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имени М.В. ЛОМОНОСОВА»

ФИЗИЧЕСКИЙ ФАКУЛЬТЕТ

Кафедра общей физики и волновых процессов

Laser-controlled cooperative nucleation and growth of ordered nanoparticle ensembles

Two-stage mechanism of formation of ordered surface nanostructures of adatoms (defects, dimers) under laser-controlled atomic deposition is developed. At the first stage, the cooperative defect-deformational (DD) nucleation of seeding nanostructure occurs, described by the original deterministic DD Kuramoto-Sivashinsky (DDKS) equation for the surface concentration of mobile adatoms (surface defects). At the second stage, periodic surface relief, formed at the nucleation stage, related to the surface defect deformation potential, serves as a self-organized mask for subsequent growth of nanostructures, described by the convential deterministic Kardar-Parisi-Zhang (KPZ) equation for relief height. The numerical algorithms of original DDKS (for adatom concentration) and classical KPZ equations (for surface relief) solving were realised. Computer simulations of partial nonlinear DDKS and KPZ equations describe the two-stage formation, in dependence on the sign of the surface defect deformation potential, of disordered and hexagonally ordered ensembles of nanoparticles or honeycomb void nanostructures (superlattices). In numerical experiments nonlinear effects, such as generation of DD spatial sub-harmonics, sum and second harmonics, were discovered. The spatial DD harmonics interaction during cooperative nucleation is shown to play the key role in determination of the resulting nanostructures characteristics. The generation of second and sum frequency harmonics is shown to be crucial for the existence of steady-state solutions. A version of stochastic DDKS equation was proposed and investigated. The addition of stochastic source into the original DDKS equation leads to the purification of superlattices from point structural superdefects and selection of fundamental, second and sum harmonics in Fourier spectrum from parasitic spectrum

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of the 6th year student
Tarkhov Andrei

Scientific supervisor
Professor, Dr. V.I. Emel’yanov