LIPSS formation by nanosecond laser irradiation of Poly(ethylene terephthalate) and Poly(trimethylene terephthalate) reinforced with carbon-based fillers

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The formation of Laser Induced Periodic Surface Structures (LIPSS) is a process commonly used to nanostructure polymer surfaces [1]. Forming of LIPSS is possible because of the irradiation of the polymer surface with polarized laser pulses at fluences below the ablation threshold. This leads to a modulation of the depth of the surface, resulting from an inhomogeneous intensity distribution, due to the interference between the incoming and the surface-scattered waves, reinforced with a positive feedback process. Such structures have a spatial period close to the laser wavelength, aligned parallel to the polarization of the laser beam.

It has been demonstrated that carbon based compounds, namely Expanded Graphite (EG) [2] and Single Wall Carbon Nanotubes (SWCNT) [3], have become excellent fillers to reinforce polymers as Poly(ethylene terephthalate) (PET) and Poly(trimethylene terephthalate) (PTT) in order to improve some of their properties, for instance, mechanical resistance or electrical conductivity. These polymers are good support materials because they allow homogenous and simple dispersion of the additive in the polymer matrix.

In this work, formation of LIPSS was studied in PET, PET+EG 0.4 wt %, PTT and PTT+SWCNT 0.3 wt % films. Laser irradiation was carried out using a Q-Switched Nd:YAG laser (266 nm, 8 ns, 1-10 Hz). Topography of the irradiated samples was measured by atomic force microscopy (AFM) in tapping mode. Periodical ripples were obtained for the materials studied. We found that the formation of good quality LIPSS depends strongly on the parameters of irradiation. In all cases, ripples have a period close to the irradiation wavelength and were formed parallel to the polarization of the laser beam. In order to monitor the improvement of the properties of the surfaces after irradiation, some characterization techniques were performed in both irradiated and non-irradiated samples. Nanomechanical properties were measured by AFM with the PeakForce Quantitative Nanomechanical Mapping (PF-QNM) method, obtaining maps of elastic modulus and mechanical adhesion resistance. Also, adhesion measurements were performed by AFM with a colloidal tip in order to characterize the surface forces in the micrometer range. Moreover, contact angle (CA) measurements were carried out using different reference liquids to measure the wettability and the solid surface energies of the samples. Finally, Raman spectroscopy served to inspect possible chemical modifications in the materials after irradiation.

References.