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Organize the seminar in Conference Room , Building A

Wednesday, 12/October/2011, 13:00 - 15:00

Program:

13:00-14:00 Dr. Konstantin Nickolaievich Galkin

Thermoelectrical properties of silicon double heterostructures with buried magnesium silicide two-dimensional structures

The possibility of embedding of low-dimensional magnesium silicide inside silicon matrix has been shown in previous works [e-JSSN v.3; JAP v.73]. Si/Mg_2Si/Si(111) heterosystems are characterized by bigger thermoelectric power than the silicon substrates on which they are grown. By optical and Raman data the Mg_2Si nanocrystals are embedded in the polycrystalline silicon matrix with sizes of silicon crystallites less than 15 nm. But 2D Mg_2Si layer is embedded in polycrystalline silicon matrix with sizes of silicon crystallites appreciably more than 15 nm. The low-temperature conductivity through a two-dimensional magnesium silicide layer with high mobility of holes, formed inside the silicon matrix, or through the polycrystalline silicon cap layer at the expense of injection of holes from Mg_2Si nanocrystallites into silicon was firstly found. The hole injection from Mg_2Si NCs or 2D layer into silicon cap layer also results to increase of the thermoelectric power coefficient: the resistivity is lower the 5 $\Omega*$cm, the thermoelectric power coefficient is closer to 100 μV/K.

14:00-15:00 Prof. Nickolay Gennadievich GALKIN

Structure, luminescence and thermoelectric properties of silicon-silicide nanoheterostructures with buried nanocrystals

Semiconductor silicides (⍰-FeSi2, CrSi2, Mg2Si, MnSi1.74, a.o.) in the form of thin epitaxial films on silicon substrates attract significant attention as perspective materials for silicon planar technology. Semiconducting iron disilicide (⍰-FeSi2) having a direct gap (Eg=0.85-0.87 eV) has been used as a very attractive material for silicon-based light emitters and detectors as well as for photovoltaic applications. Chromium disilicide (CrSi2) is a narrow band gap semiconductor (Eg=0.35 eV). As a high-temperature compound, which has been epitaxially grown on Si(111) substrate, CrSi2 is a perspective material for creation of thermoelectric generators and for photovoltaic applications in middle infrared region. Magnesium silicide (Mg2Si) as a narrow gap semiconductor (Eg=0.78 eV [1]), which has the high value of thermoelectric power, is also perspective for creation of thermoelectric generators on the base of silicon planar technology.

Semiconductor materials created on the basis of buried nanocrystallites, including semiconductor silicide quantum dots in silicon matrix, can possess new optical and electric properties, which are important for construction of new kinds of device structures. It is known, for example, that iron disilicide nanocrystallites (NC's) with large sizes (100-120 nm), which are far from quantum confinement regime, demonstrate electroluminescence in the energy range of 0.82 - 0.84 eV, when it's buried in the p-layer of a silicon p-n mesa-diode. But luminescence properties of buried in silicon matrix semiconductor silicide nanodots have not been else studied in quantum confinement regime. Silicon with buried iron disilicide, chromium disilicides, manganese and magnesium silicide quantum dots are of considerable interest for creation of new silicon-based light emitters with tunable emitting wave length, photodetectors with variable sensitivity region and thermoelectric generator modules compatible with silicon planar technology, because the quantum size effect in buried NC's have led to quantization of energetic levels and changing of effective band gap value and can lead to alteration of fundamental transition type.

In this work the common approaches to a growth and study of optical properties of multilayer silicon – silicide heterostructures with buried semiconductor silicide (FeSi2, CrSi2, Ca3Si4, MnSi1.74 and Mg2Si) nanocrystallites have been developed and discussed.

The formation of nanosize (5–30 nm) islands of Fe, Cr, Ca, Mn and Mg silicides on Si(111)7x7 and Si(100)2x1 surfaces, silicon growth atop nanosize silicide islands and multilayer repetition of developed growth procedure for all silicides have been carried out. Optimization of growth parameters has permitted to create monolithic multilayer nanoheterostructures (NHS) with buried nanocrystals (NCs) of iron, chromium and manganese disilicides and polycrystalline NHS with buried Ca3Si4 and Mg2Si NCs. It was shown that β-FeSi2, MnSi1.74 and CrSi2 NC (5-30 nm) are elastically embedded in silicon lattice due to introduction of tension in the NC lattice and silicon lattice around NC without formation of misfit dislocations on the interface. The electronic structure and morphology of calcium silicide films formed by reactive deposition epitaxy at 130 oC on Mg2Si film and at 500 oC on Si(111)7x7 surface, their optical and electrical properties have been investigated. The formation of new calcium silicide phase with high Si concentration (Ca3Si4), indirect band gap (0.63 eV), high conductivity at low temperatures (50-450 K) has been obtained after calcium deposition at 500 oC on Si(111)7x7 surface. Formation of semiconducting Mn silicide (MnSi1.74) with 0.32 eV band gap was found, when Mn atoms were deposited on the Si(111)-2×2-Fe phase. Optical, photoluminescence, electrical, photoelectrical and thermoelectrical properties of multilayer nanoheterostructures and thin silicide films were studied and perspectives of light emitting diodes and thermoelectric converters for photonics and thermoelecronics were discussed.