L.5: Development of optoelectronic devices based on III-V semiconductors

Semiconductor Physics and Devices Laboratory of RRCAT is working on the development of optoelectronic devices based on GaAs, InP and GaN semiconductors. Multilayer semiconductor device structures are grown by using the metal organic vapour phase epitaxy (MOVPE) technique. An in-depth characterization of epitaxial layers and quantum structures is carried out by using the laboratory and synchrotron radiation based facilities. Various optoelectronic devices like high power Laser diode arrays, radiation hard GaAs based quadrant detectors, and novel spin-photonic detectors are indigenously developed at RRCAT. A brief summary of the recent developments is given here.

L.5.1: Development of laser diode arrays

Semiconductor laser diode arrays operating at 980nm are developed. The laser diode arrays delivered 23.5 W peak power under pulsed operation and 3 W CW power. Laser diodes arrays are fabricated by implementing numerous device processing steps including facet coating and bonding. Surface and interface properties of single and multilayer facet coatings of ZrO_2 and ZrO_2/SiO_2 are investigated by optical and X-ray reflectivity (at Indus-1). The output is coupled to 400 µm diameter, Yb-doped fiber for demonstrating the pumping in a fiber media.

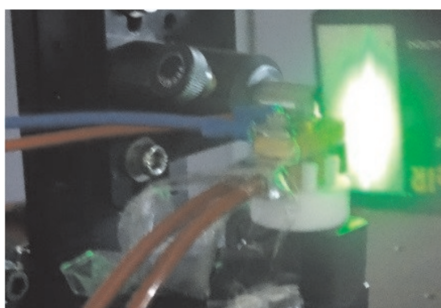

Fig.L.5.1: Photograph of 980 nm laser diode array under operation. The laser emission is recorded on an IR card. The laser diode arrays are packaged by RRCAT.

L.5.2: Development and application of radiation hard GaAs quadrant photodetectors

Radiation resistant GaAs based quadrant detectors have been developed. The device is consisted of 4 active elements of GaAs p-i-n structure which lie in close proximity. The detectors operate in the wavelength range of 200-900 nm. Electronic read out circuit was also developed to record the output of each detector. The developed detectors are tested for the precise alignment of laser beam. Further, the radiation hardness of GaAs detectors is found to an order of magnitude higher than that of the commercially available Silicon detectors. It makes GaAs based quadrant detectors an attractive device for precise alignment of laser and charged particle beams in high radiation zones.

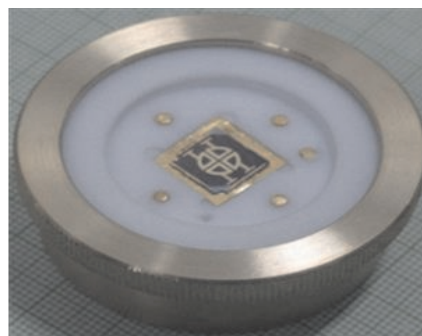

Fig.L.5.2: Photograph of GaAs based radiation hard quadrant detector.

L.5.3: Spin-optoelectronic device for simultaneous detection of light polarization and intensity

In many advanced technological applications, simultaneous measurement of the degree of circular polarization and intensity of a laser beam is essential. However, it is not possible with conventional helicity dependent detectors, where a small fluctuation in intensity leads to misleading information about the polarization. We have developed a spin-optoelectronic device that can measure these two critical parameters independently and simultaneously. The device is based on two fundamental phenomena occurring in metal/semiconductor hybrid structures namely Inverse Spin Hall Effect (ISHE) and the Photo-Voltaic (PV) Effect. For this purpose, Au/InP hybrid structures are indigenously grown by using metal evaporation and MOVPE techniques at RRCAT.

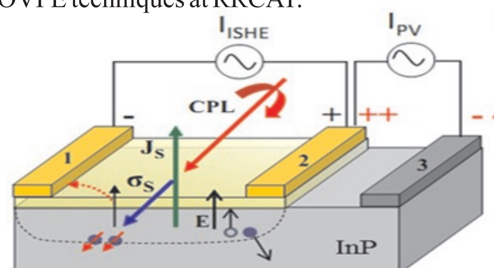

Fig.L.5.3: Three terminal spin optoelectronic device to measure light polarization and intensity simultaneously. Here contacts '1' and '2' are used to measure light polarization whereas contact '2' and '3' are used to measure light intensity

For details please see Dixit et al., *J. Phys. D: Appl. Phys.* ***48***, *105102 (2015), Nuclear Instruments and Methods in Physics Research A* ***785***, *93 (2015),* Khamari et al., *Appl. Phys. Lett.* ***104***, *042102 (2014), Appl. Phys. Lett.* ***107***, *072108 (2015).*

Reported by:
S.K. Khamari, V.K. Dixit (dixit@rrcat.gov.in), and T.K. Sharma