Nanocomposites and nanomaterials

Polarized luminescence of nc-Si- SiO_x nanostructures on silicon wafers with patterned surface

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We report on the results of comparative investigations of polarized photoluminescence (PL) of nc-Si-SiO_x structures deposited on the patterned and planar c-Si wafers. The patterned Si substrates were formed using interference lithography with vacuum chalcogenide photoresist and anisotropic wet etching. The resulting pattern has a form of periodic grating with depth of relief about 0.3 μm and groove profile close to trapezium. The studied nc-Si-SiO_x structures were produced by evaporation of SiO powder in vacuum and oblique deposition on Si wafer, oriented at the angle 75° between the normal to the substrate surface and the direction to the evaporator. Deposited SiO_x layers with porous column-like structure were annealed in the vacuum chamber at 975° C and passivated in HF vapors.

The linear polarization memory (PM) effect in the PL of studied structures is manifested after treating in HF and explained on the bases of the dielectric model, assuming elongated Si nanoparticles (nc-Si) in SiO_x nanocolumns. On the samples with planar substrates there is well-defined orientation dependence of the PL polarization degree in the sample plane (anisotropy of PM effect). It was found that the anisotropy of PM effect significantly increases on the patterned substrates in comparison to that on the planar ones. The samples on the patterned substrates exhibite the degree of PM effect (polarization memory factor ρ) up to 30% when the polarization of exciting light is parallel to the direction of the grating grooves. For orthogonal polarization ρ value became negative and is equal to from -12 to -30%. Obtained negative value of ρ indicates that the PL on the patterned substrates is polarized mostly along grating grooves, regardless on the polarization direction of the exciting light. The above effect can be associated with different diffraction efficiencies of the patterned substrate (diffraction grating) for p and s-polarized light. Investigation of the reflection spectra of these structures has shown that for polarization of light parallel to the grating grooves (p-polarization)

the reflection in the region of the PL band is much higher than for perpendicular polarization. This can affect the extraction of polarized PL from the nc-Si-SiO_x structures on the patterned c-Si substrates by amplifying the p-polarized radiation in comparison with the s-polarized radiation.