CHAPTER-VI

GENERAL CONCLUSION AND FUTURE MODIFICATION OF
THE DESIGNED OPTOELECTRONIC SYSTEM:

6.1. SCOPE OF FUTURE MODIFICATIONS IN SYSTEM DESIGN:

The present research work as reported in the previous chapters have been carried out in designing a modest laser based optoelectronic system which is simple enough to be used as a first hand tool for the study of thin films as well as characterization of semiconductor devices. Although various sophisticated characterization techniques such as AFM, STM, SEM, TEM etc. are available nowadays for surface studies, they are costly and not easily available in laboratories. They are also complex to operate and maintain. Taking into account the above factors, a simple laser based optoelectronic system for studying surface properties of thin films and characterization of semiconductor devices has been designed and fabricated. Utmost efforts have been put to make the system flexible, user-friendly, compact as well as cost-effective at the time of designing. Also, our research work was concerned with the designing of the optoelectronic system with high resolution at a lower cost with as many as locally available materials and components without compromising the quality of the system.

Although utmost care has been taken while designing and experimenting with the optoelectronic system, we have come across certain
shortcomings which will need future modification. Although, numerous advantages of the designed system have been found such as:

(i) Flexibility
(ii) User-friendliness
(iii) Compactness in size (3’ × 1.5’ × 1’)
(iv) Light weight (10 Kg. approx.) and easily portable.
(v) Cost-effective (Rs.20,000/- approx. excluding the laser source and the PC)
(vi) Easy to repair and maintain

The following difficulties have been observed while experimenting with the designed optoelectronic system despite being designed with utmost care:

(i) Although suitable noise suppression has been done at different sections of the designed system, the effect of RF noise from the AIR Guwahati Radio Station, which is close to our laboratory premises, is found to be quite significant on the experimental results. Therefore, the experimentation with the designed system has been carried out during night hours after closing the Radio Station.

(ii) Despite being properly shielded and utmost care taken, certain amount of effect of stray light on experimental observations taken during day time have been found to exist due to the use of high quality and highly sensitive detectors. Therefore, most of the observations under the designed system have been carried out during night hours.
(iii) In the present system design, an external He-Ne laser source has been incorporated with its own separate power-supply unit for scanning the specimen under study. With use of this external laser source, alignment problem arises too often whenever its position gets disturbed during experimentation.

Taking into account the above mentioned difficulties (i) and (ii), the designed system will need certain modifications in future for day time experimentation without any dark-room facility. There is also scope for making the laser source an integral part of the system itself by replacing the external laser source with semiconductor laser incorporated inside the system which is much cheaper and easily available nowadays. Also, there is scope of making the system design more compact by rearrangement of its various sections.

Apart from the future modifications as regard to the above mentioned shortcomings of the designed optoelectronic system, future plan of the present research work includes PC interfacing of the present set up to make the system PC based.
6.2. COMPUTER INTERFACING OF THE DESIGNED OPTOELECTRONIC SYSTEM:

Acquisition and analysis of data under the present optoelectronic system has been carried out with the help of Cathode Ray Oscilloscope (CRO), digital camera and Laptop PC as discussed in Chapter-II of this thesis. The output analog signals displayed on the CRO has been photographed by a high resolution digital camera and then transferred to PC for final analysis and processing which is quite a delayed process. Therefore our future plan is to Interface the designed system with computer for analysis and storing of the data at a much faster rate. Also interfacing of the system with computer gives a much detailed output as well as gives scopes for processing the output signal of the optoelectronic system in making the image of a specimen. A brief idea of our future scheme for computer interfacing of the designed system set-up has been put forward in this chapter.

As described in Chapter-II the basic principle of the designed system involve the information collection of spatial transmittance of a specimen probed point by point mechanically through a focused laser spot at the focal point and finally obtained as a series of time varying signals by photo-detector. The voltage-time signal obtained from the photo-detector is then amplified and processed by electronic circuits and generates the image of the specimen point by point in a CRO screen by locking its raster to the scanning raster. To get an actual space image of an object, in place of voltage-time signal a voltage-space signal is obtained by replacing the signal generator by a microprocessor based processing and display unit for which suitable hardware and associated software programming is necessary.
Fig. 6.01 shows the schematic diagram of the present system design and Fig. 6.02 shows the future scheme for interfacing the designed optoelectronic system with a computer. Some part of the proposed scheme has already been designed and implemented successfully.

Interest in digitization of an analog system and digital image processing stems from two principal application areas: Improvement of pictorial information for human interpretation and processing of scene data for autonomous machine perception. One of the applications of image processing technique in the 1st category is sending a picture in digital form and in 2nd category is that of scanner.
Fig. 6.01. Schematic diagram of the present system design
Fig. 6.02. Scheme for Computer Interfacing the Designed Optoelectronic System.
For carrying out various experiments as related to conversion and digitization of signal data and digital image processing, a typical computer must consist of the components, e.g.:

(i) an analog to digital converter (ADC) which would convert the analog signals as acquired by the sensing device into digital form so that it would become possible for the central processor to process those digital signals;

(ii) a data latching circuit for latching the digital data obtained from the A/D circuit and buffers them till the computer read them all one by one bit at a time in serial fashion.

(iii) A central processor which would interpret and analyze those information and display the results.

To provide the above mentioned facilities, the proposed computer vision system to be developed for digitization and intelligent image processing of the information from the present optoelectronic system will have to be equipped with the following elements, i.e.:

The data converting circuit will comprise of an A/D converter to covert the analog signal to a digital form of 1 and 0 levels for computer processing. After digitization of the signal the data is transferred to a Data Latching Circuit. The data latching circuit latches the digital data obtained from the A/D circuit and buffers them till the computer read them all one by one bit at a time in serial fashion. The serial interface provides the necessary circuitry for serializing the parallel data obtained.
from the data latching circuit. It will also convert the TTL logic levels to the RS-232 compatible logic level i.e. 0 to +12 volts and 1 to -12 volts.

The PC will take the data supplied to it via the COM1 port. The port will be used in the receiving mode. In the receiving mode, the port uses its own receive data line.

The control logic circuit comprises of a decade counter and a timer. The pulse wave generator supplies the required clock pulses to the counter as well as the shift registers comprising the data latching circuit. The output of the counts produced by the counter is decoded by a logic circuit comprising of 4-input NAND gates and an inverter. The decode output is fed to the data latching circuit and the serial interface card.
6.3. PREPROCESSING OF THE SENSED IMAGE FOR NOISE REDUCTION:

Preprocessing has been the process of filtering or transforming the raw input data so as to aid computational feasibility, feature extraction and noise reduction. In pattern recognition, the concept of noise would represent a number of non-ideal circumstances, including distortions or errors in the input signal/pattern, errors in feature extraction etc. The key function of preprocessing has been to improve the image quality in various ways that would increase the chances of success for further processes. Preprocessing would typically deal with the techniques for enhancing the contrast, removing noise and isolating regions etc. The neighborhood averaging method has been found to be one of the simple techniques as used for image smoothing which would generate a smoothened image by averaging the intensity values of the pixels of the predefined neighboring points of every pixel of the given image. But this technique would cause blurring of the edges and other sharp details of the image. This difficulty of neighborhood averaging can be reduced by using filters which would transform the image intensities in some way so as to enhance the features of the image. There has been a number of filtering methods which can be enumerated as below¹:

(a) Template Matching: Template matching has been a filtering method for detection of a particular feature in an image. While appearance of this feature in this image would be known in advance, it can be detected in the image with the help of an operator called as template. A similarity measure has to be computed which would reflect how well the image data would match the template for each template location. The point of maximal match would then be the location of the desired feature.
(b) Histogram Transformation: A grey-level histogram of an image has been a function that would represent graphically the frequency of occurrences of each grey level in the image. In the histogram, the background and the object pixels has to be grouped into two dominant modes. A threshold value $T$ has to be selected which would separate these two modes. Then the background would consist of those pixels whose grey-level $< T$ and the object would correspond to the pixels whose grey-level $> T$.

(c) Background Subtraction: Background subtraction can be as another filtering method during preprocessing. Many images can have slowly varying background grey-levels; background subtraction would attempt to remove these variations by first approximating those by a background image $fb$ and then subtracting this approximation from the original image. Thus the new image $fn$ could be given by the following expression:

$$ Fn(x) = f(x) - fb(x) \quad \ldots \ldots \ldots \quad 6.01 $$
6.4. IMAGE THRESHOLDING FOR BINARY CONVERSION:

Thresholding has been found to be one of the most important approaches for image binarization. Thresholding can be performed with the help of histogram. A histogram has been the graphical representation showing the distribution of pixels as a function of intensity values. A black pixel has the lowest intensity value of 0 and a white pixel has the highest intensity value of 255. If an object \( f(x,y) \) would represent light objects on a dark background, then the object and background pixels can be grouped into two dominant modes. For the image, a threshold value, \( T \) has to be selected that would separate these two modes. If an image has been composed of reasonably evenly illuminated pixels against an evenly toned background, then a histogram of the brightness levels would show two distinct peaks: one of the foreground and the other for the background. A histogram of this nature, having two peaks is termed as bimodal histogram. If a threshold has to be chosen to separate these two peaks, the background would be assigned with a value 0 and the foreground would be assigned with a value 1, thus giving good representation of the original image. A pixel \((x,y)\) for which \( f(x,y) > T \) can be called as an object pixel. A threshold image \( G(x,y) \) can be defined as below:

\[
G(x,y) = \begin{cases} 
1 & \text{if} \quad f(x,y) > T \\
0 & \text{if} \quad f(x,y) < T 
\end{cases}
\]
6.5. CONCLUSION:

The above discussion shows the possibility of designing a more compact, user friendly, low-cost and portable modified form of a PC based optoelectronic system for thin film and semiconductor studies by interfacing it with computer by fulfillment of necessary and suitable hardware and software requirements as well as intelligent image processing.
Reference:

1. Mrs. R. Bordoloi; Ph.D. Thesis; Jadavpur University; 2002.