TEMPERATURE DEPENDENT DIFFUSION COEFFICIENT, DIFFUSION LENGTH AND LIFETIME IN GeSn EPILAYER

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Silicon materials are key semiconductors in all electronic and photonic devices and dominate the market for few decades [1]. The main drawback of Si and Ge, which are indirect band-gap semiconductors, is a lower performance in comparison to direct band-gap III-V semiconductors [2]. The development of new technology which would be able to shift photosensitivity of Si devices to the mid-infrared range, preserving the benefits of silicon, is in current effort [3]. Group IV GeSn based materials have recently shown promising optoelectronic characteristics, allowing to extend the detection range to the mid-infrared region [4]. The applications in short-wave infrared photo-sensors [5], and electrically driven lasers [6] on Si substrates show continuous improvement. Both these devices rely on the material electronic properties as carrier lifetime, carrier diffusion coefficient and diffusion length.

Therefore, in this work, we provide temperature-dependent studies of carrier lifetime, diffusion coefficient and diffusion length in $Ge_{0.95}Sn_{0.05}$ epilayer on silicon by applying contactless light-induced transient grating technique. Light-induced transient gratings is a variety of pump-probe technique, which employs an interference light field to photoexcite a sample under study. The interference field is created by two coherent laser beams (527 nm) that are made to overlap in the sample at an angle Θ. A period Λ of the resulting interference field is determined by the angle Θ and wavelength of the pump beam λ_p: $\Lambda=\lambda_p/(2\sin(\Theta/2))$. The probe (1053 nm) monitors the diffraction efficiency decay and allows to determine carrier diffusion coefficient (D) and lifetime (τ_R) from grating decay rate $1/\tau_G = 1/\tau_R + 4\pi^2 D/\Lambda^2$. The determined temperature dependences of carrier lifetime and diffusivity are provided in Fig. 1.

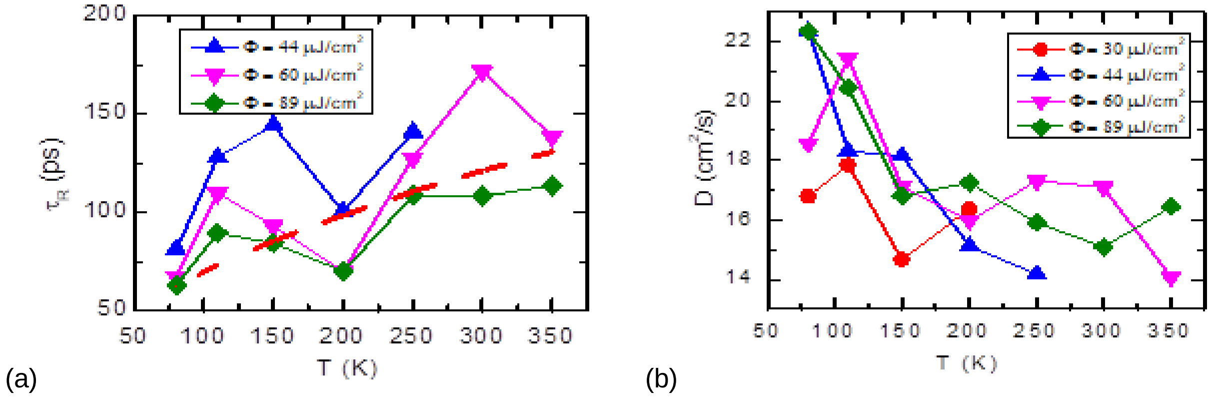

Fig. 1. Lifetime (a) and diffusion coefficient (b) temperature dependences in $Ge_{0.95}Sn_{0.05}$ epilayer.

We show rather weak temperature dependences of these parameters and explain them by defect recombination and scattering processes. Lifetime increases with temperature due to reducing carrier capture cross-section, while diffusivity decreases due to increasing scattering by acoustic phonons. Weak excitation dependences of the parameters are related to saturated trap regime.

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