IPID4all Research Internship at the University of Oldenburg

Feedback report

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Exchange Topic: Photoluminescence investigation of thin film solar cells

Introduction

The Laboratory for Chalcogenide Photovoltaics (LCP) Group under the Energy and Semiconductor Research in University of Oldenburg works on the material sciences of chalcogenide semiconductors and their applications to solar cells and modules. The group works specifically on the physics of heterojunction solar cells and the efficiency limiting properties of the materials being used. Furthermore, the group explores the lateral and vertical inhomogeneities of the cells being developed. Under the supervision of Dr. Stephan Heise, I worked on the inhomogeneities of thin film solar cells by investigating their photoluminescence response.

Research Undertaken

Photoluminescence (PL) investigation is a common technique to characterize solar cells. It provides information on the absorber quality of solar cells. The LCP group of the University of Oldenburg has been working on PL characterization of thin film solar cells. The purpose of this work is to look into the inhomogeneities of thin film cells by investigating its laterally resolved PL response.

An existing PL setup was modified for the purpose of this work. The light source used in the setup is provided by a continuous laser and a pulsed laser. A deflecting mirror is used to choose between the two light sources. An optical chopper with a specific chopper frequency was coupled with a lock-in amplifier. A series of various optical components were also placed to direct the light onto the sample. This then excites a sample cell to produce PL emissions. The PL emissions are gathered through a collecting lens that directs it to a monochromator before it is being fed to a detector. The detector is also connected to the lock-in amplifier to synchronize with the chopper frequency and the measurement frequency. An existing script developed in Labview is used to gather the PL emission measurement before the data is saved. In the initial setup, single point measurements(single wavelength or full spectrum PL measurement) are done at different areas on the cell. The main objective of this work is to investigate the inhomogeneities of thin film solar cells. This was attained by implementing a 2D scanning feature that enables PL measurement on a selected scan area on the cell. Before the implementation of the 2D scanning feature, the ideal illumination spot size and optimum motor step size, based on the measured spot size, were determined.

The spot size was adjusted by placing a focusing lens in the optical path before the sample. The spot was measured using a beam profiler that provides necessary information such as the dimensions and shape of the beam. The step size was chosen based on the dimension of the illuminating spot.

The scanning feature which was added to the existing PL script of the setup allows a 2D measurement scan. Motor stages were controlled by the script to move the sample in a bidirectional raster pattern wherein PL measurements are done at every point in the selected scan area. The amount of measured points were based on the dimensions of the scan area and the selected step size. The PL measurements were saved in a data file for every measurement point. The script then compiles these data files into a single file that can be used to provide a 3D graph showing the PL level at each point of the scanning area. The gathered data files may also be used in a different existing Matlab script to fit time constants to PL decays.

A separate LabView script was also developed to measure the edge resolution of the system. The system measures the PL yield along a straight line from an active region to an inactive region (usually busbar or finger). This gives a PL-yield vs position graph. The graph is differentiated to provide a gaussian-like curve. A gaussian model is then fitted on the data. The FWHM of the gaussian model is calculated using the fit parameters. The calculated FWHM then represents the edge resolution of the system.

The expected task was finished ahead of time allowing for an extra task to be done. The second task was to implement the same scanning feature on a different setup, time-resolved photoluminescence (TRPL). The TRPL setup is more complicated due to the unavailable software support. This unavailability served as a challenge to implement the same scanning routine. However, a temporary workaround was developed to achieve the desired output.

Personal Experience

This internship is a very humbling and enriching experience. Being alone in a totally new place and culture was a challenge for me, but the welcoming and helping environment in the University of Oldenburg made everything possible. The research experience was fun due to the approachable people that I work with. I rarely felt alone on my work because every time I have questions or clarifications, everyone was willing to help. The city is great and has everything that I need to enjoy my stay in Germany.

Conclusions

PL investigations of various thin film solar cells were able to show the inhomogeneities on the cell by using laterally resolved PL measurement. Inhomogeneities were found to have a standard deviation less than 1%. The PL setup may now be used for future data gathering that requires lateral PL measurement.

Outlook

- Having similar studies for the host and visiting university, an exchange of data was discussed to compare results on the topic.