laser power was almost constant. The average laser power reduced from 4.5 W to 3.5 W during the next 100 hours, under the same operating conditions. This power drop is due to the deposition on the discharge tube windows from inside.

The laser can be used for applications like marking on different type of surfaces. Oscillator - amplifier set up of two such CuBr lasers can be used for various micro-machining applications.

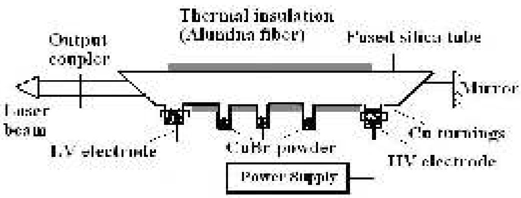

Fig.L. 8.1: Schematic of the CuBr laser

Fig.L.8.2 : Photograph of the sealed-off CuBr laser

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L.9 : Development of Red Diode Lasers

Red diode lasers operating at 670 nm wavelength have been developed at Semiconductor Laser Section of RRCAT. The complete laser structure was grown by metal organic vapour phase epitaxy (MOVPE) technique.

A typical red laser consists of 8 nm thick InGaP quantum well (QW) sandwiched between undoped AlInGaP quaternary waveguide layers. The InGaP QW structure was further sandwiched between n and p type cladding InAlP layers. The epitaxial layers were characterized using several techniques like photoluminescence, surface photo voltage and high resolution x-ray diffraction techniques. The ionized doping and free carrier density were estimated from Hall and ECV experiments. The net ionized doping was also estimated at different depth of the laser diode structures using ECV. Laser diodes were fabricated through standard procedure using photolithography process. Laser diodes were tested for light versus current and longitudinal characteristics using a homemade current source. Laser diodes with different cavity lengths and widths were also developed and tested for measuring the device parameters. About 100 mW peak power was measured for the indigenous laser diodes operating at 670 nm.

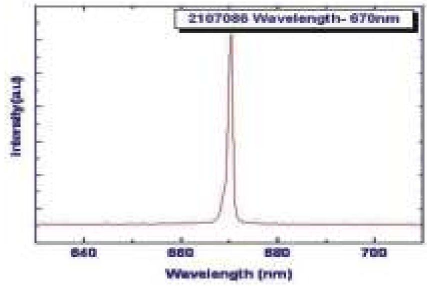

Fig.L.9.1 : A typical lasing spectrum for indigenous red laser diode.

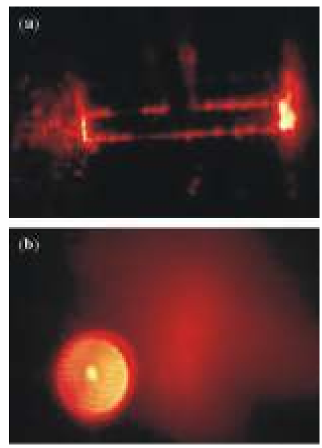

Fig.L.9.2 : Photographs of red laser diode (a) showing emitting light from both facets. (b) photograph of laser diode beam.

Fig.L.9.1 shows a typical longitudinal spectrum. Fig.L.9.2a shows photographs of the red laser diode showing emitting light from both facets and Fig.L.9.2b shows photograph of the laser diode beam.

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L.10:MOVPE growth of quantum dot Structures on GaAs substrate

a. InAs quantum dots :

InAs quantum dots (QD) have been grown on GaAs substrates using MOVPE technique, at the Semiconductor Laser Section of RRCAT. QD structural parameters were fine tuned by varying various growth conditions like In As layer coverage, growth temperature, V/III ratio, growth rate and the ripening time.

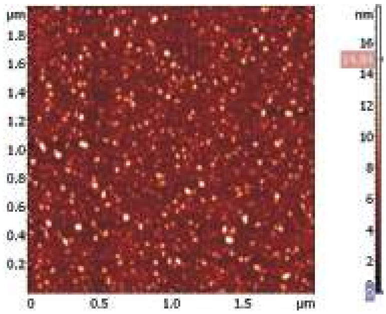

Fig L.10.1 : AFM picture of InAs QD

Figure L.10.1 shows an AFM scan of the optimized QD sample where a QD density of about $2x10^{10}$ cm^{-2} was obtained. The typical QD diameter was about 30 nm with the height of about 15 nm under optimized MOVPE growth conditions.

b. InP quantum dots :

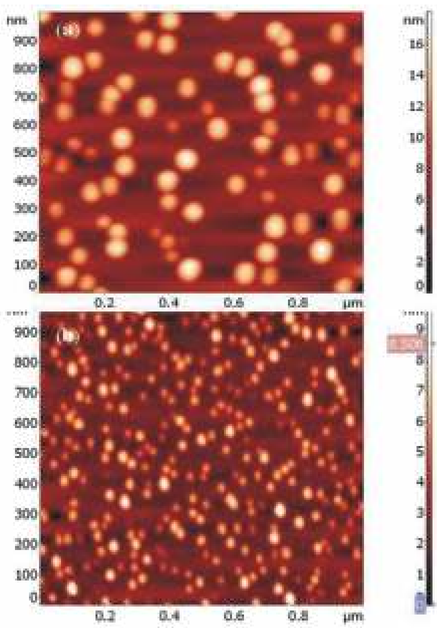

Fig.L.10.2 : AFM pictures of InP QD grown at a temperatures of (a) 600^{0}C and (b) 550^{0}C

InP self-assembled quantum dots (QDs) have been grown on a nominally (001) oriented n^+-GaAs substrate through Stranski-Krastanov growth mode. InP/GaAs QD system has type-II band alignment, where only electrons are confined in the QD region while holes are in the GaAs barrier regions. Structural properties of the InP QDs were optimized by varying the InP coverage, growth temperature, V/III ratio, growth rate etc. Variation of growth temperature on the structural properties of InP QD are shown in Fig.L.10.2, where it was observed that the QD size decreases while the density increases with the decrease in growth temperature.

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L.11 : Ab initio study of the electronic and geometric structures of ultra-small single-walled nanotubes

All-electron calculations based on density functional theory have been carried out at Semiconductor Laser Section to study the electronic structures of single walled nanotubes with sub-nanometer diameters. Our studies emphasize the need for performing all-electron calculations, specifically for the nanotubes with very small diameters. A complete geometry optimization is found to be very crucial for predicting the correct electronic properties of these tubes. In the band structures of these tubes, systematic variations of a nearly-free-electron-like-state and a nearly-dispersion-free-state are observed as a function of n. From this one is able to indicate the possibility of accumulation of a *large density of states at the Fermi level*, after moderate hole or electron doping, in some of these tubes, which make them interesting for further probing. The Fermi surfaces calculated for the metallic SWCNTs show the signature of a collection of *quasi-Fermi-points*. This clearly shows the quasi-one-dimensional nature of these tubes [For more details, please see: *C. Kamal et al, Phys. Rev. B, 76, 075113, 2007*].

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L.12 : Development of zinc sulphide blanks and domes using chemical vapour deposition technique

Zinc Sulphide (ZnS), due to its transparency in the infrared region (8-12 μm range) and good mechanical strength, is used as protective windows to shield high quality infrared imaging systems on airborne platforms and as infrared optical elements. At Laser Materials & Device Development Division of RRCAT, sub-atmospheric pressure Chemical Vapour Deposition (CVD) process has been successfully implemented to produce dense, highly pure, crystalline ZnS blanks and domes of aperture size up to 80 mm. A schematic of homemade CVD reactor is shown in Fig. L.12.1.