Mesoscopic Materials Research Laboratory Seminar

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

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Quantum Cones Formation in Semiconductors by Laser Radiation: Experiments, Modeling and Application

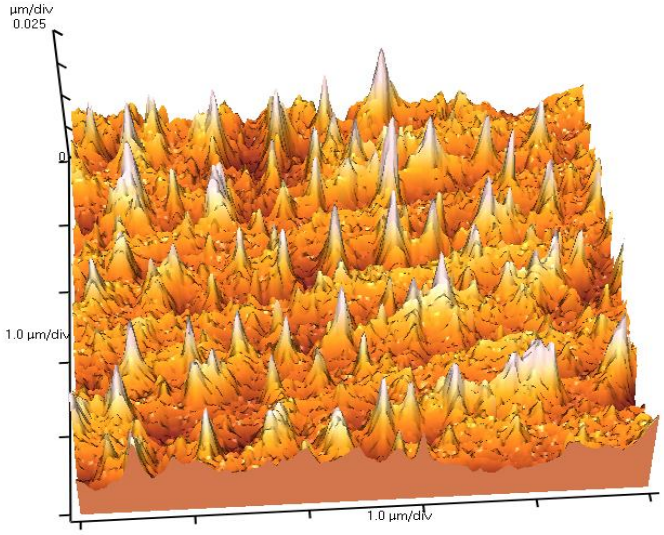
Nowadays, nanostructures are one of the most investigated objects in semiconductor physics, especially due to Quantum confinement effect in quantum dots (0D), quantum wires (1D) and quantum wells (2D). A new laser technology elaborated for quantum cones formation in semiconductors is reported. A cone possesses the following unique properties: a small cone is a quantum dot – 0D and a long one is a quantum wire – 1D with the gradually decreasing diameter from the base till the top of the cone. Such quantum cone luminesces like rainbow. Everywhere radii of cone are equal or less than Bohr’ radius of electron, exciton or phonon Quantum confinement effect takes place. Quantum cones on the surface of elementary semiconductors Si and Ge single crystals, and on a surface of of $Si_{1-x}Ge_x$ (x=0.3 and x=0.4) and $Cd_{1-x}Zn_xTe$ (x=0.1) solid solutions were formed by fundamental frequency and second harmonic of Nd:YAG laser radiation. Strong change of the optical, mechanical and electrical properties of the semiconductors after irradiation by Nd:YAG laser are explained by the presence of Quantum Confinement Effect (QCE) in quantum cones. “Blue shift” of photoluminescence spectra and “red shift” of phonon LO line in Raman spectrum are explained by exciton and phonon QCE in quantum cones, correspondently. Asymmetry of the photoluminescence band in the spectrum of Si quantum cones is explained by 1D graded band gap structure. Experimental data on quantum cones formation on a surface of Si, Ge and their solid solution and CdZnTe crystal and their optical properties are presented. Two-stage mechanism of quantum cones’ formation on a surface of the semiconductors is proposed [1]. The first stage of the mechanism is characterized by the formation of a thin strained top

layer, due to redistribution of point defects in temperature-gradient field induced by laser radiation. The second stage is characterized by mechanical plastic deformation of the stained top layer leading to arising of quantum cones due to heating up of the top layer.

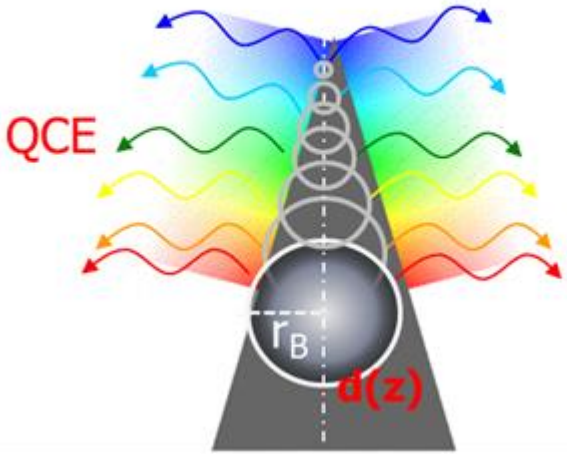
Formed quantum cones can be applied for design of third generation solar cells, Si white light emitting diode, photodetector with selective or "bolometer" type spectral sensitivity and Si tip for field electron emitting with low work function [2].

References

1. Artur Medvid, Pavels Onufrijevs and Alexander Mychko, Nanoscale Research Letters, 6, 582(2011).
2. Artur Medvid', Laser growth and processing, Edited by N.Vainos, London, (WOODHEAD), 488(2012).



3D AFM image of Ge surface irradiated by Nd:YAG laser at intensity 6.0 MW/cm^2.



A schematic image of a nanocone-nanowire with a gradually decreasing diameter from Si substrate till the top.