Nanocomposites and nanomaterials

Formation of the semiconductor nanophases at ion-beam ultrasound synthesis

V. Litovchenko[1], V. Melnik[1], B. Romanyuk[1], V. Popov[1], Ya. Olikh[1]

[1]V. Lashkarev Institute of Semiconductor Physics NAS of Ukraine, 41 Prospect Nauky, 03028, Kyiv, Ukraine.
E-mail: romb@isp.kiev.ua

The ion-stimulated processes of phase formation in a solid run under nonequilibrium conditions and at a high concentration of radiation-induced defects. New effective methods to control the system of radiation induced defects, which make it possible to affect the technological processes of phase formation in nano-sized structures. For this purpose, a combined method was proposed to control the system of radiation-induced defects in nano-sized surface layers by exciting a target with ultrasound (US) and simultaneously by irradiating it with a flux of accelerated ions. Interaction of US waves with defects in semiconductor crystal has a complicated character, when point defects and acoustic waves are dynamically generated by ion beam. This method allows to influence the quasi-chemical reaction rate in the nano-scale structures, stimulate the acceleration or deceleration mass transfer processes and to modify the conditions of formation, the phases in solid matrices. It is possible significantly increase the photoluminescense (PL) efficiency compared with the traditional method of formation of luminescent structures. We have investigated the effect of implantation a number of impurities (H, C, N, Al, Ti) with/without US on the formation and modification of luminescent structures containing silicon nanoclusters embedded in the dielectric matrix. It was established that implantation of C, N and Al and the high-temperature annealing (1100-1200 °C) significantly accelerates the nucleation/growth processes of silicon nanoclusters. The basic mechanisms of this effect is the binding of excess oxygen in the region of Si-nc growth, and reduction of local mechanical stress during silicon nano-inclusion growth. Controlled introduction of these impurities (at 0.1 - 2 atomic %) influence the size and concentration of nano-clusters and thus change the spectral characteristics of the luminescent structures. In particular, the introduction of carbon and nitrogen increases the concentration of smaller clusters accompanied by increased (several times) PL intensity in spectrum. In addition, nitrogen effectively passivates non-radiative recombination centers, which leads to a general increase in the intensity of radiative recombination.

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