Acoustoelectronic Effects in Nanoheterostructures and Their Practical Significance

Peleshchak R.M.[1], Kuzyk O.V.[1], Dan'kiv O.O.[1], Peleshchak I.R.[2]

[1]*Drohobych Ivan Franko State Pedagogical University, Drohobych, Ukraine,*
[2]*Lviv Polytechnic National University, Lviv, Ukraine*

In works [1, 2] it has been demonstrated that by means of a supersonic wave one can control the transport properties of semiconductors and change their structure due to the processes of impurity atom diffusion, dissolution and formation of complexes, and formation of impurity atom clusters and intrinsic defects in periodic deformation fields. The extrinsic heterogeneous deformation causes the change of point defect chemical potential, thus leading to the directional diffusion flows. In work [3] it has been empirically determined that Si ultrasonic processing can stimulate diffusion at room temperature.

In this work, the deformation-diffusion model of the formation of periodic structures under the influence of acoustic wave in semiconductors with a two-component defect subsystem is constructed. The offered theory considers the deformation, created by an acoustic wave and dot defects. It is shown, that under the influence of an acoustic wave the periodic defect-deformation structures with the period equal to length of a wave are formed in the semiconductor.Within this model the possibility of ultrasonic stimulation of hydrogen passivation of Cl electrically active centers in the CdTe semiconductor and a decrease of dispersion of the sizes of InAs/GaAs strained quantum dots doped by isovalent impurity is analysed.

The obtaining of semiconductor structures with the self-organized nanoclusters by methods of molecular beam epitaxy and ionic implantation, and also possibility control of their physical properties are the subject of intensive researches. Information on nucleation (incipient state of formation) of periodic nanostructures of adsorbed atoms (adatoms) and implanted impurities is important for optimization of technological process and predicted control of physical properties of semiconductor structures with nanoclusters. The theory of spontaneous nucleation of the surface nanometer lattice which is caused by instability in system of the adatoms interacting with the self-consistent surface acoustic wave (SAW) is developed in [4]. Within this theory the conditions of formation of nanoclusters on the surface of solid states are established and the periods of a nanometer lattice as functions of concentration of adatoms and temperature are defined. However, the offered theory adequately describes the processes of formation of nanoclusters only at low temperatures. It is bound to that this model does not consider temperature dependence of concentration of the adatoms, and also interaction of electronic and defect subsystems which significantly depends on the temperature.

In this work, the theory of formation of nanoscale structures of the adsorbed atoms (adatoms), which occurs as a result of the self-consistent interaction of adatoms with surface acoustic wave and electronic subsystem is developed. Temperature regimes of formation of nanoclusters on *n*-GaAs surface under the influence of laser irradiation are investigated. The offered model allows to choose the optimal technological parameters (temperature, doping degree, intensity of laser irradiation) for formation of the surface periodic defect-deformation structures under the influence of laser irradiation. It is shown that at the fixed value of average concentration of adatoms the increase in degree of a doping donor impurities leads to increase in critical temperature below which there are self-organization processes.

The unique electronic and mechanical properties of single-layer graphene, including high carrier mobility at room temperature, the electron-hole symmetry and high values of Young's modulus ($E \sim 10^{12}\ Pa$), make this material very promising for nanoelectronics [5], in particular for creation of generators of mechanical oscillations, infrared light-emitting diodes. Among the main characteristics defining the possibility of practical use of devices on the basis of electromechanical properties of graphene nanotubes there is the frequency characteristic of this device. The higher the frequency of the electric signal to which this device adequately reacts, the greater speed of transformation of information, and eventually, a huge increase in its effectiveness. In this work, the model of the nanoacoustoelectronic converter on the basis of graphene nanotube is constructed. The offered model considers dimensional dependences of elastic constants and the sound velocity in graphene. Within this model, the frequency dependences of amplitude of the deformation, the surface concentration of electrons and the electrostatic potential are established. It is investigated that at increase in an electron concentration, an electron mobility and decrease of radius of nanotube the sensitivity of the converter increases. It is shown that at increase in radius of graphene nanotube there is the monotonic decrease of the amplitude of the electrostatic potential. This results from the fact that graphene nanotubes of the smaller sizes are more sensitive to deformation.

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