CHAPTER 8

CONCLUSIONS

The effect of module design flaws was studied by using *I-V* curves obtained from each module in the array of a commercially available high concentration point focus concentrator PV system. The position of reverse bias steps revealed the severity of mismatch in a string of series-connected cells. By understanding the effects of the various types of mismatch, power losses and damage to the solar cells resulting from hot spot formation can be minimized, and several recommendations for improving the basic performance of similar systems were made.

An overview of existing and developing LBIC techniques revealed that the original standard LBIC techniques have found widespread application, and that far-reaching and important developments of the technique have taken place over the years. These developments are driven by natural progression as well as the availability of newly developed advanced measurement equipment. Several techniques such as Lock-in Thermography and the use of infrared cameras have developed as complimentary techniques to advanced LBIC techniques. As an accurate contactless evaluation tool that is able to image spatially distributed defects in cell material, the basis of this method seemed promising for the evaluation of concentrator cells.

A study on the theory of the interaction of light with a solar cell revealed factors that affect the efficient operation of solar cells. The influence of these factors at high photon flux densities and changing cell biases are discussed. The interactions of a beam of narrowly focused monochromatic of concentrated solar light with the different parts of a solar cell structure were also discussed.

Practical limitations were found when using a concentrated solar beam to perform LBIC scans. Measurement precautions also had to be taken into account when dynamically applying an alternating voltage to a solar cell. Steps taken to limit these effects were discussed.

The results of S-LBIC scans that were performed on solar cells demonstrate that the defects yielded a signal response that more closely resembles the electrical behaviour of defects under full spectrum outdoor solar radiation. This was verified by comparing the results from the S-LBIC system with results obtained by using a high intensity He-Ne laser as a beam probe.

The biasing and scanning of flat plate multi-crystalline and EFG Si solar cells with full spectrum solar radiation revealed that the grain boundaries are visible even under high carrier saturation conditions. The induced current response from certain grain boundaries seems also to be bias dependent. Results of S-LBIC scans on one of the point-contact concentrator Si cells revealed that no material related defects or degradation occurred.

A basic one-diode model was used to fit parameters to the current-voltage (*I*-*V*) data that was extracted from the bias dependence of the S-LBIC

measurements. Although the extracted cell characteristics are not directly quantifiable, the results from the fitted *I-V* characteristics show that the relative values obtained for R_{shunt} and R_{series} give a useful impression of the spatial distribution of these characteristics. It was also found that erroneous conclusions are made when simply mapping the measured shunt and series slopes obtained from the measured *I-V* data. Trends and features that would normally not be visible by using the measurements from standard LBIC techniques were found by using the newly developed parameter fitting technique.

The novel S-LBIC measurement technique that is described in this study may be extended in future research efforts to include the characterization of direct band gap III-V PV materials as well as several polycrystalline thin film materials and other novel multijunction structures. Although this technique is specifically suited to materials and structures that operate optimally under high illumination levels, the high carrier saturation conditions that are achieved at the beam probe position my lead to a significant amplification of the effects of some existing defects as well as the creation of new stress induced defects that are not commonly found in PV materials under normal operating conditions. The full solar spectrum composition of the S-LBIC beam probe may improve on standard LBIC investigations of high efficiency, novel tandem and multiple band cells that are optimized for wider solar spectrum absorption.