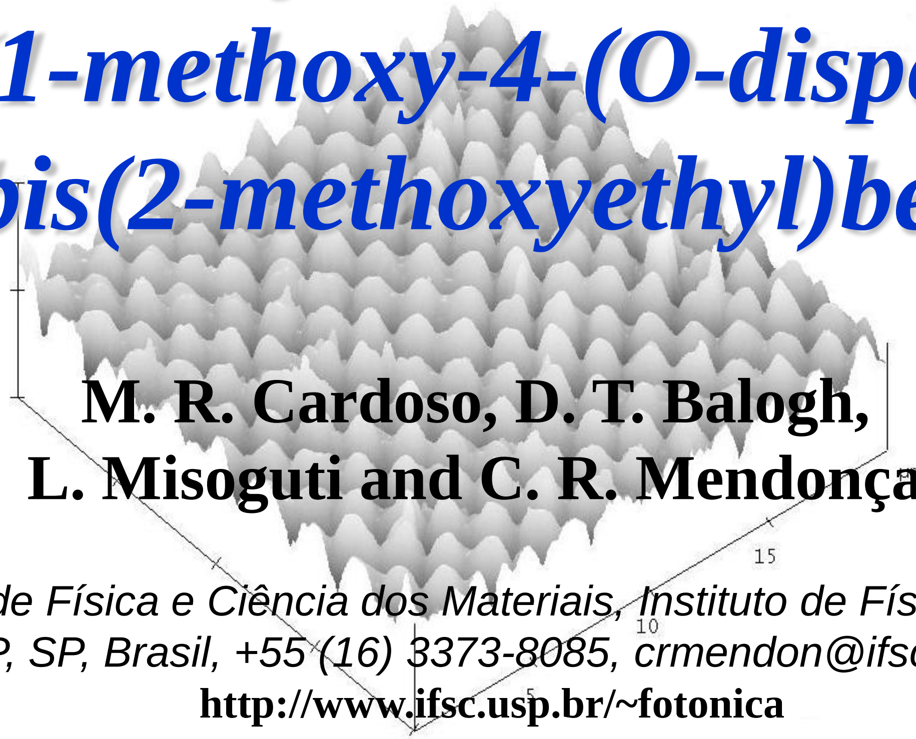
Polymeric Surface Microstructuring on Poly(1-methoxy-4-(O-disperse Red 1)-2,5-bis(2-methoxyethyl)benzene)



M. R. Cardoso, D. T. Balogh,
L. Misoguti and C. R. Mendonça

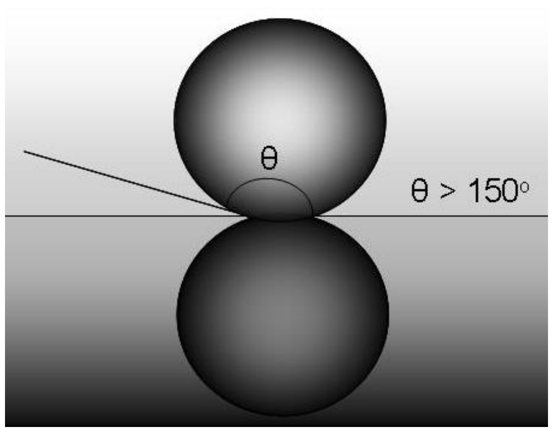
Departamento de Física e Ciência dos Materiais, Instituto de Física de São Carlos / USP, SP, Brasil, +55 (16) 3373-8085, crmendon@ifsc.usp.br

http://www.ifsc.usp.br/~fotonica

Abstract

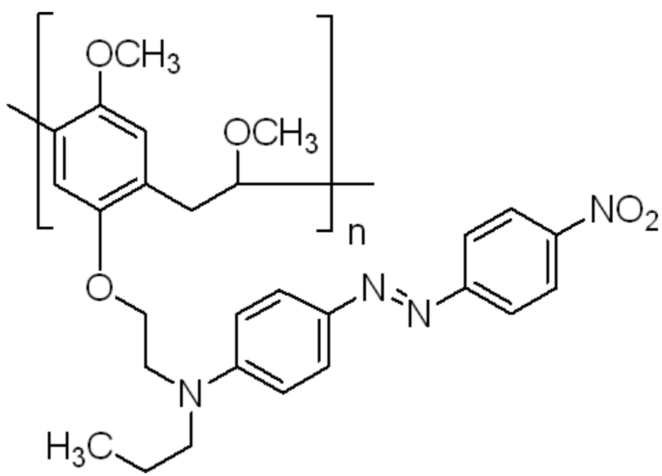
Inspired by the topology of the Lotus leaf, that naturally have a superhydrophobic surface, we used laser light to structuring polymeric surfaces. Thus we present two simple structuring process that uses laser to microstructuring surfaces, with potential applications to fabricate superhydrophobic polymeric surfaces.

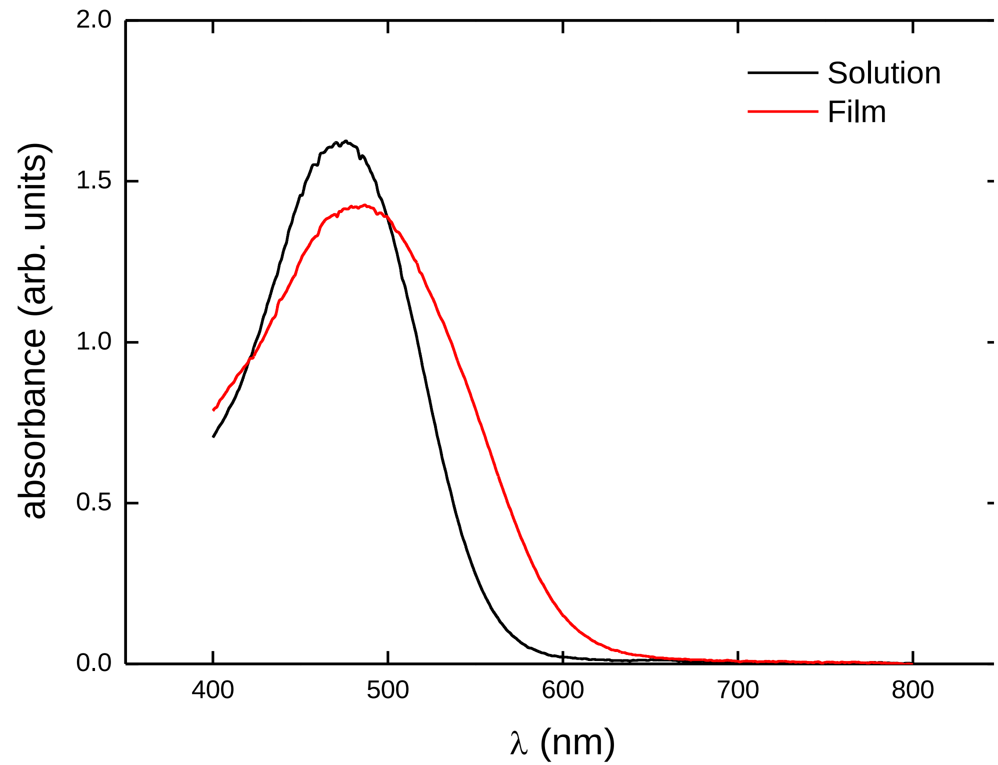
Superhydrophobic surfaces exhibit contact angles with water that are larger than 150º and insignificant hysteresis. This effect, so called Lotus effect, decreases the contact area between the surface and water, reducing contamination and abrasion.



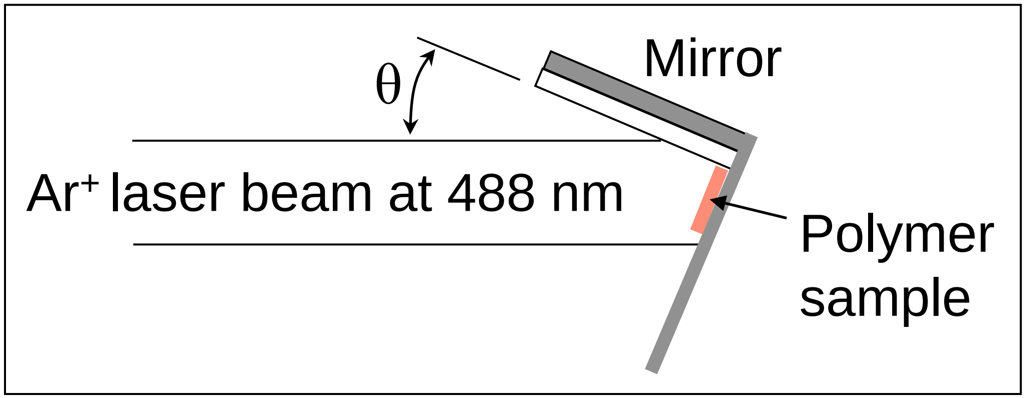
Sample Studied

We used the polymer Poly(1-methoxy-4-(O-disperse Red 1)-2,5-bis(2-methoxyethyl)benzene), whose molecular structure (monomer) is shown below. The UV-Vis absorption spectra of a chloroform solution (black) and film (red) are presented in the figure to the right.





Methodology I

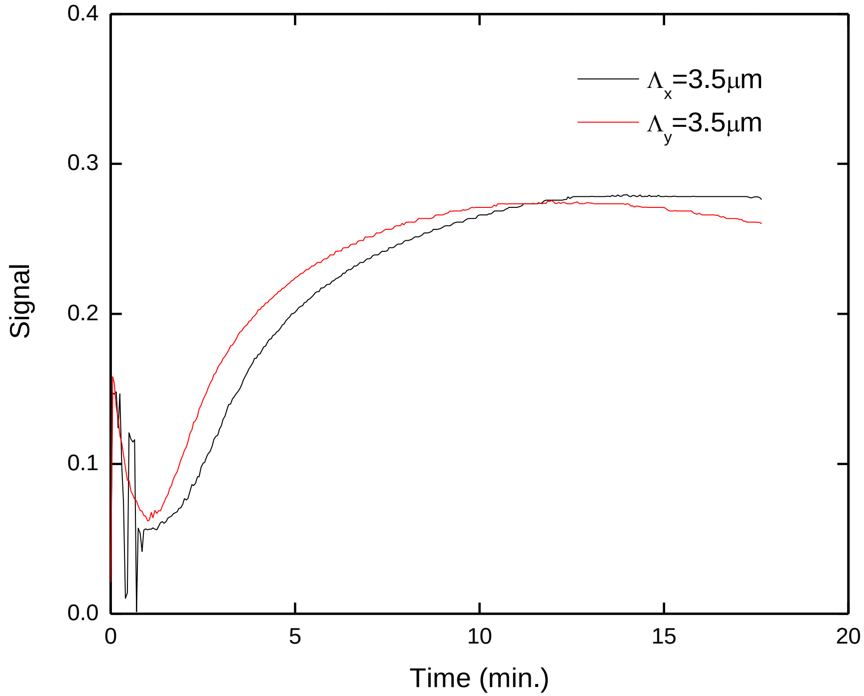


Surface-relief gratings (SRG) are formed when a film of azopolymer is exposed to an laser interference pattern, as a result of large scale molecular migration.

Such gratings are formed due to the interaction of the molecule dipole with the electric field gradient, which results in the movement of the molecule. Besides, the photoinduced *trans-cis-trans* isomerization of the azo chromophores facilitates this movement.

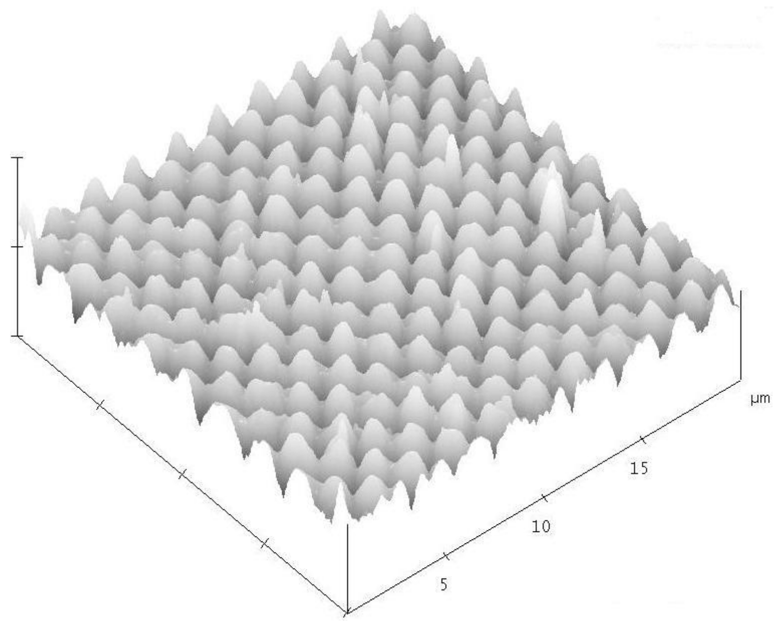
The films were exposed to an interference pattern generated by a linearly p-polarized Argon ion laser at 488 nm, with an irradiance about 70 mW/cm^2 for about 50 min.

Results



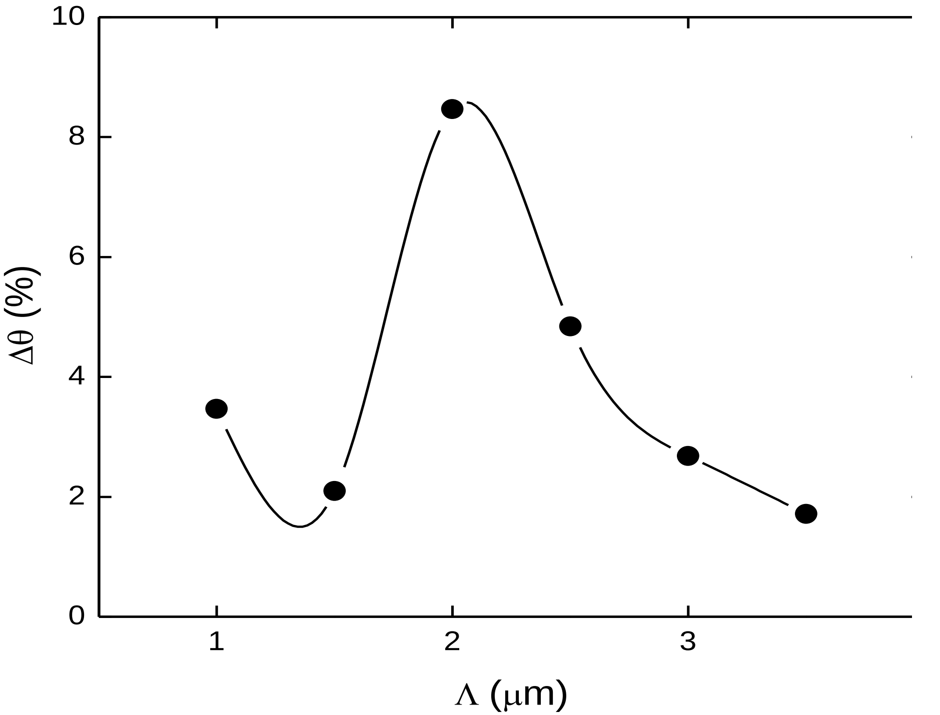
This figure shows the first order diffraction, used to monitor the microstructuring process.

The microstructured surface acquires the shape showed below, where we can observe a topology similar to that of Lotus leaf.



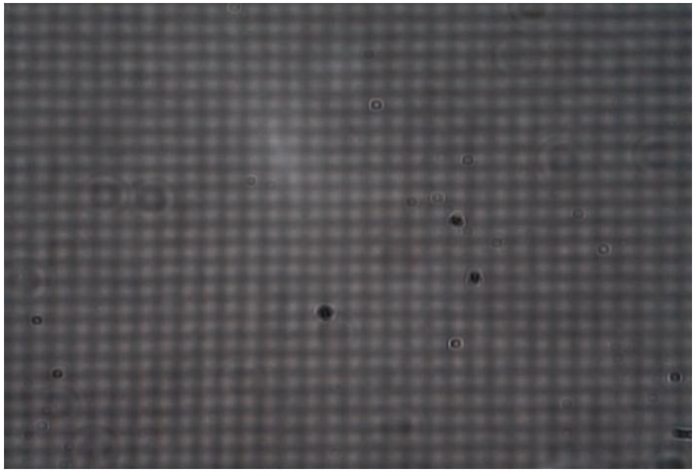
Atomic force microscopy: 3-D topography image of the surface relief gratings on a MDI film.

Results

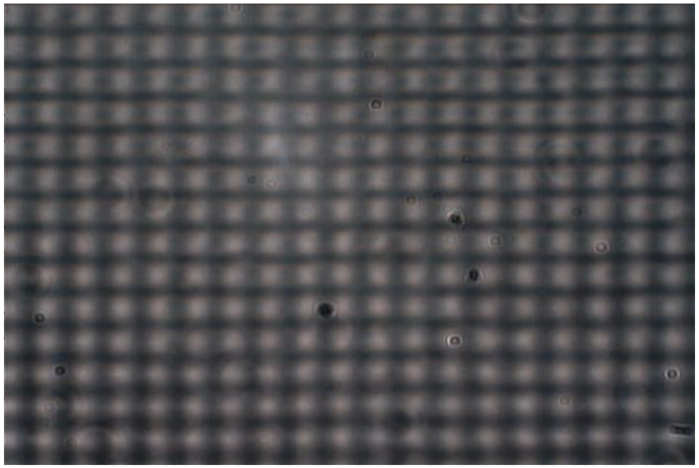


Increase in the contact angle with the period of the microstructuring.

Optical micrographs of the microstructured surfaces



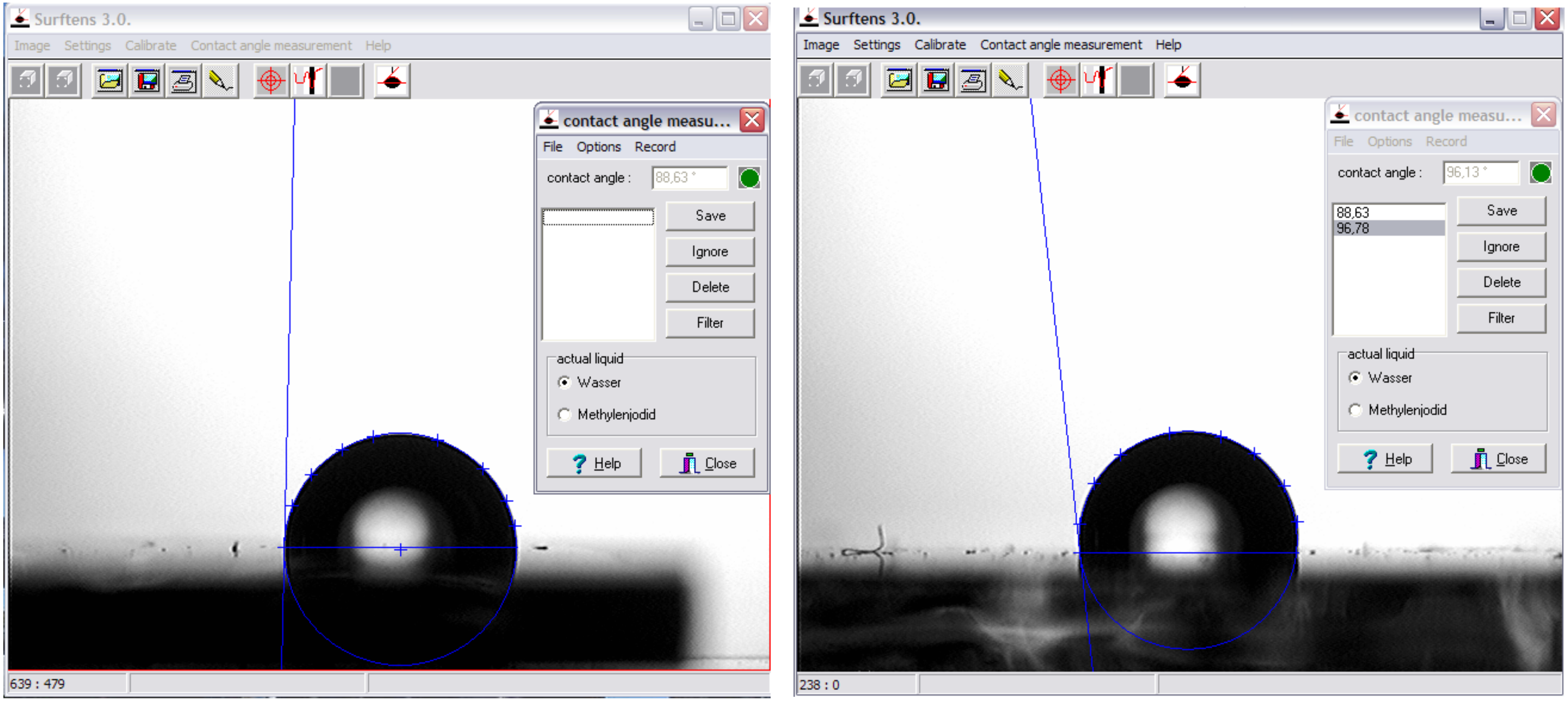
$\Lambda = 2\ \mu m$



$\Lambda = 3.5\ \mu m$

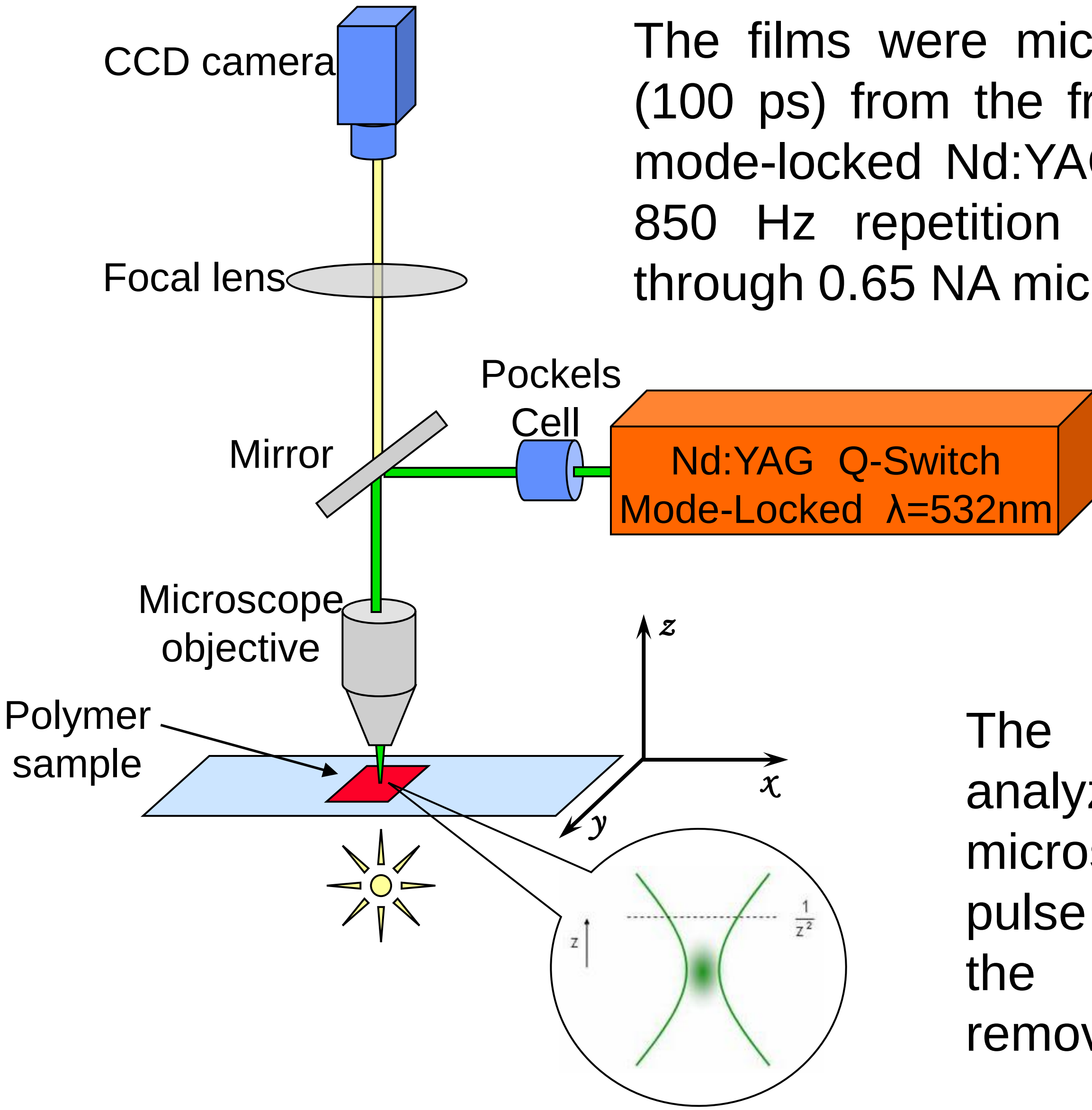
Results

The static contact angle on the flat surface is ~ 89º. In the microstructured surface the contact angle is ~ 97º, which correspond to an increase of about 10%.



Pictures of water droplets on flat (left) and microstructured (right) polymeric surfaces obtained by a horizontal microscope equipped with a goniometer.

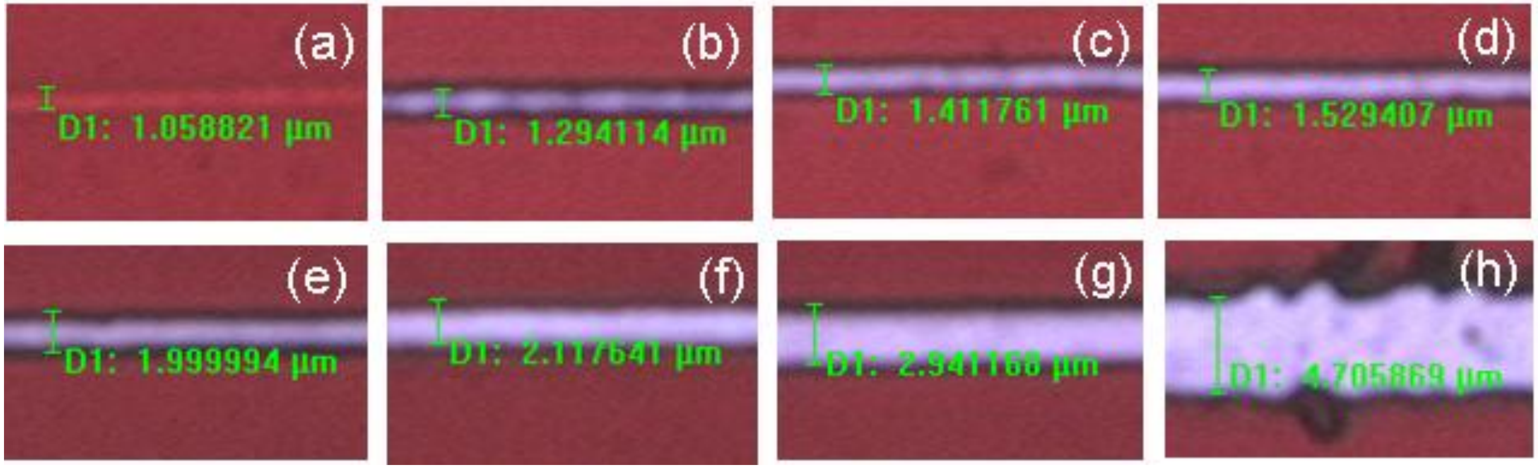
Methodology II



The films were micromachined using a single pulse (100 ps) from the frequency-doubled Q-switched and mode-locked Nd:YAG laser operating at 532 nm at a 850 Hz repetition rate. The pulses were focused through 0.65 NA microscope objective onto the sample surface, which was translated at a constant speed (1mm/s) with respect to the laser beam. The speed was maintained by a computer controlled translation stage.

The micromachined samples were analyzed by transmission optical microscopy to study the influence of pulse energy on film and determining the energy threshold for polymer removal.

Results



(a) E=0.7 µJ
(b) E=1.9 µJ
(c) E=2.6 µJ
(d) E=4.0 µJ
(e) E=6.5 µJ
(f) E=14.7 µJ
(g) E=31.1 µJ
(h) E=130 µJ

This figure shows optical microscope images of microstructures produced in the sample at a translation speed of 1 mm/s and various pulse energies. The transmission of visible light by the micromachined lines clearly increases with the pulse energy. At an energy of 0.7 µJ, the smallest pulse energy employed, little contrast is obtained, whereas at higher pulse energies a much higher contrast is observed. The widths of the microstructured lines varies from 1 to 4.7 µm when the pulse energy is increased from 0.7 to 130 µJ. For a translation speed of 1 mm/s, the threshold energy for inducing visible modification in the sample was measured to be about 0.7 µJ.

Conclusion

We show that it is possible to increase the hydrophobicity of polymeric surfaces by laser microstructuring.

Our initial results revealed an increase of 10% in the contact angle for water in the microstructured surface. The best increase in the contact angle was obtained with a microstructure period of 2 μm.

The results show that the methods presented are good candidates for microstructuring azopolymeric surfaces for this application.

Further work is still needed to improve the surface microstructure, which can lead to a better enhancement in the hydrophobicity.

Acknowledgements

The authors acknowledge FAPESP, CNPq, CAPES and IMMP for financial support, and are grateful to André L. S. Romero for his assistance.

http://www.fotonica.ifsc.usp.br