Nanocomposites and nanomaterials

Formation of nanocomposites by oxidizing annealing of SiO_x and SiO_x<Er,F> films: ellipsometric analysis

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Nanocomposites consisting of crystalline or amorphous silicon nanosize inclusions in dielectric matrices (including those doped with Er) are suitable for obtaining silicon-based light emitters [1]. One of the most common methods for obtaining such composites is the thermally stimulated phase separation in silicon suboxide films (SiO_x, x<2). This process has been studied in some detail. However, the investigations concerned mainly the study of structural-phase transformations caused by thermal annealing of SiO_x films in vacuum or inert atmosphere. There is a small number of studies of the luminescent nanocomposites formation by thermal annealing of SiO_x films in oxygen-containing environment that produced rather contradictory results. It is not surprising if one takes into account the fact that decomposition of SiO_x films and their oxidation are competing processes.

SiO_x and SiO_x<Er,F> films on c-Si substrates were prepared using vacuum evaporation of SiO powder and coevaporation of SiO and ErF_3 powders. The films were subjected to one-hour annealing in air at T_{ann} = 650–1150 °C. The annealing-induced structural-phase transformations were investigated by multiangle ellipsometry. Using a set of optical models we obtained the results that characterize the structural changes at both macro- and micro level. At the micro level the formation of silicon nanoparticles was examined. At the macrolevel the character of in-depth distribution of the films' properties in the dependence on the T_{ann} was identified.

It was found that the temperature regularities of the silicon nanoinclusions formation are similar at the annealing in air, vacuum or inert atmosphere. This proves that phase separation in SiO_x films proceeds much faster than the oxidation. The formation of Si inclusions proceeds more intensely in SiO_x<Er,F> films than in SiO_x films. It is explained by the action of Er centers as promoter for SiO_x disproportionation. In the top portion of the SiO_x and SiO_x<Er,F> films due to oxidation the single a-SiO_2 phase is formed, and, in a "macroscopic sense", with increasing T_{ann} the SiO_x and SiO_x<Er,F> films gradually transform from the single-layer system into two-layer system. The oxidation proceeds more intensely in SiO_x films. It is explained by inhibiting action of F.

1. *Sopinskyy M., Khomchenko V.* Electroluminescence in SiO_x films and SiO_x film-based systems // Curr Opin Solid State Mater Sci.- 2003.-**7**, N2.-P. 97-109.