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Digital DLTS studies on radiation induced defects in Si, GaAs and GaN

by

Walter Ernst Meyer

Submitted in partial fulfilment of the degree

PhD (Physics)

in the Faculty of Natural & Agricultural Science

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Supervisor: Prof F D Auret

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Since the development of deep level transient spectroscopy (DLTS) in the 1970's by Lang and others, the technique has become a powerful analytical tool to characterise the electrical properties of defects in semiconductors. With the development of more powerful computers and improved data acquisition systems, it has become possible to replace the original analogue boxcar analysers and lock-in amplifiers that were commonly used in early DLTS systems with digitisers and digital signal processing equipment.

The use of a computer for signal processing allows for much more flexibility in the DLTS system. For instance, a digital DLTS system is capable of measuring a much wider range of emission rates than an analogue system. Furthermore, since the digital DLTS system does not rely on a repetitive signal, such a system can observe phenomena such as defect metastability that cannot be observed in an analogue system.

In this thesis, the design and characterisation of a digital DLTS system is described. The results of a number of experiments that illustrated the capabilities of the system are reported.

The extended range of emission rates that could be measured by the system were illustrated by the measuring of the EL2 defect in GaAs over the temperature range 270 – 380 K (corresponding to emission rates ranging from less than 10^{-3} s^{-1} to more than 10^{3} s^{-1}). The results compared well with previous results obtained by means of an analogue DLTS system. Further low temperature measurements on the E2 defect in GaAs showed that in the low temperature region, thermal radiation from the cryostat shroud influenced carrier emission.

The field dependence of the emission rate of a number of defects, including defects in as-grown n-GaN, He-ion irradiated n-GaN and Si, was investigated as well.

The ability of the digital DLTS system to measure single transients was used to investigate configurationally bistable defects in He-ion irradiated *p*-Si and a sputter-induced defect with negative-U properties in n-GaN. In both of these cases, the results proved far superior to those obtained by means of an analogue system.

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