Seminar

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Institute for Plasma Research

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Title: Defects Studies in Low Energy Ion-Implanted Silicon Carbide

Speaker: Dr. Kamalakkannan
University of Madras, Chennai

Date: 14th June 2024 (Friday)

Time: 03.30 PM

Venue: Seminar Hall, IPR

Abstract

Silicon Carbide (SiC), is the most promising wide bandgap semiconductor with exceptional material properties, like high-electron mobility, and high saturated electron drift velocity which is highly suitable for the development of more stable semiconductor chips. However, issues closely connected with the defects, are necessary to understand. Free carriers can be trapped by defects which influence the carrier movements to limit their mobility. In some applications, point defects and defect complexes in SiC are identified as useful domains in spintronic and quantum computing applications.

For many potential applications and to improve the performance, controlled dopant levels need to be introduced to make p- and/or n-type as well as insulating layers in SiC. High-density selective depth doping by conventional thermal diffusion process for multilayered structures is much involved and limited in dense materials due to dopants saturation at high temperature. Ion-implantation is the key technology to resolve the saturation limit and selective planner doping in SiC. Selective depth doping by ion implantation techniques with controlled ion energy and flux for high-density n/p type layer formation can be realized with the highest precision and patterning. However, implantation-induced structural damage is inevitable and their curing leading to dopant activation is very crucial. Ion implantation alters the material properties due to predominant ion collisions with atoms through electronic and nuclear energy loss mechanisms. Resulting the process, various redundant defects with bond breakages leading to amorphization alter the mechanical strength and electrical and thermal conductivity. However, some types of defects in SiC are also identified for potential applications.

Many analytical methods have been explored to describe the defects and structural changes owing to ion implantation. Among all, Raman and Positron annihilation Doppler broadening spectroscopy (PAS- DBS) is a powerful non-destructive characterization technique to identify the implantation-induced defects at the atomic level to deduce qualitative and quantitative information on the type and concentrations of depth-resolved defects. Considering the importance of high-performance SiC device fabrication, it is much needed to implant a high concentration of dopants to make n- and/or p-type layers in SiC and annealed to high temperature to activate dopants, recrystallization and defect recovery. Based on the development of selective depth high dense n- and/or p-type layer in SI- 6H- SiC using low energy implantation with different fluencies are studied. Also, presenting with the nature of defects, defects accumulation from near-surface to the implanted region, and its recovery mechanism probed by Raman and by variable energy positron beam coupled DBS measurements.

Presentation is outlined as,

[1] Introduction to silicon carbide and its physical property and applications
[2] Low-energy ion- implantation procedures and identification of various defect types induced in SiC by ion-implantation. Monte Carlo method of simulation procedure of stopping and ranges of ions in matter (SRIM- 2013) tool to identify the ion- depth profile, concentration, the vacancy profile for the calculation of displacement per atom for the selected ion fluence are prior important in ion- implantation.
[3] Reports on the effect of 1015 N+ /cm2 and 1016 N+/cm2 of 130 keV N+ and 1014 Al+/cm2, 1015 Al+/cm2 and 1016 Al+/cm2 of 400 keV Al+ implantation in semi-insulating 6H-SiC and recrystallization probed by Raman scattering.

[4] Positron annihilation Doppler broadening spectroscopy (DBS) studies on N+ implantation-induced vacancy type defects and their recovery in SI: 6H- SiC. Defects recovery, accumulation, and its behaviour with two annealing temperatures are also considered. Defect types and their effect on annealing are analyzed and modelled as layers using variable energy positron fitting (VEPFIT) methods.
[5] Positron- DBS analysis of Al+ implanted SI- 6H- SiC to investigate the depth-resolved defects produced by three fluencies at 400 keV, implanted in SI 6H-SiC. Stopping and Ranges of Ions in Matter (SRIM) analysis resulted in the implanted ions producing damage near the surface to the depth of 650 nm with peak damage at 500 nm. Defects induced by various dose rates and their recovery for two annealing temperatures are considered. The distribution of defects modelled with the variable energy positron fitting (VEPFIT) method is considered with three distinct layers. Positron analysis gives clear information on the deformation and recrystallization.
[6] Summary and salient results of the work and discusses the outcome of the described work.