based rapid scanning optical delay line (scanning frequency of 2 kHz) was used in the reference arm to achieve path length scan of about 3 mm. Lateral scanning was done at 8 Hz using a single-axis galvanometer-driven mirror. The free space axial and lateral resolutions of the setup were both estimated to be 20 μm.

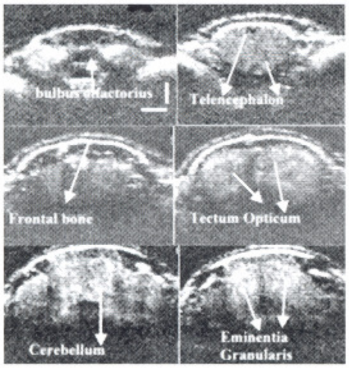

Fig. L.5.1: 2-D cross sectional OCT images showing internal structures of Zebrafish brain. Scale bar is 0.5 mm.

The real time OCT setup was used to acquire two-dimensional cross sectional images of the adult brain of anaesthetized Zebrafish. About 90 cross-sectional images (XZ plane) of the brain were taken by moving the sample in the Y direction in a step of 0.05 mm. Fig.L.5.1 shows the 2-D cross-sectional images of Zebrafish brain. Internal structures such as bulbus olfactorius, telencephalon, tectum opticum, cerebellum, frontal bone and eminentia granularis were clearly distinguishable in these images. The raw images were thresholded for minimizing the speckle noise. Using these images, a three-dimensional model of the Zebrafish brain was constructed in the axial plane (Fig.L.5.2) with *AMIRA* software. To the best of our knowledge, this is the first report of *in-vivo* imaging of Zebrafish brain structures using OCT.

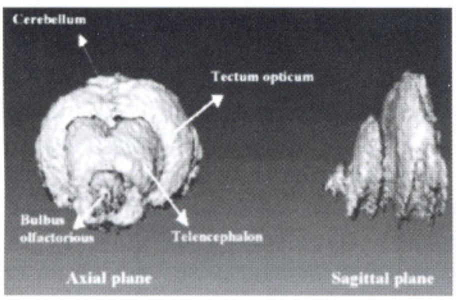

Fig. L.5.2: 3D reconstructed view of the Zebrafish brain in axial plane.

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L.6 : Development of supervisory control for Gallium Nitride metal organic vapour phase epitaxy (GaN MOVPE) system

Metal Organic Vapour Phase Epitaxy (MOVPE) is a highly controlled method for the deposition of semiconductor epitaxial layers and heterostructures, which are required for the development of several opto-electronic and electronic devices. A commercial MOVPE system has been installed at Semiconductor Laser Section of RRCAT to develop III-V semiconductor based laser devices and related material research. In view of the increasing interest in nitride based semiconductor materials for UV/near UV opto-electronic devices and high power electronics, a nitride MOVPE system is being developed for the growth of nitride based semiconductors like GaN, AIN, InN, etc. Laser Electronics Support Section of RRCAT has designed and developed a supervisory control and data acquisition system for the above MOVPE system.

The control of MOVPE machine involves precise control of gas mixture, temperature and pressure inside the reactor. This is essential in order to maintain the quality of growth. Also, since hazardous gases like ammonia and hydrogen are involved in the process, a separate interlock circuit is needed which must shut down the system in case of malfunction or gas leak.

The MOVPE machine consists of 31 mass flow controllers, 24 sensors (both digital and analog), 24 solenoid valves, compressor, vacuum system, temperature controller, and a pressure controller unit. Intelligent controllers for the control of these units have been developed. The system includes a PC for user interface, which has software running on *LabView* platform, while various intelligent controllers located inside the MOVPE machine perform the actual control task. The communication between these distributed controllers and PC is established using RS-485 network. Modbus protocol is used for data transfer. The schematic of the control system is shown in Fig.L.6.1.

Analog Input Output (AIO) controller provides the set point for Mass Flow Controller (MFC) and reads back the actual gas flow. Each controller is capable of connecting eight MFC's. The set point and read back accuracy is 12-bit. Digital input output controller can set 32 digital outputs and can read 32 digital inputs. The digital inputs are connected to sensors through signal conditioning circuits. The digital outputs are used to control ON/OFF operation of various solenoid valves connected in the gas line. In the interlock logic, sensor signal and control signal are compared and if the control operation is within the operating limit of the machine, then control operation is allowed to take place, else it is aborted.

The hardware and software of this system has been developed and installed. The view of MOVPE machine is shown in Fig.L.6.2. The system is presently being operated on trial basis. Software for automation of growth process with sequential programming feature and recipe is to be implemented soon.

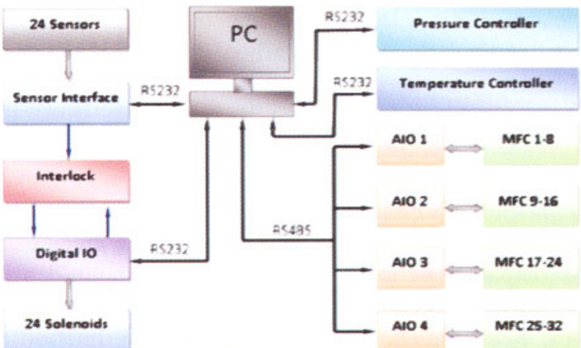

Fig. L.6.1 : A schematic of the control system.

Fig. L.6.2: A view of MOVPE system with the AIO control units in operation

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L.7: Multi-keV x-ray dispersionless spectrograph based on the x-ray CCD camera

A multi-keV x-ray spectrograph based upon back illuminated x-ray CCD detector has been set up and characterized in the Laser Plasma Division of RRCAT. This spectrograph covers a spectral range of 2 - 20 keV and has a spectral resolution better than ~3 %. It has been used to measure the x-ray continuum and K- α line emission from femtosecond laser irradiated targets.

The study of K-α radiation produced by interaction of ultra-short, ultra-intense laser pulses has been a subject of considerable importance for research investigations of inertial confinement fusion and potential application in femtosecond x-ray probing. Such x-rays originate from the fast electrons generated by the laser interaction with the target surface. They penetrate into the cold target material to generate continuum hard x-ray bremsstrahlung and characteristic K- α line radiation.

The underlying principle of a dispersionless spectrograph is operation of a solid state detector (such as Si(Li), Ge(Li)) in "single photon counting" mode. The incident x-ray photon converts into electron-hole pairs whose number is proportional to the incident photon energy. The photon energy is stored into the energy channels of a multi-channel analyser and the spectrum is built over several events. However, such a system tends to be bulky, costly, and needs data to be collected over several thousands of shots. In order to make the spectrograph compact and single-shot, an x-ray CCD camera has been used as the detector. In this case, the spectrum is simply a histogram of the energy of the x-ray photons received by the various pixels of the CCD. Thus, it enables one to record the spectrum without any dispersive element. Back-side illuminated, thinned CCD cameras are preferred to extend the detection range to high x-ray energies.

The high energy x-ray spectrograph has been set up and characterized for recording x-ray spectrum from plasma produced by 45 fs Ti:sapphire laser focussed to an intensity ~10^{18} W-cm^{-2}. The spectrograph consists of an x-ray CCD camera (Reflex SRO, Model: X-Vision 4M) equipped with a back-illuminated chip (E2V) consisting of 2048 x 2048 pixels, each of 13.5 x 13.5 μm^2 size. The CCD chip has a regulated two-stage thermo-electric cooler to cool the CCD chip down to -30° C to reduce the thermal noise. The CCD output is digitalized by a 16 bit ADC. The readout noise is < 7 counts (rms) at 30° C. The detector is kept at a distance of 580 mm with a collimator subtending a solid angle of ~ 9.3 x 10^{-4} steradian. Appropriate filters (depending on target material) are used to attenuate the signal to operate in single photon counting mode (i.e. not more than one photon falls on each pixel every shot). The data was analysed with the versatile image processing software *"Promise"* developed by the Laser Systems Engineering Division of RRCAT.

The spectrograph was used to record the x-ray