LASER PROCESSING AND SPECTROSCOPIC CHARACTERIZATION OF SEMICONDUCTOR NANOMA TERIALS

Scholor
Khalid Mutashar Omar

Supervisor
Prof. Z. H. Khan
Department of Physics
Jamie Millia Islamia
Co-Supervisor
Dr. R. K. Soni
Indian Institute of Technology
New Delhi

The luminescent GaP layers are synthesized by laser-induced etching of a n-type GaP wafer immersed in hydrofluoric acid with and without ethanol. By using spectroscopic methods, the nanostructures have been characterized and investigated. Both photoluminescence and Raman spectroscopy could give significant information on the size and size distribution of GaP nanostructures available in the etched area. The quantum confinement model involving a Gaussian function for the three-dimensional confinement has been used to analyze the experimental data with phonon confinement for Raman spectra and electron confinement for the photoluminescence spectra. Different preparation conditions, viz. laser power density, irradiation time and electrolyte concentration, have been used in the synthesis of porous layers. The surface morphology of the different structures, when investigated by Scanning Electron Microscopy (SEM) shows evidence of a three-dimensional confinement. The surface morphology of n- GaP substrates indicates that laser-induced etching is a highly oriented process.

In this work, we have employed an Argon-ion laser for etching using different processing parameters. The used laser wavelength had photon energy of 2.41 eV, which is far from the GaP indirect band gap energy of 2.26 eV. This non-resonance etching condition could produce a porous layer with smallernanocrystallite sizes. The photoluminescence (PL) emission band from porous layers is characterized by a number of peaks from the blue to the UV regions. The analysis of photoluminescence spectra reveals a narrow PL band of 136 to 176 meV with smaller nanocrystallite sizes due to the etching effects. The first-order Raman lines shapes have been studied for porous layers under different preparation parameters. The phonon confinement model, used in this work, incorporated a Gaussian distribution function for the nanocrystallites size distribution within the porous layer. Our experimental data could be fitted well by this model.

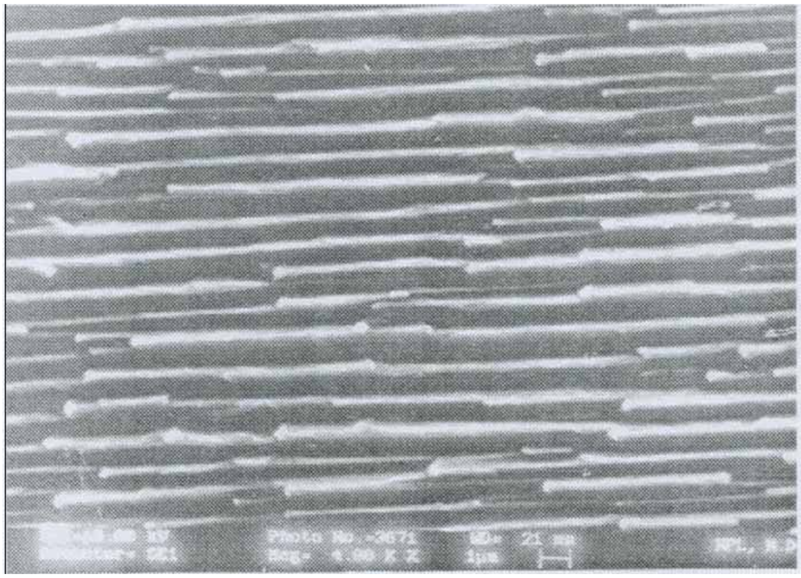

Fig. 1: SEM of GaP nanostructure

The Raman peak position shifts toward lower wave numbers, indicating a phonon softening, when the irradiation time increases and this is due to the nanocrystallite size reduction for samples prepared by laser-induced etching in a 40% HF solution diluted in ethanol in a proportion of 1: 1 and at a laser power density of 12 W/cm2, The effect is related to the particle shape and should be taken into account to explain the observed shift of the surface mode peak due to the dielectric constant of the surrounding medium. The Raman scattering spectra shows a narrowing of the LO phonon peak and a shift to lower frequencies, which depends on a changes in the state of the surface of the pores during the progress of etchil)g. The temperature dependent of Raman scattering in bulk GaP has been studied. The peak width and peak position of the first-order phonon were found to vary with the change in temperature and this is attributed to the anharmonic vibrational potential. Raman, photoluminescence and surface morphology studies, reveal that smaller nanocrystallites with three-dimensional confinement are distributed in the porous layer surfaces produced by the laser-induced etching process.