Nonlinear optical response of TiO_2:Ag-based nanocomposite gratings

Andreeva Ya M[@], Ageev E I and Larin A O

ITMO University, Kronvergskiy 49, Saint-Petersburg 197101, Russia

[@] andreeva.ym@itmo.ru

This work reports on the direct formation method of nanocomposite periodical gratings and investigation of their optical properties. The samples composed on TiO_2 thin porous film on the glass substrate with silver particles were taken as initial material. To produce periodic lattices the third harmonic of Y-doped fiber laser with the 1.5 ns pulse length was used ($\lambda = 355$ nm).
Using direct laser writing with different scan speed and fluences, we are able to produce different periodical gratings. When the fluence is lower, namely within the range of $F = 21$–23 mJ/cm^2 and at scan speeds $V_{\rm sc} = 50$–500 mm/s structures oriented perpendicularly to the $\boldsymbol{E}$ vector in the order of the wavelength were formed due to partial densification of the porous matrix. With the increase of $F > 39$ mJ/cm^2 and for lower scan speeds $V_{\rm sc} = 50$–300 mm/s we observed the formation of high-frequency periodical structures with the period of the half of the wavelength oriented parallel to $\boldsymbol{E}$. The second type structures were recorded due to melting of the film with the consequent re-crystallization. We than investigated nonlinear optical properties of such periodical nanocomposite lattices under the pumping of Y-doped fs laser with $\lambda = 1045$ nm. The first type of gratings demonstrate broadband multi-photon photoluminescence. For the second-type gratings such effect was less pronounced. However, the intense peak near 520 nm appeared indicating second harmonic generation on the second lattice. The demonstrated results are promising for single step fabrication of photonic device circuits and nonleniar optical metasurfaces.
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