Mesoscopic Materials Research Laboratory Seminar

Date : July 28, 2016, 10:00-12:00

Room **204,** Science and Technology Research Building 3

Supported by “Smart materials team” in organization of advanced science and technology, Kobe University

Dr. Denis Zhigunov

Department of General Physics and Molecular Electronics, Faculty of Physics,
M.V. Lomonosov Moscow State University,
Email: dmzhigunov@physics.msu.ru

Optical and structural properties of multilayered SiO_x/SiO_2 and SiO_xN_y/SiO_2 thin films with Si nanocrystals

An experimental as well as theoretical evidence of intermixing of multilayered SiOx/SiO2 and SiOxNy/SiO2 thin films upon high temperature annealing is demonstrated. The films were fabricated using reactive evaporation and PECVD techniques and subsequently annealed at high temperatures (>1100 ^oC) in order to form Si nanocrystals by means of the well-known superlattice approach. The thickness of the SiOx and SiOxNy layers was varied from 1.5 to 5 nm, while for the SiO2 layers it was fixed at 4 nm. Using transmission electron microscopy it is shown that the multilayered structure generally sustains the high temperature annealing for both types of films. However, for samples with ultrathin SiOx or SiOxNy layers a breakdown of the superlattice structure and a complete intermixing of layers were observed at high temperatures. On the contrary, annealing at lower temperature (900 ^oC) preserves the multilayered structure even of such samples. Theoretical calculations showed that the intermixing of $SiOx/SiO_2$ and $SiOxNy/SiO_2$ superlattices in the ultrathin layers thickness limit may be explained thermodynamically by the gain in the Gibbs free energy, which depends in turn on the annealing temperature.

An effective approach for the control of the optical properties of photonic nanostructures is also presented. Extinction and photoluminescence spectra are studied for a thin multilayered film with silicon nanocrystals and periodic array of gold nanowires deposited on top. It is shown both experimentally and theoretically that metal grating can strongly influence the optical properties of silicon nanocrystals. Calculations performed by the scattering matrix method are found to be in good agreement with the experimental results. Both extinction and photoluminescence spectra of experimental samples are characterized by sharp peaks which are explained by the excitation of quasiguided modes in the layer with silicon nanocrystals. The appearance of these modes leads to enhancement of silicon nanocrystals photoluminescence intensity at the corresponding photon energies. It is demonstrated that the periodicity provides a powerful tool for achieving a high photoluminescence out-coupling efficiency of photonic nanostructures.