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Microplasticity and electrical properties of subsurface layers of diamond-like semiconductors strained at low temperatures

V.Nadtochiy, N.Nechvolod, N.Golodenko

Slavyansk State Pedagogical University,
19 General Batyuk St., 84116 Slavyansk, Donetsk Reg.,Ukraine

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Microplastic deformation of Si, Ge, GaAs and InAs at low temperatures was discovered while investigating the fine spectrum of the dependence $\sigma - \varepsilon$ and $\varepsilon - t$. The migration of point defects and generation of dislocations at room temperatures in the subsurface layers of cyclically deformed and simultaneously ultrasound irradiated Ge was found by means of optical and electron microscopy. It was ascertained that deformation defects such as dislocations and clusters are generated in the subsurface layer under the action of the mentioned factors. These defects reduce the lifetime of the main charge carriers. Removal of the subsurface defect layer causes the recovery of this parameter.

Исследования тонкого спектра зависимостей $\sigma - \varepsilon$ и $\varepsilon - t$ позволили обнаружить микропластическую деформацию полупроводников Si, Ge, GaAs и InAs при пониженных температурах. Методами оптической и электронной микроскопии обнаружена миграция точечных дефектов и зарождение дислокаций в приповерхностных слоях Ge, циклически деформированного с одновременным ультразвуковым облучением при комнатной температуре. Установлено, что возникающие деформационные дефекты типа дислокаций и кластеров снижают время жизни неосновных носителей заряда. Удаление поверхностного дефектного слоя приводит к восстановлению этого параметра.

Examinations carried out before [1] have allowed to explain the physical nature of the low-temperature microplasticity of crystals with high Peierls relief (Ge and Si) at low and moderate stresses from the standpoint of the diffusion-dislocation microstraining mechanism. In accordance with this mechanism, the directional diffusion flows arise at low stresses and under gradients of stress and point defect chemical potential. These directional diffusion flows promote a non-conservative motion of dislocations. These processes have the highest intensity in the subsurface layers of semiconductors because the free surface provides easy origination and drain of point defects.

Since the majority of studies [2–4] in this field have been carried out on elemental semiconductors, it is of importance to establish opportunity of microplasticity in semiconductor compounds A_3B_5, to study the structural changes in subsurface layers and their influence on electrical properties of semiconductors.

Strain dependences $\sigma - \varepsilon$ and $\varepsilon - t$ were taken on a set-up with electronic-mechanical strain recording system with highest sensitivity of 4 nm at the sample basis length 10 mm. Single crystals Si (KES-0.1/0.5), Ge (GE-45 Г3), GaAs (AGChT-1-25a-1) and InAs (IME-a) with growth dislocations density of $\leq 10^3$ cm^{-2} were used. The samples were shaped as rectangular prisms of $4\times4.5\times10$ mm^3 size oriented in [110], [112], and [111] directions, respectively. Four batches of samples (Si, Ge, GaAs, and InAs), 5 pieces in each, were chosen for straining