Project I. 2

LITHOGRAPHY and PLASMA PROCESSES

Project Leader: E. Gogolides

Key Researchers: E. Gogolides, A. Tserepi

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

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

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

Projects Running:

- 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
- Contract with the company INTEL- MoleEUV, 1/5/2003-30/4/2006
- EU NMP2 STREP Nanoplasma, Contract No 016424 , 1/4/2006-31/3/2009
- GSRT, PENED 03 ED 202, 1/12/2005-31/11/2008

Objectives:

Our work in nanopatterning focuses both on lithography and etching / processing: For lithography we focused on predicting the process and material effects on Line Edge Roughness (LER) and on nano transistor operation. We have proven for the first time that not only the sigma value of LER, but also the correlation length greatly impacts the device operation. Thus, small diffusion lengths during baking processes, and molecular photoresists are recommended. A demo of our LER measurement software is online on our site, while our molecular stochastic lithography simulator is steadily progressing.

For plasma process nanopatterning / nanotexturing we are studying nanotexturing of Si, and polymers. Our results for PDMS, and PMMA polymers have shown impressive high aspect ratio plasma induced nanotexture, and creation of superhydrophobic surfaces within 1 min of plasma processing. A PCT patent was filed, and two publications in Nanotechnology have appeared. Nanotexturing is being studied both by continuum and Monte Carlo models developed in our group. The continuum approach tries bring our level set based profile simulation algorithms to the nanoscale. Our level set based profile simulator will be available as demo software on our site within 2007.

This year a new plasma based nanotechnology project was initiated. The NANOPLASMA project funded by EU brings together plasma equipment industry, research and academia to design a feedback controlled next generation plasma etcher, capable of controlling the etch rate, profile evolution, and nanotexture / nanoroughness formation. The role of our group is to provide fast zero dimensional gas and surface kinetics modules, and to study the nanotexturing-nanoroughness formation.

Microfluidics fabrication and actuation has consumed significant effort. We are proposing an alternative technology for microfluidics patterned on polymeric substrates using plasma etching and plasma functionalisation. First results have been achieved on PMMA. Within less than half an hour processing in our ICP etcher we fabricate rectangular 20micron deep channels in polymers such as PMMA, and we are evaluating them for capillary electrophoresis. First results are available this year and demonstrate the viability of this mass production amenable technology.

RESEARCH RESULTS

A. Nanopatterning: Metrology, simulation and impact on nano-transistor performance of Line Edge Roughness (LER, LWR)

a_1 Effect of LER on nano transistor performance: a metrological point of view

V. Constantoudis, G. Patsis, E. Gogolides

From the metrological analysis of LER in previous years, we have concluded that the characterization of LER demands the determination of three parameters : a) the r.m.s. value R_q measured at infinite line length, b) the correlation length ξ and c) the roughness exponent α. (see Demo Software, http://www.imel.demokritos.gr/software.html). This year, the aim has been to determine the impact of these LWR parameters on transistor electrical operation and to connect material and process parameters with these effects. To this end, we have examined first the impact of LWR on threshold voltage shifts by using model lines with fractal self-affine characteristics for the simulation of transistor gate morphology. It has been found that for resist lines or transistor gates with constant sigma LWR σ_{LWR}, the decrease of spatial LWR parameters (correlation length ξ and roughness exponent α) leads to smaller deviations from the designed electrical transistor performance (see figure I.2.1). Second, the effects of photoresist polymer length and acid diffusion length on LWR parameters and transistor performance are investigated. Through the application of the simulator of the lithographic process described in the next sub-task, it has been shown that photoresists with small polymer chains and small acid diffusion lengths form lines with low LWR parameters (r.m.s. LWR σ_{LWR}, ξ ,α) and thus lead to transistors with more reliable electrical performance. We also found that CD variation has more drastic effects on threshold voltage shift than LWR.

a_2 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 (a) 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, 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.2.2)

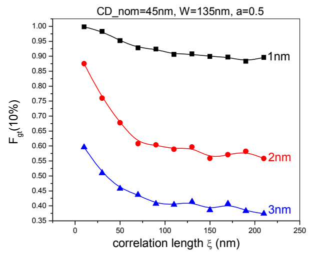


Fig. I.2.1:

Fraction of reliable transistors (yield) F_{gt} vs correlation length for LER 1sigma=1,2 and 3nm. Notice the dramatic effect on yield of both sigma value and correlation length.

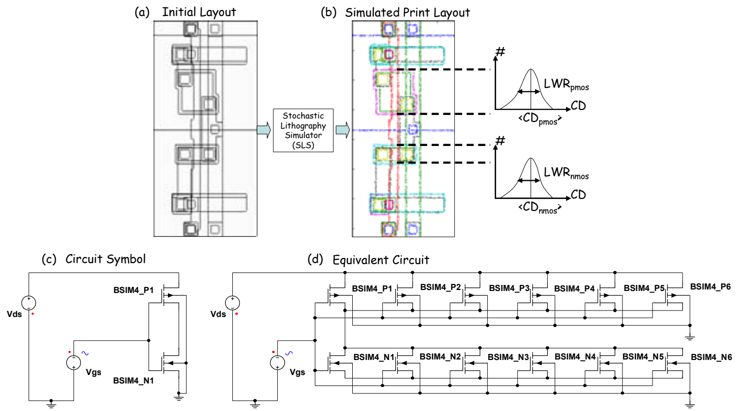


Fig. I.2.2:
(a) Drawn layout of CMOS inverter. (b). Simulated layout with the proposed methodology, and determination of the transistor gate length distributions. (c) Standard device level description of the the CMOS inverter. (d). Proposed CMOS inverter description where the sub-devices have properties determined by the gate length distributions determined in (b).

B. Microfluidics fabrication and actuation using plasma processes

b1 <u>Plasma etching for fabrication of PMMA Microfluidic devices</u>

N. Vourdas, K. Kontakis, K. Tsougeni, E. Gogolides

The fabrication of microfluidic devices with features of 10-1000 μm 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).

We propose an alternative method for fabrication of microfluidic devices based on direct O_2 plasma etching of polymers -PMMA in particular- using photosensitive Si-containing polymeric mask (poly-dimethylsiloxane-PDMS). Surface roughness characteristics are controlled by means of plasma parameter tuning. Electroosmotic flow (EOF) measurements are conducted to validate the functionality of our devices. Electrokinetic parameters found to be greatly influenced from the time after the fabrication of the device (recovery phenomena).

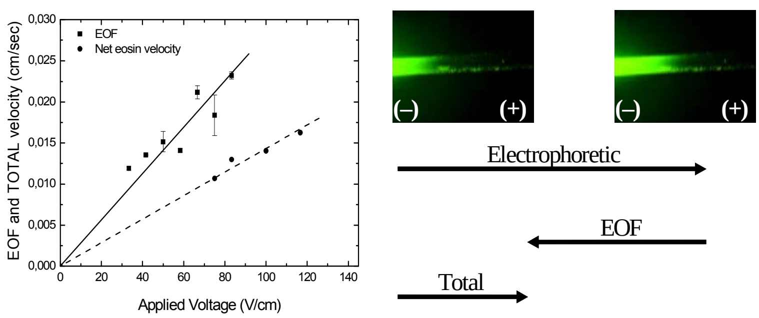


Fig. I.2.3: *(Left) EOF and net Eosin velocities against applied voltage (Right) Snapshot from the fluorescence microscope monitoring the negatively charged Eosin transport in an aged device. EOF mobility is lower than the electrophoretic, causing the Eosin to move towards the anode.*

b2 <u>Fabrication technologies for microfluidic devices based on soft lithography and novel bonding techniques</u>

M. Vlachopoulou, A. Malenou, A. Tserepi, K. Misiakos

We have adopted the process of replica molding (soft lithography) based on the lithography of SU(8) (mold fabrication) for the rapid prototyping of PDMS-based microfluidic devices. Open PDMS channels have been fabricated by this technique and are sealed using O_2 plasma activation for bonding PDMS channels on PDMS or glass, as shown in Fig.I.2.4 below. We have developed a novel process using a combination of O_2 plasma activation and surface functionalization with APTES for irreversibly bonding channels fabricated in PDMS on a

PMMA cover plate, as shown in Fig.I.2.5, or bonding PDMS with Polysterene, and SU8. This novel process is also useful for irreversible bonding of PMMA with PMMA, using a thin flat piece of PDMS as intermediate layer, as well as for improving the adhesion of a PDMS spin-coated film on a PMMA sheet. The same process can be used for the irreversible bonding of PMMA with Si and glass, without using a flexible intermediate layer; it is thus suitable for a wide range of materials. A variety of devices have been fabricated with the above process. The closed channels shown in Fig. I.2.4 are appropriate for capillary electrophoresis experiments, while in Fig. I.2.6 a PDMS-based gas chromatography microcolumn is shown, which combined with a gas sensor enhances the resolution of gas detection on the sensor.

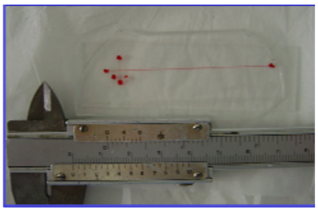


Fig. I.2.4: *75μm deep PDMS microchannel fabricated with soft lithography & irreversibly bonded on a glass substrate, appropriate for capillary electrophoresis experiments.*

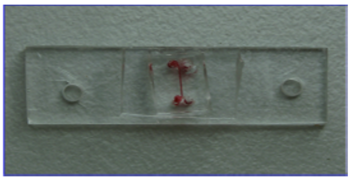


Fig. I.2.5: *100 μm deep PDMS microchannels fabricated with soft lithography and irreversibly bonded on a PMMA plate*

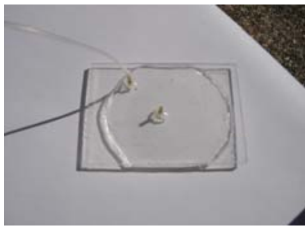


Fig. I.2.6: *Chromatography microcolumn fabricated in PDMS with soft lithography and irreversibly bonded on spin-coated PDMS spin-film, well-adhered on a PMMA plate used for mechanical support of the fluidic interconnects*

b_3 Plasma deposited films for electrowetting-based actuation in microfluidics

P. Bayiati, A. Tserepi, K. Misiakos

Our work in the use of plasma-deposited fluorocarbon films started a few years back for application in electrowetting-based actuation in microfluidics. Droplet-based microfluidics, or "digital" microfluidics, is a fascinating emerging field, promising to offer an enabling technology for manipulating micro- to pico-liter sample volumes, and an expanding spectrum of potential applications in drug discovery, diagnostics and health care. Although several actuation methods have been employed so far, electrowetting on dielectric (EWOD) seems to be very promising. In the present work, optimized fluorocarbon films were deposited in C_4F_8 plasma on Si_3N_4 (for improvement of dielectric properties) and electrowetting experiments were conducted using protein solutions. Such hydrophobic films show high contact angle modulation upon voltage application, good contact angle reversibility upon voltage removal and negligible protein adsorption, all independent of pH and concentration of protein solutions, and applied voltage polarity. Thus, plasma deposited fluorocarbon films, have certain advantages compared to spin-coated commercial films (thickness homogeneity across the covered surface and good adhesion to the substrate) could replace the latter materials used routinely in electrowetting-based applications. Ultimately, fluid transport was demonstrated on an open microfluidic device fabricated using plasma deposited hydrophobic fluorocarbon films of optimized properties.

C. Plasma nanostructuring-nanotexturing of polymers and silicon

c_1 Design and Control of Surface Wetting properties of PDMS by plasma processing and casting solvents

M. Vlachopoulou, A. Tserepi, K. Beltsios, E. Gogolides

Polydimethyl-siloxane (PDMS) is a material widely used as a structural material of microfluidic devices. Control of the surface topography and the resulting wetting properties has been achieved using SF_6 plasma treatment. The dependence of PDMS surface topography on processing parameters is investigated and specifically on the casting solvents used for the preparation of PDMS samples. For the first time is demonstrated that chain packing arrangement can affect the topography of PDMS under plasma-based nanostructuring of its surface and controlled variation of surface roughness and column spacing is achieved. In

Fig.I.2.7 the monotonic dependence of the PDMS etch rate on the solvent quality is presented and the effect of relaxation of polymeric chains is shown as samples are refrigerated at -20^{0}C, while in Fig.I.2.7.b the height of nano-columns seems to be monotonically dependent on the solvent quality, for samples with fixed film thickness. Consequently, the quality of casting solvents is found to affect in a controlled way the PDMS nanostructuring.

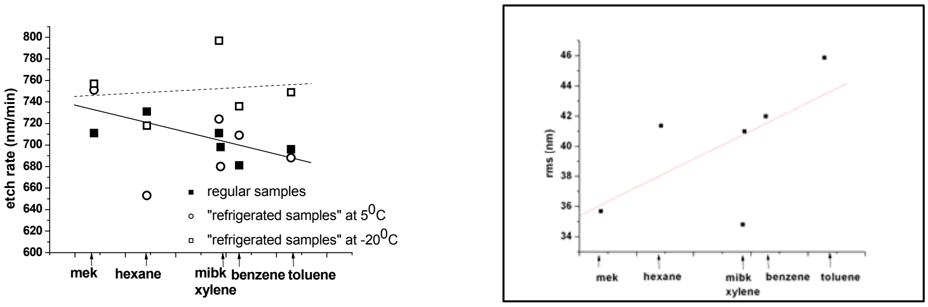


***Fig. I.2.7**: Monotonic dependence of the PDMS etch rate and of the height of nanocolumns created in SF_6 plasma on the casting solvent quality.*

c$_2$ <u>Design and Control of Surface Wetting properties of PMMA by plasma processing</u>

N. Vourdas, A. Tserepi, E. Gogolides

Wettability control of polymers is of great importance in many industrial and scientific areas; from manufacturing of water repellent surfaces to droplet frictionless motion in microfluidics, and biocompatibility tuning. Wetting or repellent behavior is governed by both surface chemistry and topography. In particular, super-hydrophobicity (SH) is attained by combining low surface energy coatings and high-aspect-ratio (HAR) geometrical characteristics. In this study we proposed a novel, simple, generic and fast technique to fabricate stable SH, yet transparent poly(methyl methacrylate) (PMMA) surfaces by means of high-density plasma etching and deposition. Similar method has been already utilized to produce SH poly(dimethyl methacrylate) (PDMS) by our group (see above) .

Our Inductively Coupled source is used to generate cold plasma within a low-pressure reactor which is used to treat the PMMA surfaces. First oxygen based plasma is applied to etch the surface and create surface roughness. The time of the process may differ from 1 min to several min depending on the roughness amplitude and on the degree of transparency desired. After this first step the gas chemistry is altered into a fluorocarbon one which leads to a Teflon-like deposition and controlling thus the surface chemistry. Following this process SH surfaces are produced, which attain water contact angle: ~150^o, with low hysteresis: <10^o.

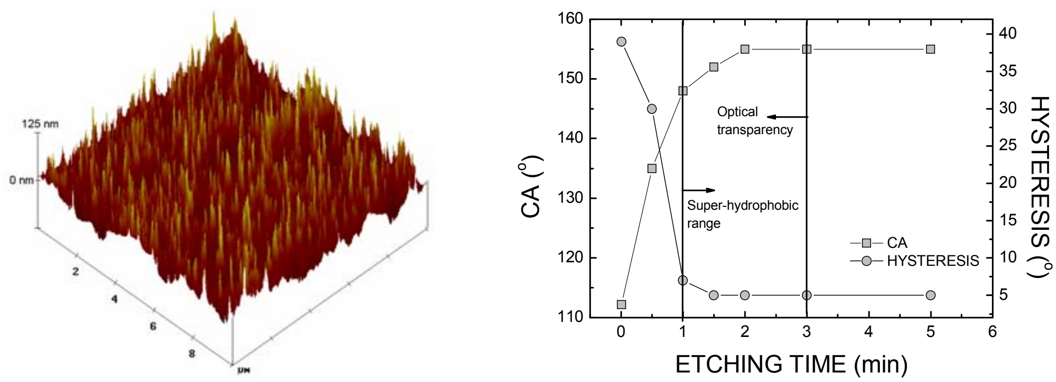


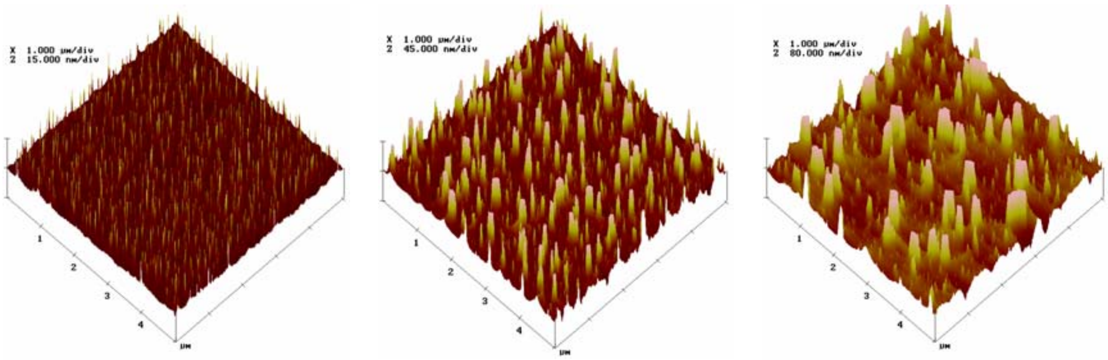
***Fig. I.2.8:** AFM image of the 1 min Oxygen plasma treated PMMA surface. (right) Contact angle (CA) and CA-hysteresis of plasma treated PMMA surfaces vs. Oxygen plasma treatment time (after Teflon coating).*

c_3 Dual scale Nanoroughness formation on silicon surfaces using SF6 plasma etching

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

The primary target of this work is the control and understanding of roughness, which is created in a silicon substrate after fluorine based plasma-etching process, targeting smooth Microsystems fabrication or deep trench isolation etching. Roughness evolution is studied as as a function of etch-time, temperature, wall reactor condition and intentionally introducing depositing gases in the plasma.

Roughness is studied with AFM and scaling analysis of the AFM image is done. We find that roughness always increased with time, and the fraction rms/etch-depth remains below 0.1 %. It is observed that the etched silicon surfaces show dual scale topography namely an underlying nanoroughness with superimposed nanoneedles (nanograss, nanopillars). Scaling Analysis of the AFM images using Height-Height correlation functions and Fast Fourier Transforms (software developed in house) provide the periodicity of surface λ (related to the period of underlying nanoroughness structure), the correlation length ξ (related to the nanoneedle diameter) and the component of roughness of each surface. It is found that all these components increase linearly with time resulting in coarser and larger pillars and valleys as time progresses.



a) b) c)

Fig. I.2.9: *AFM images of SF_6 plasma etched silicon substrates for a) 1min with $rms_{u.s.}$=0.9549 nm, $rms_{needles}$=0.3010 nm, etch depth=5.4 μm, rms/E.D.=2.08 x 10^{-4}, peak to peak=22.169 nm, b) 4 min with $rms_{u.s.}$=6.8414 nm, $rms_{needles}$=3.4354 nm, etch depth=21.2 μm, rms/E.D.=4.31 x 10^{-4}, peak to peak=113.97 nm, c), 8 min with $rms_{u.s.}$=14.4736 nm $rms_{needles}$=9.2828 nm, etch depth=38.7 μm, rms/E.D.=5.37 x 10^{-4}, peak to peak=278.80 nm.*

D. Simulation of micro and nano-structuring evolution from plasma processes

d_1 Nanoscale topography evolution using continuum models

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

A robust framework for the simulation of topography evolution of rough curves (2d) and surfaces (3d) has been developed. It is based on the level set method and is applied in the simulation of profile evolution in the nano-scale. Rough surfaces (and curves) which usually result from nano-fabrication processes, both periodic and self-affine, evolve under plasma etching (low sticking coefficient conditions) or under wet etching. The evolution of root mean square (rms) roughness, correlation length (ξ) and roughness exponent (α) is studied. The surface roughness is shown to decrease under etching through a cusp formation mechanism. The effect of etching mechanisms (isotopic, anisotropic) on the topography evolution is investigated. Comparison with Monte Carlo Simulation (see below) is done.

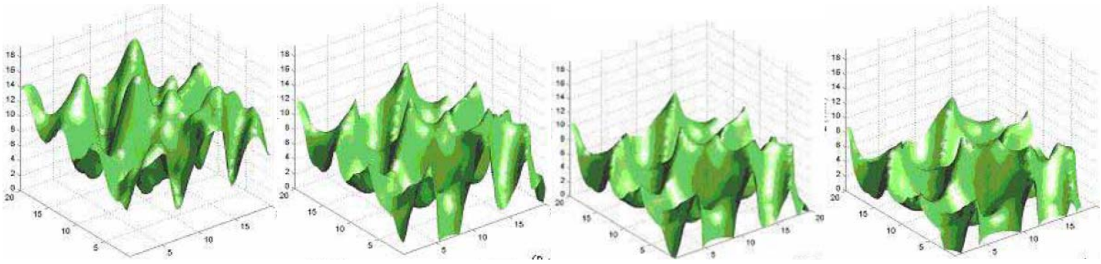


Fig. I.2.10: *The evolution of a rough surface under plasma etching (50% isotropic + 50% anisotropic)*

d_2 Stochastic simulation of roughness evolution of homogeneous and composite materials during plasma etching

A kinetic Monte Carlo simulator of the roughness formation on surfaces of films during their plasma etching has been developed. This simulator can consider etching by neutral etchants and ions. It can also include the simultaneous deposition of etch resistant particles (inhibitors). Multiple reemissions of neutrals and/or inhibitors are taken into account. It has been found that the combination of inhibitor deposition and neutral reemission may lead to the formation of surface roughness with dual scale features in agreement with experimental results.

We also examined roughness formation on composite materials. In the case of composite material sputtering, it has been shown that even tiny correlations in the phase material distributions increase significantly the growth rate of surface roughness. Whereas, in chemical etching, the roughness growth is slower and depends on the etch selectivity of the two phases in the film as well as their relative volume fractions. Also, an interesting transition from anomalous to normal scaling behavior has been observed in surface roughness as etching proceeds for large values of selectivity.

Finally the roughness reduction of initially rough surfaces of homogeneous films induced by chemical etching has been simulated. It has been found that surfaces with lower correlation length and wavelength “lose” their roughness faster than those with larger spatial features. Further, the rate of roughness reduction decreases with the fractal dimension of initial surface. Comparing with the continuum simulation results of wet etching (see above), we reached the conclusion that wet etching leads to faster reduction of periodic surfaces whereas the opposite is true for fractal self-affine surfaces.

PROJECT OUTPUT in 2006

Publications in International Journals

1. “Plasma oxidation of polyhedral oligomeric silsesquioxane polymers”, Eon, D., Raballand, V., Cartry, G., Cardinaud, C., Vourdas, N., Argitis, P., Gogolides, E., Journal of Vacuum Science and Technology B: Microelectronics and Nanometer Structures 24 (6), pp. 2678-2688, 2006
2. “Multiwavelength interferometry and competing optical methods for the thermal probing of thin polymeric films”, Vourdas, N., Karadimos, G., Goustouridis, D., Gogolides, E., Boudouvis, A.G., Tortai, J.-H., Beltsios, K., Raptis, I., 2006 Journal of Applied Polymer Science 102 (5), pp. 4764-4774, 2006
3. “Integrated framework for the flux calculation of neutral species inside trenches and holes during plasma etching”, Kokkoris, G., Boudouvis, A.G., Gogolides, E., Journal of Vacuum Science and Technology A: Vacuum, Surfaces and Films 24 (6), art. no. 006606JVA, pp. 2008-2020, 2006
4. “Partially fluorinated, polyhedral oligomeric silsesquioxane-functionalized (meth)acrylate resists for 193 nm bilayer lithography”, Douvas, A.M., Van Roey, F., Goethals, M., Papadokostaki, K.G., Yannakopoulou, K., Niakoula, D., Gogolides, E., Argitis, P., Chemistry of Materials 18 (17), pp. 4040-4048, 2006
5. “Nanotexturing of poly(dimethylsiloxane) in plasmas for creating robust super-hydrophobic surfaces”, Tserepi, A.D., Vlachopoulou, M.-E., Gogolides, E., Nanotechnology 17 (15), art. no. 062, pp. 3977-3983, 2006
6. “Thickness-dependent glass transition temperature of thin resist films for high resolution lithography”, Marceau, S., Tortai, J.-H., Tillier, J., Vourdas, N., Gogolides, E., Raptis, I., Beltsios, K., van Werden, K., Microelectronic Engineering 83 (4-9 SPEC. ISS.), pp. 1073-1077, 2006
7. “Effects of model polymer chain architectures and molecular weight of conventional and chemically amplified photoresists on line-edge roughness. Stochastic simulations”, Patsis, G.P., Gogolides, E., Microelectronic Engineering 83 (4-9 SPEC. ISS.), pp. 1078-1081, 2006
8. “Monolithic silicon optoelectronic transducers and elastomeric fluidic modules for bio-spotting and bio-assay experiments”, Misiakos, K., Petrou, P.S., Kakabakos, S.E., Vlahopoulou, M.E., Tserepi, A., Gogolides, E., Ruf, H.H., Microelectronic Engineering 83 (4-9 SPEC. ISS.), pp. 1605-1608, 2006
9. “A review of line edge roughness and surface nanotexture resulting from patterning processes”, Gogolides, E., Constantoudis, V., Patsis, G.P., Tserepi, A., Microelectronic Engineering 83 (4-9 SPEC. ISS.), pp. 1067-1072, 2006
10. “Alternative micro-hotplate design for low power sensor arrays”, Triantafyllopoulou, R., Chatzandroulis, S., Tsamis, C., Tserepi, A., Microelectronic Engineering 83 (4-9 SPEC. ISS.), pp. 1189-1191
11. “Hyperacceleration in a Stochastic Fermi-Ulam Model”, A. K. Karlis, P. K. Papachristou, F. K. Diakonos, V. Constantoudis and P. Schmelcher, Phys. Rev. Lett. 97, 194102 (2006)

Publications in International Conference Proceedings

1. “Modeling of Roughness Evolution and Instability during Si Plasma Etching”, P. Angelikopoulos, V. Constantoudis, G.Kokkoris, G. Mpoulousis, P. Xidi, E. Gogolides, 53rd AVS Symposium, San Francisco, PS2-ThA3, p. 167, November 12-17, 2006
2. “Super-hydrophobic transparent polymer surfaces fabricated by plasma etching and deposition”, N. Vourdas, M.-E. Vlachopoulou A. Tserepi, E. Gogolides, 53rd AVS Symposium, San Francisco, PS2-ThM7, p. 149, November 12-17, 2006
3. “Electroweting-based fluidic transport on hydrophobic fluorocarbon films deposited in plasma”, P. Bayiati, A. Tserepi, P. S. Petrou, K. Misiakos, S. E. Kakabakos, E. Gogolides, 5th International Electrowetting Meeting, University of Rochester, New York, USA, p. 15, 31 May- 2 June 2006
4. “Biofluid transport on hydrophobic plasma deposited fluorocarbon films”, P. Bayiati, A. Tserepi, P. S. Petrou, S. E. Kakabakos, K. Misiakos, E. Gogolides, C. Cardinaud, 32nd International Conference on Micro- and Nano-Engineering, Barcelona, p. 113, Spain, 17-20 September 2006
5. “Photosensitive Poly-dimethylsiloxane (PDMS) materials for Microfluidic Applications”, K. Tsougeni,A. Tserepi, E. Gogolides, 32nd International conference of Micro- and Nano- Engineering, Barcelona Spain, p. 797, Sept. 2006
6. “A novel process for irreversible bonding of PDMS and PMMA substrates”, M.E. Vlachopoulou, A. Tserepi, K. Misiakos, 32nd International Micro and Nanoengineering, Sept. 2006, Barcelona Spain, p. 421, Sept. 2006
7. “Nanostructuring of PDMS surfaces: Dependence on casting solvents”, M-E. Vlachopoulou, A. Tserepi, K. Beltsios, G. Boulousis, E. Gogolides, 32nd International Micro and Nanoengineering, Barcelona Spain, p. 635, Sept. 2006
8. “Line-width roughness analysis of EUV resists after development in homogenous CO2 solutions using CO2 compatible salts (CCS) by a three-parameter model”, Constantoudis, V., Gogolides, E., Patsis, G.P., Wagner, M., DeYoung, J., Harbinson, C., SPIE - The International Society for Optical Engineering, 6153 II, art. no. 61533W, 2006

9. “Integrated simulation of Line-Edge Roughness (LER) effects on Sub-65 nm transistor operation: From lithography simulation, to LER metrology, to device operation”, Patsis, G.P., Constantoudis, V., Gogolides, E., Proceedings of SPIE - The International Society for Optical Engineering, 6151 II, art. no. 61513J, Cited 1 time, 2006
10. “Monolithic silicon optoelectronic devices for protein and DNA detection”, Misiakos, K., Petrou, P., Kakabakos, S.E., Vlachopoulou, M., Tserepi, A., Gogolides, E., Proceedings of SPIE - The International Society for Optical Engineering, 6125, art. no. 61250W, 2006

Conference Presentations

1. “Anomalous scaling behaviour in the kinetic roughening of etched surfaces”, V. Constantoudis, P. Xydi, G. Kokkoris, H. Zakka, P. Angelikopoulos, G. Boulousis and Evangelos Gogolides, Dynamic Days Conference, Crete, Greece, September 27-29 2006
2. “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, Poster 11th International Conference on Computational Electronics IWCE: 25-27 May 2006, Technical University of Wien Austria
3. “Fabrication of super-hydrophobic, water repellent pmma surfaces by plasma processes”, N. Vourdas, A. Tserepi, E. Gogolides, 6th Panhellenic Conf. on Polymers, ELEP, Patras, Hellas, 3-5.11.06
4. “Thermal characterization of thin supported polymer films via interferometry and spectroscopic ellipsometry”, N. Vourdas, G. Karadimos, D. Goustouridis, E. Gogolides, A.G. Boudouvis, K. Beltsios, I. Raptis, 6th Panhellenic Conference on Polymers, ELEP, Patras, Hellas, 3-5.11.2006
5. “A novel microfabrication technology for plastic sensors formation”, K. Tsougeni , G. Kaltsas, A. Petropoulos, P. Asimakopoulos, D. N. Pagonis, T. Speliotis, E. Gogolides, A.G. Nassiopoulou, XXII Panhellenic Conference of Solid State Physics and Material Science. Patras 24-27 September 2006
6. “Control of Poly(dimethylsiloxane) surface wetting properties from very hydrophilic to super-hydrophobic by tuning surface topography in O_2 plasmas”, K. Tsougeni, A. Tserepi, G. Boulousis, E. Gogolides, 6th Panhellenic Polymer Conference, Patras 3-5 November 2006
7. “Surface Silylation of Epoxidized Polymers for Micromachining Applications”, D. Kontziampasis, K. Beltsios, E. Tegou, E. Gogolides, 6th Panhellenic Polymer Conference, Patras 3-5 November 2006
8. “Stochastic modeling of roughness formation during etching of composite materials”, E. Zakka, V. Constantoudis, E. Gogolides, XXII Panhellenic Conference of Solid State Physics and Material Science. Patras 24-27 September 2006
9. “Polydimethyl Siloxane Microfluidic chip for gas chromatographic separations”, A. Malainou, ME Vlahopoulou, A. Tserepi, S. Chatzandroulis, XXII Panhellenic Conference of Solid State Physics and Material Science. Patras 24-27 September 2006
10. “Metallization using an epoxy resist and lift-off process for microsystem fabrication”, D. Kontziampasis, E. Gogolides, XXII Panhellenic Conference of Solid State Physics and Material Science, Patras, 2006

M. Sc theses

1. “Modeling of the gas phase of oxygen plasma discharges with global zero dimensional models”, P. Geka, NTUA 2006
2. “Plasma etching of composite materials: Stochastic simulation of roughness formation”, E. Zakka, UOA 2006
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