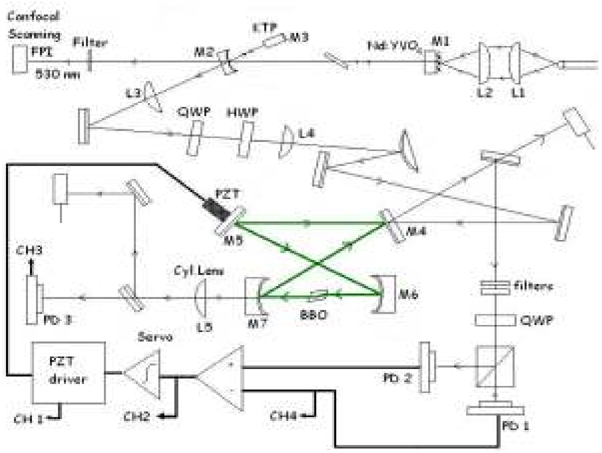

Fig.L.9 : Schematic of an all-solid-state SLM UV laser by intra-cavity doubling in a frequency locked slave ring cavity.

A relatively new concept to design optical resonators, known as the Degree of Optical Stability (DOS) or the S parameter has been used. This express the stability in a numerical scale ranging from zero to 100% with 100% corresponding to $g_1 g_2$ of ½ (Thermal lens insensitive design) and zero corresponding to marginally stable cavity. It was also found experimentally that the misalignment tolerance of a resonator is larger if the S parameter lies in the range of 60%-100%. For example, the ring cavity under consideration had ~100% DOS in the sagital direction and it was ~94% in the tangential direction. The equivalent free space distance between the curved mirrors (M6-M7) was ~109.1mm and the total length of the cavity was ~823mm.

The system generated more than 3.4mW of SLM UV laser at 266nm from an incident pump power of 200mW at 532nm. Accounting for the 26% reflection at the Brewster surface for the s-polarized UV laser at the BBO crystal, the effective collection efficiency at 266nm was only 71%, and so the estimated value of the generated UV power was ~4.78mW at 266nm. The measured short-term power stability was ~1% over 24 s.

In conclusion, an all solid-state SLM UV laser at 266nm has been demonstrated with more than 3.4mW output power by resonant cavity doubling of a highly efficient single frequency green laser at 532nm generated by diode end pumping an $Nd:YVO_4$/KTP laser with a 1W laser diode at 809nm.

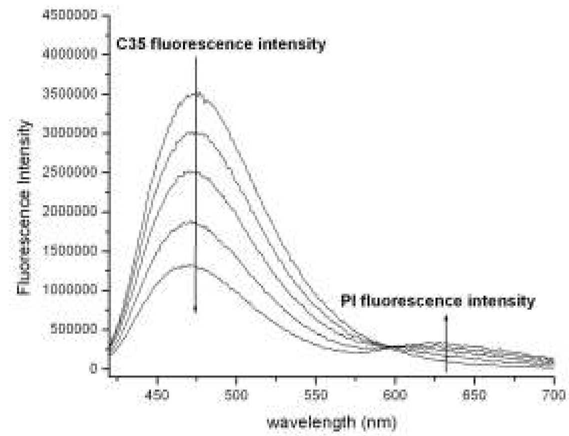

Figure L.10.1: FRET between C35 doped Si-NP and DNA labeled with PI. The arrows denote successive addition of DNA.

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L.10 : Preparation of dye-doped silica nanoparticles and exploration of their use as fluorescent probe

Silica based nanoparticles, being biocompatible and non-toxic, are receiving considerable attention for possible applications in bio-imaging and drug and gene delivery. To initiate activity in this direction, Bio-Medical Applications and Instrumentation Division has prepared silica nanoparticles (Si-NPs) in the hydrophobic core of a micellar template. Transmission electron microscopy showed a narrow size distribution with >60% particles having a diameter of ~26 nm. The Si-NPs were loaded with a fluorescent dye, Coumarin 35 (C35), and functionalized with a positively charged amino group so that they can bind to negatively charged DNA. To confirm the binding of Si-NPs with DNA, fluorescence resonance energy transfer (FRET) between the C35 (loaded in the core of the Si-NPs) and propidium iodide (PI) which is used as a stain for DNA, was investigated. Fig.L.10.1 shows the reduction in fluorescence of C35 and appearance of the band at 625 nm (that is characteristic of PI fluorescence) with an increasing concentration of DNA labeled with PI. The observation of FRET between C35 & PI confirmed electrostatic binding between DNA and the amine functionalized Si-NPs.

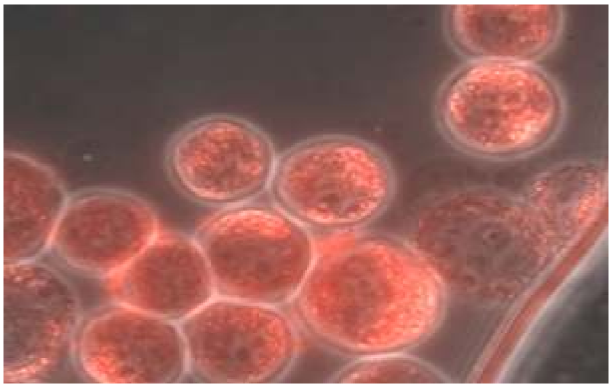

Fig. L.10.2: Fluorescence images (superimposed with phase contrast image) of Colo cells containing Nile Red doped Si-NPs after one hour incubation time. Excited at 532 nm and emission collected after 580 nm.

To use these fluorescent Si-NPs for cellular imaging, C35 is not a desirable fluorescence label because its excitation is near UV region, which may adversely affect cells. Therefore, the Si-NPs were loaded with another fluorescent dye, Nile red, having excitation wavelength in the green region and its uptake was monitored in the Colo cells by fluorescence microscopy. Incubation of Colo cells with Nile Red doped Si-NPs was observed to lead to significant intracellular staining (Fig.L.10.2). These results show that Si-NPs with appropriate functionalization may be used as fluorescent probes to target intracellular objects.

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L.11 : Development of high power laser diodes

High power laser diodes in the wavelength range of 740 nm to 1000 nm have been developed in the Semiconductor Laser Section of SSLD. The complete laser structure was grown by metal organic vapour phase epitaxy (MOVPE) technique. A typical semiconductor laser structure is consisted of about 10 epilayers with different composition, thickness and doping values. For example, a laser diode operating at 0.8 μm has either GaAs or GaAsP quantum well as an active layer. The quantum well is sandwiched between AlGaAs wider band gap waveguide and cladding layers. Laser structures 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. A quick method of laser diode processing has also been successfully implemented using shadow mask technique. Laser diodes were tested for light versus current and longitudinal characteristics using a home-made current source. Laser diodes with different cavity lengths and widths were also developed and tested for measuring the device parameters. For the laser diodes developed, an internal quantum efficiency of 92% and internal loss of 4 cm^{-1} was measured. More than 5 watt peak power at several wavelengths was achieved.

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L.12 : Fundamental studies on MOVPE grown semiconductor heterostructures

a. Studies on MOVPE growth of GaP epitaxial layer on Si (0 0 1) substrate and effects of annealing :

Growth of gallium phosphide layer on silicon substrate has been carried out using MOVPE. Epitaxial layers were grown at 845°C with a V/III ratio of 100 and a growth rate of 1.7Å/s at a reactor pressure of 30mbar. Growth of gallium phosphide epilayer was confirmed by Raman spectra studies. High-resolution x-ray diffraction studies show that the epilayer is of single crystalline nature and structurally coherent with silicon substrate. As-grown epilayer shows p-type behavior with a hole carrier density of ~$1.2x10^{18}cm^{-3}$ and hole mobility $114cm^2/V$-sec at room temperature. Annealing at 550°C for 10 minutes shows significant improvements in crystalline quality of the epilayer. The annealed layer shows a reduced hole density (~$6.7x10^{17}cm^{-3}$) and increased hole mobility ($155cm^2/V$-s). [*Ref: Dixit et. al., J. Crystal Growth 293, 5, 2006*]