Laser formation of periodical structures on composite thin films

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Functional periodical microlattices are the objects of a great interest in optics and photonics. Common methods for their fabrication include interefrence or photolithographic recording, although the direct laser writing methods offer the higher flexibility of patterns. In this work we report on the formation of subwavelength periodical structures on composite thin films by direct laser processing. The film composed on titanium dioxide porous matrix dopped with small silver nanoparticles with a diameter less than 7 nm. For the formation of periodical structures, the third harmonic of nanosecond-pulsed fiber laser ($\lambda = 355$ nm, $\tau = 1.5$ ns) was used. Depending on the laser processing parameters namely laser intensity in the range of $I_0 = (1.5–5) \times 10^7$ W/cm^2 and scan speed $V_{sc} = 50$ to 500 mm/s two different types of periodical structures formed. At low intensities, when heating is lower, the periodical structures with a period of about 330 ± 5 nm oriented along laser polarization formed. With the increase of intensity, the formation of other set of subwavelength nanostructures perpendicular to the laser polarization was observed. Interestingly, that there is a narrow parametric gap where the formation of two-dimensional periodical lattices occurred. Recording results demonstrate the influence of competitive temperature-driven effects based on interference of the irradiation wave with waveguide modes or surface plasmon polaritons.
Optical properties of such periodical composite structures depended not only on the periodicity of the structures but also on the size and distribution of silver particles. The reported study was funded by the Russian Science Foundation (project No. 21-79-10241).