Hybrid electromagnetic surface modes impact on low spatial frequency LIPSS formation and periodicity reduction

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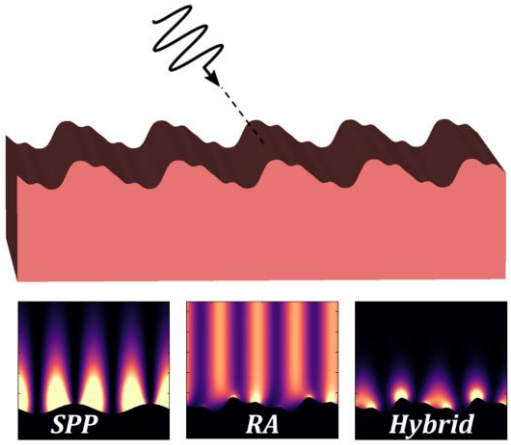
The impact of the excited electromagnetic surface modes in an investigation of the formation of laser-induced periodic surface structures (LIPSS) is analyzed. It is demonstrated that the electromagnetic origin of low spatial-frequency LIPSS (LSFL) is the frequency detuning between propagating and localized modes due to their coupling/hybridization. The influence of the pattern profile, inhomogeneity, and material type on the coupling strength, electric-field spatial distribution, and associated near-field scattering are highlighted. Exploiting the potential of the approach, evidence of a universal manifestation of LSFLs is provided irrespective of the material predicting and validating the experimentally-proven lower limit of LSFL periodicity (i.e., $\lambda_L/2$, where λ_L stands for the laser wavelength) [1]. The analysis of the electromagnetic modes predicts that the periodicity of LSFL is practically unaffected by the laser fluence, while a suppression of LSFL at high excitation levels or large number of pulses is also predicted. It is also shown that plasmonic-active materials are not necessary for LSFL formation perpendicular to polarization. Toward these directions, an important generic metric, namely the resonance quality factor, is inserted. The approach can, thus, serve as a guide for controlling laser-induced surface topography.



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References: [1] G. Perrakis, O. Tsilipakos, G. D. Tsibidis, E. Stratakis, Impact of Hybrid Electromagnetic Surface Modes on the Formation of Low Spatial Frequency LIPSS: A Universal Approach, Laser & Photonics Reviews, DOI: 10.1002/lpor.202301090 (2024)