CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 Summary :

A computer controlled automatic DLTS system has been designed and developed. The system consists of the following modules.

1. Data acquisition system
2. Voltage source
3. PID temperature monitor and controller
4. DLTS controller
5. Programmable bias pulse generator
6. Baseline restorer and amplifier
7. Thermocouple signal conditioner and amplifier and
8. sample cryostat.

All the modules are integrated and suitably interfaced to the computer. Suitable software in TURBO BASIC has been developed to enable the the computer to control the working of the DLTS controller, to collect and analyse the data, for extraction of deep level parameters such as activation energy, capture cross-section and trap density.

This spectrometer has been used to study the deep levels of platinum silicon and process induced deep levels in aluminium deep diffused thyrisor grade silicon.

The PID temperature controller maintains sample temperature with an accuracy of ± 0.2°C in the range of 77K to 300K.

The sensitivity of the data acquisition system is 2.4 mV. This system is provided with facility to work in software control mode or hardware control mode. In hardware control mode, used for capacitance data acquisition, the data transfer is done by interrupting the computer thereby, most of the computer time is used in temperature control and graphics display etc. Programmable bias pulse generator constructed as part of the DLTS controller works well. It can supply bias pulses to the test device in the range of +5V to −10V in steps of 40mV. Pulse width minimum to 100 ns can be produced with this circuit.

The developed DLTS controller provides all control signals required for running the DLTS experiment. Once this module is loaded with the desired parameters then it become independant of computer except for trigger pulse for every set of data acquisition. This module takes care of the distortion of the bias pulse (when the bias pulses are very short) due to internal bias circuit of the capacitance meter. Further, as this system run on its own clock, the parameters that are controlled by this circuit is independant of the computer clock.

Thermal activation energies (Ec−0.28 eV,Ec−0.522 eV) and capture cross-sections (2.2 x 10^{-15} cm^2, 4.3 x 10^{-15} cm^2) of the platinum related acceptor levels are estimated using

DLTS. It is observed that the midgap level Ec-0.522 eV anneals out near the surface at 450°C. It is also observed that after gamma irradiation the concentration of the Ec-0.52 eV level increases substantially. These results suggest the origin of the midgap level may be due to interstitial platinum-divacancy complex.

Further, hydrogenation of the platinum diffused samples reveals that hydrogen is passivating acive platinum in n-type silicon. Thermal reacivation of the platinum levels upto 80% is achieved when the samples are annealed at 500°C for 10 minutes. The estimated thermal reacivation (2.6 eV) compares well with the reported values.

Studies carried out on the aluminium deep diffused thyristor grade silicon under different ambients show different process induced deep levels. Diffusion carried out in oxygen ambient gives only two deep levels (0.22 eV and 0.49 eV), whereas diffusions carried out in vacuum gives four deep levels (0.23 eV, 0.28 eV, 0.32 eV and 0.50 eV). Further, diffusions carried out with fresh quartz tubes give two deep levels only. It is observed that the minority carrier lifetimes in the devices prepared under the above conditions very short (around < 6 μs). Gettering of these deep levels is carried out by diffusing boron and phosphorous seperately. The minority carrier lifetimes are substantially increased to 120 μs (in the case of boron) and 28 μs (in the case of phosphorous).

DLTS studies and RBS results of the aluminium doped silicon reveal that the major contaminants are platinum and iron related.

5.2 Limitations and shortcomings :

Because of the lack of processing facilities in our laboratory, platinum diffusion and hydrogenation are carried out at Solid State Laboratory, Department of Physics, Indian Institute of Science, Bangalore, India. And Al,Ga,B and P diffusions are carried out at the devices laboratory of M/S Bharat Heavy Electrical Limited, Bangalore, India. The gamma ray irradiations are carried out at Bhaba Atomic Research center, Bombay, India. Since the access to the facilities are limited, we could not vary the process parameters to underatand the exact origin of the platinum related acceptor level (Ec-0.52 eV). Also, the exact source of impurities in the aluminium diffused samples could not be identified with the limited variation of the process parameters. As the junctions used for DLTS (Al diffused samples) are linearly graded, it is not possible to assign the observed levels either to the conduction band or to the valence band.

DLTS measurements are limited to 77K and above only. This restricts the range of measurements to deep levels greater than about 0.15 eV from the respective band edges. Further the response time of the capacitance meter (100 µs) and the conversion time of the ADC (35 µs) limit the study of capacitance transients not faster than 500 µs.

5.3 Suggestions for future work :

For understanding the nature of the platinum acceptor levels Ec-0.52 eV further, further work is necessary such as

i. Annealing characterstics of this level at different depths in the sample.

ii. Irradiation studies by varying the dose and energy of irradiation.

Schottky barrier dioded may help in assigning the observed deep levels to the band edges in the case of aluminium deep diffused thyristor grade silicon.