The spread of microelectromechanical systems (MEMS) application to diverse industries (e.g. automotive, aerospace, bio-medical, computer peripherals and telecommunications) poses several and different demands in the construction of the building blocks of MEMS. A common and key requirement in MEMS fabrication is the capability of making silicon structures with high aspect ratio (ratio of the depth to the width of the structure). The Bosch process, a multiple step etching process, including successive etching and deposition steps, is the most



Fig. 1.2.13: Experimental and simulation results of etching Si trenches with the Bosch process.

common one used to construct deep silicon structures.

An integrated simulation framework for topography evolution during plasma etching of structures consisting of three modules a) a flux calculator module, b) surface etch module and c) a topography evolution algorithm is applied in the Bosch process. The theoretical study has been complemented with experiments to a) define the parameters and coefficients of the surface models required and b) develop a recipe for high aspect ratio and anisotropic etching, i.e. the so-called parameter ramping.

b. Monte Carlo simulation of roughness formation during plasma etching V. Constantoudis, G. Kokkoris, E. Gogolides

The aim of this research activity is to understand and control the formation of surfaces roughness on Si and polymer films during plasma etching by developing kinetic Monte Carlo simulation algorithms. Simulation algorithms considering both anisotropic etching by ions and isotropic etching by neutrals have been developed in both (1+1) and (2+1) dimensions. These algorithms have been used for the explanation of the experimentally observed behaviour in plasma etched Si films consisting of the linear increase of roughness with etching time and the occurrence of columnar surface structures that are diluted and widened with time. We have found that the inclusion in the etching process of the simultaneous isotropic deposition of etching resistant particles forming a local nano-masking on the film is able to explain the experimentally observed roughness morphology (fig. 1.2.14). Further, we have addressed the influence of the reflection of ions and the isotropic etching by neutrals on roughness formation.



Fig. 1.2.14a: Si Surface morphology vs etching time as aiven bv Monte Carlo simulation

Fig. I.2.14b: Experimental Si surface morphology vs etchina time.

PROJECT OUTPUT in 2005

PUBLICATIONS in INTERNATIONAL JOURNALS and REVIEWS

- "Fractal roughness of polymers after lithographic processing", Constantoudis, V., Gogolides, E., Patsis, G.P., Sarris, V., Tserepi, A., Diakoumakos, C., Valamontes, E.S., (2005) Japanese Journal of Applied Physics, Part 2: Letters, 44 (1-7), Pages L186-L189.
- 2. "Increased plasma etch resistance of thin polymeric and photoresist films", Vourdas, N., Boudouvis, A.G., Gogolides, E., (2005) Microelectronic Engineering, 78-79 (1-4), Pages 474-478.
- 3. "Monte Carlo study of surface and line-width roughness of resist film surfaces during dissolution", Patsis, G.P., (2005) Mathematics and Computers in Simulation, 68 (2), Pages 145-156.
- 4. "Stochastic simulation of thin photoresist film dissolution: A dynamic and a quasi-static dissolution algorithm for the simulation of surface and line-edge roughness formation", Patsis, G.P., (2005) Polymer, 46 (7), Pages 2404-2417.
- 5. ^aDetermining the impact of statistical fluctuations on resist line edge roughness", Leunissen, L.H.A., Ercken, M., Patsis, G.P., (2005) Microelectr. Engineering, 78-79 (1-4), Pages 2-10. Cited 3 times.
- 6. "Tailoring the surface topography and wetting properties of oxygen-plasma treated polydimethylsiloxane", Tserepi, A., Gogolides, E., Tsougeni, K., Constantoudis, V., Valamontes, E.S., (2005) Journal of Applied Physics, 98 (11), Pages 1-6.
- "A Stochastic Photoresist-Polymer Dissolution Model Combining the Percolation and Critical Ionization Models", V. Sarris, G. P. Patsis, V. Constantoudis, A. G. Boudouvis and E. Gogolides, (2005) Japanese Journal of Applied Physics, Part 2: Letters, 44 (10), Pages 7400-7403.
- "Material and process effects on line-edge-roughness of photoresists probed with a fast stochastic lithography simulator", G. P. Patsis & E. Gogolides, J. Vac. Sci. Technol. B 23(4), 1371, Jul/Aug 2005

PUBLICATIONS in CONFERENCE PROCEEDINGS

- "Patterning of thick polymeric substrates for the fabrication of microfluidic devices", Vlachopoulou, M.E., Tserepi, A., Vourdas, N., Gogolides, E., Misiakos, K., (2005) *Journal* of Physics: Conference Series, 10 (1), Pages 293-296.
- "Characterization and modeling of Line Width Roughness (LWR)", Constantoudis, V., Gogolides, E., Roberts, J., Stowers, J.K., (2005) Progress in Biomedical Optics and Imaging - Proceedings of SPIE, 5752 (III), Pages 1227-1236.
- "Plasma etch rate measurements of thin PMMA films and correlation with the glass transition temperature", Vourdas, N., Boudouvis, A.G., Gogolides, E., (2005) *Journal of* Physics: Conference Series, 10 (1), Pages 405-408.
- 4. "Effects of model polymer chain architectures of photo-resists on line-edge-roughness: Monte Carlo simulations", Patsis, G.P., Gogolides, E., (2005) J. of Physics: Conf. Series, 10 (1), Pages 389-392.
- 5. "Characterization and Modeling of Line Width Roughness (LWR)", V. Constantoudis, E. Gogolides, (2005) Proceedings of SPIE, v. 5752 (3), pages 1227-1236
- 6. "Electron-beam lithography simulation for EUV mask applications", Patsis, G.P., Glezos, N., (2005) Journal of Physics: Conference Series, 10 (1), Pages 385-388
- Plasma Etching Fabrication Of Pmma-Based Microfluidic Devices For Bioanalytical Applications", N. Vourdas, A. Tsougeni, A. Tserepi, A.G. Boudouvis and E. Gogolides, S. Tragoulias, T.K. Christopoulos, In Proceedings of 17th International Symposium on Plasma Chemistry (ISPC) (CD vesion, Nr.693_Vourdas et al(1)), Toronto-Canada, August 7-11, 2005, R. D' Agostino et al, Eds.
- "Effects of model polymer chain architectures on the self-affine-characteristics of dissolving photopolymer films", G. P. Patsis, N. Tsikrikas, E. Gogolides, In Proceedings of 3rd International Symposium on Nanofacturing (ISNM), (CD version, TMP3), Limassol-Cyprus, November 3-5, 2005
- "Combined Metrology and Simulation of imprinted photopolymer lines/ spaces. Extraction of Line-Edge roughnessdescriptors", G.P. Patsis, N. Tsikrikas, V. Constantoudis, E. Gogolides, In Proceedings of 3rd International Symposium on Nanofacturing (ISNM), (CD version, TAA4), Limassol-Cyprus, November 3-5, 2005
- "Mechanisms of Nano-Roughness Formation on Plasma Etched surfaces", V. Constantoudis, A. Tserepi, G. Boulousis, P. Papasimakis, E. Gogolides, In Proceedings of 3rd International Symposium on Nanofacturing (ISNM), (CD version, FMB2), Limassol-Cyprus, November 3-5, 2005
- "Design of PDMS surfaces with controlled nano-texturing and wettability", A. Tserepi, K. Tsougeni, G. Boulousis, V. Constantoudis, E. Gogolides, In Proceedings of 3rd International Symposium on Nanofacturing (ISNM), (CD version, FAA1) Limassol-Cyprus, November 3-5, 2005
- Nanofacturing (ISNM), (CD version, FAA1) Limassol-Cyprus, November 3-5, 2005
 12. "Plasma Treatment Of Polymers For Bioanalytics", (in greek) N. Vourdas, A. Tserepi, M. Vlachopoulou, E.Gogolides, In Proceedings of 2nd Panhellenic Conference on Plastics (CD-version, neestexnologies 15), Athens, 20-21 March, 2005, K. Papaspyrides et al. Eds.
- "New Nanocomposite materials. Thermomechanical characterization and morphology studies after O₂ plasma treatment", (in greek) S.I. Marras, I. Zoubourtikoudis, N. Vourdas, V. Constandoudis, A. Tserepi, E. Gogolides, C. Panagiotou, In Proceedings of 2nd Panhellenic Conference on Plastics (CD-version, neaylika 32), Athens, 20-21 March, 2005, K. Papaspyrides et al. Eds.

INVITED TALKS

- 1. In MNE 2005:E. Gogolides, V. Constantoudis, G.P. Patsis, A. Tserepi, "Line Edge nano-roughness nad surface nano-texture resulting fron patterning processes: A blessing or a curse?"
- SEMATECH Workshop on Resist Line Edge Roughness (27th February 2005)
 E. Gogolides, V. Constantoudis, G.P. Patsis, « Metrology Characterization and Simulation of Line Edge Roughness »

CONFERENCE PRESENTATIONS

Presentations in MNE 2005:

- 1. "Molecular resists based on novel polycarbocycle derivatives", D. Niakoula, P. Argitis, I. Raptis, E. Gogolides, V.P. Vidali, E.A. Couladouros, Wang Yueh, Janette Roberts, Robert Meagley
- 2. "Effects of model polymer chain architectures and molecular weight of photoresists on line-edge roughness. Monte Carlo Simulations", G.P. Patsis, E. Gogolides
- 3. "Micro- and nano-structuring of polydimethylsiloxane for production of super-hydrophobic surfaces", M.E. Vlachopoulou, A. Tserepi, P. Bayiati, E. Gogolide
- "Monolithic silicon optoelectronic transducers and elastomeric fluidic modules for bio-spotting and bio-assay experiments", K. Misiakos, P.S. Petrou, S.E. Kakabakos, M.E. Vlachopoulou, A. Tserepi, E. Gogolides, H.H. Ruf
- 5. "Line Edge nano-roughness nad surface nano-texture resulting fron patterning processes: A blessing or a curse?", E. Gogolides, V. Constantoudis, G.P. Patsis, A. Tserepi
- "Material and processing impact on thermal propeties of thin resist films for high resolution lithography", J.H. Tortai, S. Marceau, G. Karadimos, N. Vourdas, E. Gogolides, I. Raptis, K. van Werden
- 7. "Alternative micro-hotplate design for low power sensor arrays", R. Triantafyllopoulou, S. Chatzandroulis, C. Tsamis, A. Tserepi
- "Simulation of deep etching of silicon structures for MEMS fabrication", G. Kokkoris, P. Papassimakis, E. Gogolides, and A. Tserepi, International Conference on micro and nano-Engineering (MNE) 2005, Vienna, Austria, September 19-22.

Presentations in ISNM 2005:

- "Effects of model polymer chain architectures on the self-affine-characteristics of dissolving photopolymer films", G.P. Patsis, N. Tsikrikas, E. Gogolides
 "Combined Metrology and Simulation of imprinted photopolymer lines/ spaces. Extraction of Line-
- 10. "Combined Metrology and Simulation of imprinted photopolymer lines/ spaces. Extraction of Line-Edge roughnessdescriptors", G.P. Patsis, N. Tsikrikas, V. Constantoudis, E. Gogolides
- 11. "Mechanisms of Nano-Roughness Formation on Plasma Etched surfaces", V. Constantoudis, A. Tserepi, G. Boulousis, P. Papasimakis, E. Gogolides,
- 12. "Design of PDMS surfaces with controlled nano-texturing and wettability", A. Tserepi, K. Tsougeni, G. Boulousis, V. Constantoudis, E. Gogolides

Presentations in SPIE 2005:

13. "Characterization and Modeling of Line Width Roughness (LWR)", V. Constantoudis, E. Gogolides, J.K. Stowers and J. Roberts,

Presentations in CIP (15th International Colloqium on Plasma Processes) 2005

- "Simulation of deep reactive ion etching of silicon (Bosch process)", G. Kokkoris, P. Papassimakis, E. Gogolides, and A. Tserepi, 15th International Colloquium on Plasma Processes (CIP 05), Grenoble, France, June 6 – 9, 2005.
- "Mechanisms of roughness formation during plasma etching", V. Constantoudis, G. Kokkoris, A. Tserepi, and E. Gogolides, 15th International Colloquium on Plasma Processes (CIP 05), Grenoble, France, June 6 – 9, 2005.

Presentations in ISPC 2005:

 "Plasma Etching Fabrication Of Pmma-Based Microfluidic Devices For Bioanalytical Applications", N. Vourdas, A. Tsougeni, A. Tserepi, A.G. Boudouvis and E. Gogolides, S. Tragoulias, T.K. Christopoulos, In Proceedings of 17th International Symposium on Plasma Chemistry (ISPC) (CD), Toronto-Canada, August 7-11, 2005, R. D' Agostino et al, Eds.

Presentations in 2nd Panhellenic Conference on Plastics (in greek):

- 17. "Plasma Treatment Of Polymers For Bioanalytics", (in greek) N. Vourdas, A. Tserepi, M. Vlachopoulou, E.Gogolides, In Proceedings of 2nd Panhellenic Conference on Plastics (CD-version), Athens, 20-21 March, 2005, K. Papaspyrides et al. Eds.
- "New Nanocomposite materials. Thermomechanical characterization and morphology studies after O2 plasma treatment", (in greek) S.I. Marras, I. Zoubourtikoudis, N. Vourdas, V. Constandoudis, A. Tserepi, E. Gogolides, C. Panagiotou, In Proceedings of 2nd Panhellenic Conference on Plastics (CD-version), Athens, 20-21 March, 2005, K. Papaspyrides et al. Eds.

Presentation in "Dynamics Days Conference" Berlin, July 2005.

- 19. "Fractal structures in nanoelectronics", V. Constantoudis, G.P. Patsis, A.Tserepi, K.Tsougeni, G.Boulousis, E.Valamontes and E. Goggolides
- Presentation in XXI Panhellenic Conference on Solid State Physics and Material Science

 "Mechanisms of roughness formation during plasma etching ", V. Constantoudis, A. Tserepi, G. Boulousis, P. Papasimakis and E. Gogolides, XXI Panhellenic Conference on Solid Physics and Material Science, Nicosia, August 2005

Presentation in 1st Panhellenic Conference on Metrology

21. "Nanoscale Roughness measurements", V. Constantoudis, G. Patsis, E. Gogolides, 1st Panhellenic Conference on Metrology, Athens, November 2005

Ph. D. theses

1. "Integrated simulation of topography evolution during plasma etching of micro and nanostructrures", Kokkoris George

M. Sc theses

- 1. "Selective deposition of fluorocarbon films and application in protein arrays", Matrozos Evrymahos
- 2. "Fabrication and simulation of microstructures by plasma processing", Papassimakis Panagiotis
- 3. "Modification of PDMS surfaces in O2-based plasmas", Tsougeni Ekaterene

Diploma theses

- 1. "Study of the lithographic process of wet silylation of epoxy polymers with emphasis in the effect of humidity", Kontziabassis D.
- "Fabrication technologies for plastic bio-microsystems", Bey Pierre, (Academic Industrial Training (9 months) for the Diplome Universitaire d' Etudes Technologiques Internationalles-IUT 1 Universite Joseph Fourier)

Laboratory Training

 Summer School "Methods in Micro-Nano Technologyand Nanobiotechnology", 6-10 June 2005 Laboratory courses: "Microfluidics with soft lithography" (A. Tserepi, M. Vlachopoulou) "Microfluidics with Plasma Etching" (E. Gogolides, N. Vourdas)

Patents granted

- 1. "Polycarbocyclic derivatives for modification of resist, optical and etch resistance properties" (E. Gogolides, P. Argitis, E. Kouladouros-PCT/EP/02/12284)
- 2. "Lithographic materials based on polymers containing polyhedraloligomeric silsesquioxanes" (E. Gogolides, P. Argitis, -PCT/Gr03/0018)

Patent applications

- 1. "Molecular resists based on polyarbocycles" (P. Argitis, E. Gogolides, E. Kouladouros-appl. no 20050100472/16.9.2005)
- "Method for the fabrication of surfaces of high surface area ratio on polymer/ plastic substrates" (A. Tserepi, E. Gogolides, K. Misiakos-appl. no 20050100473/16.9.2005)