Nanostructured surfaces

Longitudinal electromagnetic waves in metals and their role in formation of the laser-induced surface structures

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Recently, we proposed a model that explains formation of the laser-induced periodic structures at surfaces of solids [1]. In the model, we calculated the mechanical stress when light incident on a plane surface interferes with the surface plasmon polaritons. Here, we study light refraction and ponderomotive forces involving volume plasmon polaritons. These plasmon polaritons are also known as longitudinal electromagnetic waves in media with spatially dispersive permittivity.

First, we describe the properties of the longitudinal electromagnetic waves. We solve the Boltzmann transport equation and define the permittivity in the form of the Lindhard dielectric function. If the product of the wave number by the Fermi velocity is much smaller than the angular frequency, this function gives the hydrodynamic permittivity. The nonlocal electromagnetic theory was verified by calculating the experimental shift of the plasmon resonance (from 3.5 to 3.65 eV) for light scattering on nanometer-sized silver clusters.

Then, we consider reflection of a *p*–polarized electromagnetic wave at a plane air-metal interface and examine the interference of the usual transverse and additional longitudinal waves in metal. There are several distinct features in the phenomenon under study. First, the longitudinal waves can form at a flat surface, whereas special efforts should be made to excite the surface plasmon polaritons. Secondly, in the interference pattern, the electromagnetic-field intensity is modulated not along but perpendicular to the air-metal interface. Therefore, voids can appear in planes parallel to the surface due to metal spallation. Such voids were formed under irradiation of aluminum by femtosecond laser pulses [2].

1. *Pavlyniuk O. R., Datsyuk V. V.* Electrostrictive mechanism of nano-structure formation at solid surfaces irradiated by femtosecond laser pulses // Nanoscale Res. Lett.-2016.-**11**, N 1.-P. 1-6.
2. *Ashitkov S. I., Inogamov N. A., Zhakhovskii V. V., Emirov Yu. N., Agranat M. B., Oleinik I. I., Anisimov S. I., Fortov V. E.* Formation of nanocavities in the surface layer of an aluminum target irradiated by a femtosecond laser pulse // JETP Lett.-2012.-**95**, N 4.- P. 176-181.