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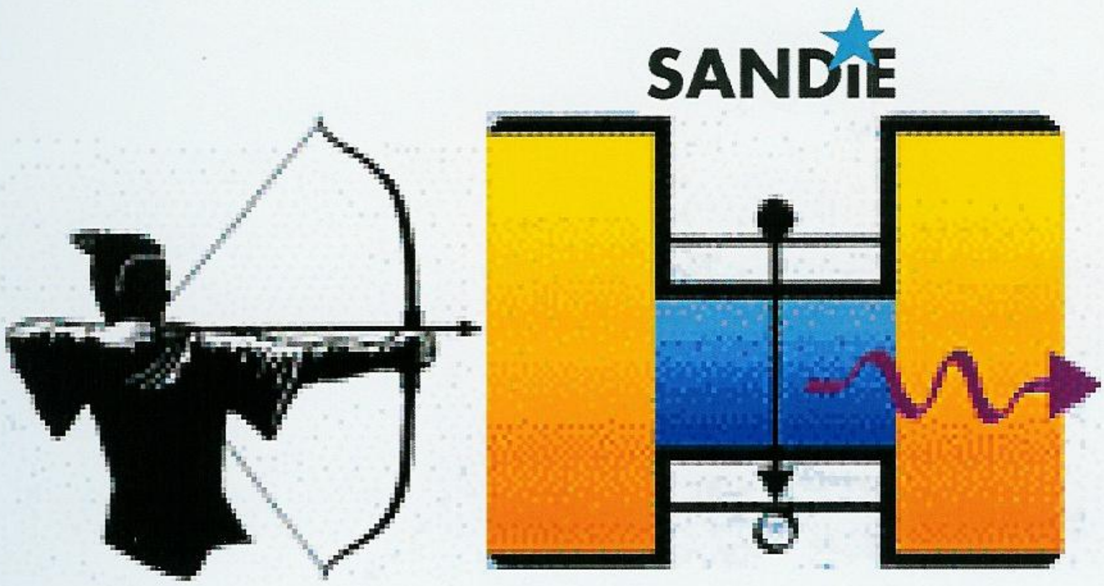
Low Dimensional Structures and Devices



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LASER INDUCED SELF-ORGANIZATION OF NANOWIRES ON SiO_2/Si INTERFACE

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Nowadays, the nanostructures are the most investigated object in solid-state physics, especially quantum confinement effect in quantum dots (QDs) [1], quantum wires (QWs) [2] and quantum wells. In case of nanosize structures the energy band diagram of semiconductor is strongly changed. This leads to crucial change of semiconductor properties.The growth of investigations of the homogeneous structures, such as well-defined one-dimensional axial heterostructures, multiheterostructures and nanowire heterostructures generate a great interest for their potential applications. The fabrication of nanostructures without lithographic process, based on the self-assembling processes is very promising for future nanoelectronics. In this case the self-assembling processes utilize the microscopic structures on the surface or the strain induced by lattice mismatch. The elaboration of new methods for self-arrangement formation of nanosize silicon structures (nanowires, nanodots, nanorods, nanohills) is very important task for future Si-based nanoelectronics and optoelectronics. Si is the basic material in microelectronics because it is low expensive and its technology is a very well developed.

The aim of this work is to study properties of nanostructures formed on the SiO_2/Si interface by the pulsed Nd:YAG laser radiation (LR). The SiO_2 covered layer transparent for the LR as protector of Si surface from contamination was used. P-type Si wafers with SiO_2 top layer which was grown by thermal oxidation were used in experiments. Experiments were performed in ambient atmosphere at pressure 1 atm, room temperature T=20°C, and 80% humidity. Radiation from a pulsed Nd:YAG laser second harmonic (pulse duration 15 ns, wavelength 532 nm, power 1MW) was directed normally to the surface of SiO_2/Si (001) structure. The spot of laser beam of 3 mm diameter was scanned over the sample surface in 1μm step. For the experiments atomic force microscope (AFM), Photoluminescence (PL) and micro-Raman back-scattering spectra were used.

Study of the irradiated surface morphology by AFM has shown formation of a very sharp nanohills on the SiO_2/Si interface after irradiation by laser at $I > 5 MW/cm^2$.

Photoluminescence of the SiO_2/Si structure in visible range of spectrum with maximum at 2.05 eV (600 nm) obtained after irradiation by the laser at intensity $I = 2.0 MW/cm^2$. PL spectrum is strongly asymmetric with long wing in IR part of spectrum. This particularity is explained by Quantum confinement effect in nanohills/nanowires with gradually decreasing of nanowires diameter from Si substrate till top – graded band gap semiconductor. In our case the maximum of band gap is 2.05 eV which corresponds to the minimal diameter 2.3 nm on the top of nanohills-nanowire [3]. Graded change of band gap in Si arises due to Quantum confinement effect.

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