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ABSTRACTS

W05,06-31 Origin of two-dimensional nanostructures formation under circular polarized femtosecond laser radiation interaction with condensed media

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It is well known that the appearance of ordered micro-and nano-structures on surface and in bulk of condensed media under the action of ultraviolet laser pulses is explained in framework of universal polariton model (UPM) [1]. But the majority of experiments have been conducted with linear polarized laser radiation. Published experimental data causing the ordered structure formation on metals, semiconductors and dielectrics under circular polarized laser pulses action were not elucidated [2 – 6]. According to theoretical model verified by experiments under the interaction of circular polarized nanosecond laser radiation with semiconductors and metals the arrays of resonant gratings were produced having different orientations for left and right circular polarizations (the Fourier images of structures are asymmetric relative to the center of image) [7].

Under the action circular polarized ultrashort laser radiation interaction with semiconductors and dielectrics the isotropic spatially ordered structures were formed in the shape of spherical nanoparticles of typical size $s \leq \lambda/\eta$ [2-4]. Under the interaction of ultrashort laser pulses with metals more complicated two-dimensional anisotropic nanostructures were produced having $s \leq \lambda/\eta$ and symmetry axis along surface normal [5, 6]. Here η is the real part of surface plasmon polaritons (SPP) refractive index for air-excited media boundary. To explain the origin of nanostructures and their peculiarities in framework of UPM the approach is suggested based on the interference of SPP (having all possible propagation directions) with incidence wave followed by array of nanospheres formation with well defined spatial scale $s \approx \lambda/\eta$ and on the mutual interference between SPPs and their spatial harmonics and nanosphere production with $s \approx \lambda/2\eta k$, where k=1, 2, 4, … . This result is confirms by known experiments for dielectric and semiconductors [2 – 4]. As for metals, one of the peculiarities of the nanostructures formation mechanism is the surface layer oxidation. This mechanism prevents from dynamic restructuration of created nanostructures. That is why the array of ordered square cells with $s \approx \lambda/\eta$ were produced on titanium film surface [5] and for selectively oxidized magnetic stainless steel the array of hexagonally symmetric nanostructures, $s \approx \lambda/\eta$ [6]. Our finding may be used for controllable production of surfaces possessed chiral properties.

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PS3-W05-4 Anomalously oriented nanograting formation under ultrashort polarized laser radiation interaction with condensed media

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In physics of ultrashort laser-matter interaction the hot topic is the elucidation the mechanism of nanograting **G** production of anomalous orientation, **G** $\perp$ **E**, where E is the electric field strength of laser radiation. One of the causes of such interest is the anomalously small periods **D** of such gratings. We present the review of the experimental publications causing anomalous nanogratings production on condensed media with sufficiently different physical properties and related mechanisms of their formation. The formation of anomalous gratings is not the peculiarity of ultrashort laser radiation action. Their formation was observed in nanosecond laser-matter interaction regimes. The variety of

proposed mechanisms of anomalous nanograting formation were analyzed: capillary waves generation, spallation of material, interference with surface plasmon polaritons (SPPs) participation, mutual interference of localized SPPs and others.

The model of mutual interference of localized (channel and wedge) SPPs (including their spatial harmonics) was analyzed in more details. The usual irradiation geometry and nonstandard one (for instance, the two-beam interference) for nanograting formation were considered. Special attention was devoted to periods of G which overcome the optical diffraction limit value and reach the values of the order of $\mathbf{D}\leq\lambda/40$. The pure physical limitation on the smallest period value formation arises from the thermal grating smoothing due to thermal conductivity which do not permit the experimental realization more smaller values from the set of Feigenbaum's universality $\lambda/2k\zeta$ of higher k values, where ζ is the real part of the refractive index of nonequilibrium solid state plasma –air boundary for local SPPs, k=1, 2, 4, … The experimentally realized values of the period D frequently overcome the Abbe criterion as a result of the nonlinear process of their production.

We show that the universal polariton model takes place for ultrashort terahertz radiation interaction with matter. For such large wavelengths the process of thermal grating smoothing is less sufficient. That is why for terahertz radiation the smallest periods $\mathbf{D}\leq\lambda/25$ (λ~100 μm) for monocrystalline silicon and $\leq\lambda/100$ for aluminum films were observed.

In summary, the phenomenon of anomalously oriented nanograting formation has universal character. It was shown, that known experimental results causing anomalously oriented gratings production are well explained in the model of mutual interference of local (channel and wedge) surface plasmon polaritons.

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PS3-W06-7 Laser-induced formation of microcones on germanium in oxidizing atmosphere and vacuum. Dynamics of relief

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The mechanisms of the laser-induced formation of micro- and nanostructures of residual relief on surfaces of materials are of fundamental interest. A strong influence of composition of gas atmosphere on the laser-induced relief structures was marked in a number of works but a reasonable explanation was lacking. The significant role of the degree of wetting by melt of its solid phase in the mechanism of the laser-induced formation of the cone-shaped peaks (microcones) on metals was proposed in [1]. Formation of the microcones on the (111) surface of germanium in vacuum, air and oxygen at the atmospheric pressure as a result of local laser irradiation with the energy density Q lower than the ablation threshold was studied in this work. The height of the microcone was growing with Q. The microcone and adjacent melted area in oxidizing atmosphere were covered by a GeO oxide. To study dynamics of the relief in air a rapid-speed video filming has been carried out. The value of wetting angle θ between the meniscus and tangent to the solid state – gas boundary $\theta=(35\pm3)^o$ in air measured in the video images was about three times more than $\theta=(13\pm1)^o$ in vacuum measured in [2]. This result correlates with the about three times growth of the microcone height in air as compared with vacuum.

The growth mechanism for microcones caused by the melt redistribution under the action of surface tension force in conditions of partial wetting and density changing at the phase transition and mathematical model for the microcone formation were proposed.

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