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Nanofabrication of Laser Induced Periodic Surface Structures on polymer thin films as revealed by Grazing Incidence Small Angle X-ray Scattering

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Formation of laser induced periodic surface structures (LIPSS) has been observed on polymers upon irradiation with linear polarized laser beams at wavelengths efficiently absorbed. LIPSS are the result of the interference between the incoming and the surface-scattered waves which creates an inhomogeneous intensity distribution that by a feedback mechanism results in an enhancement of the structural modification[1]. The use of X-ray scattering techniques with synchrotron radiation can be very useful for LIPSS analysis as they can provide kinetic information in the millisecond range and structural information statistically averaged over a large area of several hundreds of microns. In this presentation we will show the formation of LIPSS on model spin-coated polymer films as followed by in situ Grazing Incidence Small Angle X-ray Scattering (GISAXS) using synchrotron radiation (Fig.1). The samples were irradiated at different repetition rates using a Nd:YAG laser (266 nm) with pulses of 8 ns. Simultaneously GISAXS patterns were acquired during laser irradiation. The variation of both the GISAXS signal with the number of pulses and the LIPSS period with laser irradiation time reveal key aspects of nanostructure development. By considering LIPSS as one-dimensional paracrystalline lattice and using a correlation found between the paracrystalline disorder parameter and the number of reflections observed in the GISAXS patterns, the variation of the structural order of LIPSS can be assessed. The role of the laser repetition rate in the nanostructure formation has been clarified. For high pulse repetition rates (i.e. 10 Hz), LIPSS evolve in time to reach the expected period matching the wavelength of the irradiating laser. For lower pulse repetition rates LIPSS formation is less effective and the period of the ripples never reaches the wavelength value. Results support and provide information on the existence of a feedback mechanism for LIPSS formation in polymer films.

References

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Primary authors: Dr RUEDA, Daniel R. (Instituto de Estructura de la Materia (IEM-CSIC), Serrano 121, 28006 Madrid, Spain.); Dr REBOLLAR, Esther (Instituto de Química Física Rocasolano (IQFR-CSIC), Serrano119, 28006 Madrid, Spain); Dr PORTALE, Giuseppe (DUBBLE@ESRF, N.W.O., CS40220, 38043, Grenoble, Cedex 9, France); Dr MARTÍN-FABIANI, Ignacio (Instituto de Estructura de la Materia (IEM-CSIC), Serrano 121, 28006 Madrid, Spain.); Dr GARCÍA-GUTIÉRREZ, Mari Cruz (Instituto de EStructura de la Materia IEM-CSIC); Dr CASTILLEJO, Marta (Instituto de Química Física Rocasolano (IQFR-CSIC), Serrano119, 28006 Madrid, Spain.); Prof. EZQUERRA, Tiberio (Instituto de Estructura de la Materia, IEM-CSIC); Mr RODRÍGUEZ-RODRÍGUEZ, Álvaro (Instituto de Estructura de la Materia (IEM-CSIC), Serrano 121, 28006 Madrid, Spain.)

Presenter: Prof. EZQUERRA, Tiberio (Instituto de Estructura de la Materia, IEM-CSIC)

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