Nanostructured surfaces

Electrostrictive mechanism of nanostructure formation at solid surfaces irradiated by femtosecond laser pulses

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Femtosecond laser pulses interaction with matter can lead to formation of the laser-induced periodic surface structure (LIPSS). Various applications of LIPSS have been proposed. Though LIPSS was first observed in 1965, mechanisms responsible for the LIPSS formation are still debated. Two types of formation mechanism which explain the observed structures can be underlined: 1) a resonant mechanisms based on (i) a periodic electromagnetic-energy deposition due to roughness of the surface [1] and (ii) excitation of surface plasmon polaritons (SPPs) [2, 3]; 2) a non-resonant mechanisms, more related with thermal consequences of the irradiation of the target by the laser, like capillary waves formed in the melted layer.

In most cases, the ripples were found to grow along the direction perpendicular to the laser polarization [2, 3]. Therefore, it was assumed that LIPSS can be attributed to the excitation of the SPPs due to the TM polarized mode.

The goal of our study is theoretical investigation of the significance of the ponderomotive forces in LIPSS formation. So, distributions of the electrically-induced normal pressure and tangential stress at the illuminated solid surface, as well as the field of volume electrstrictive forces, are calculated allowing for SPP excitation. Based on these calculations, conditions of the surface destruction and structure formation are discussed. The calculated fields of the electromagnetic forces are compared with the experimental ripple structures. We thus show that the electrostrictive forces can be responsible for the LIPSS formation.

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