Analysis of THz Time Signals for Defect Inspection of Si Solar Cells

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Abstract:

This work presents the analysis of THz time signals for the detection of defects in poly-crystalline Si solar cells under forward bias. The reflected THz signal from regions at the solar cell with and without defects were acquired using a time-domain terahertz imaging system. Electroluminescence measurements of the solar cell were utilised for the validation of the defect and defect-free areas

Introduction

Terahertz (THz) radiation occupies the region of the electromagnetic spectrum in between infrared and microwaves radiation. It offers innovative imaging and sensing applications in photonics and semiconductor technology. There are numerous examples of material evaluation, many of which could lead to a new industrial applications.

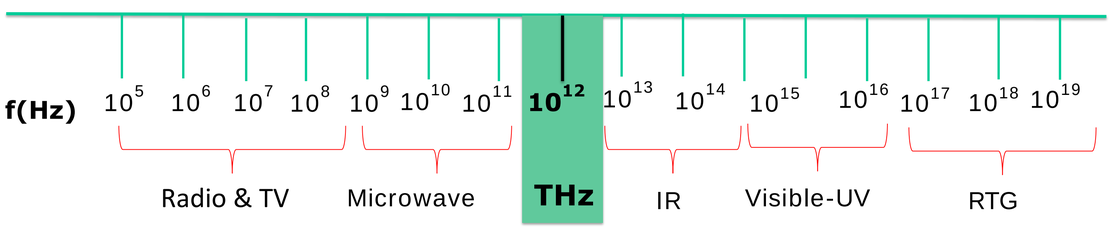

Fig. 1: The electromagnetic spectrum with the terahertz radiation

THz-System

The THz time-domain imaging system can generate and detect THz pulses in either transmission or reflection geometry. The femto-second laser pulse is split into a pump and probe beam used for THz generation and detection. A photoconductive antenna is used to generate the THz radiation and an electro-optical ZnTe crystal is used to detect the THz response. By varying the delay between pump and probe pulse the THz signal is coherently acquired.

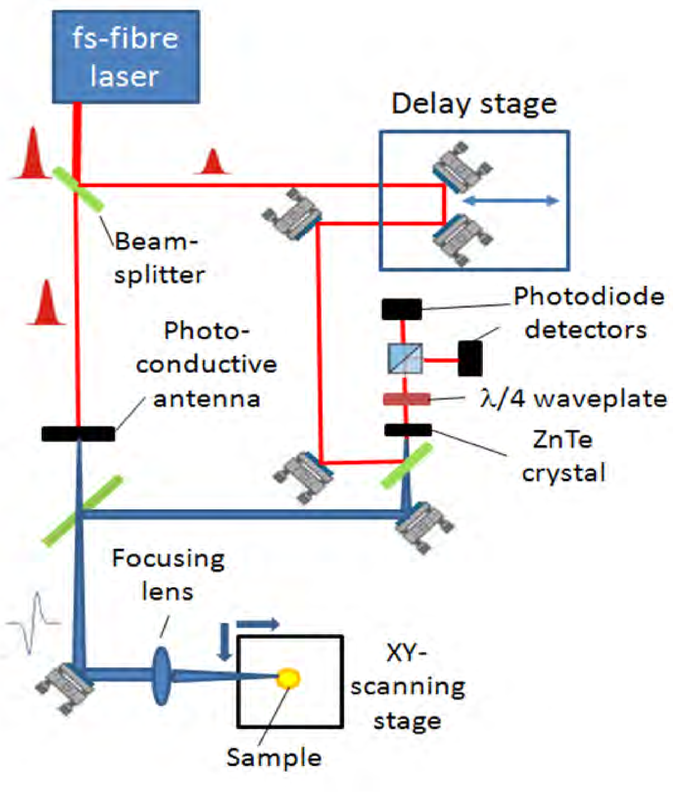

Fig.2: Schematic diagram of THz Time domain system

Defect analysis in Si- solar cells using THz signals

A THz-TD system can be used to characterize Si solar cells properties such as: conductivity, charge carrier mobility and density. This technique can also be applied for imaging and sensing of industrial materials, defect analysis in semiconductor and photovoltaic technology.

Experiment

A Si-Cell with two cracks and a couple of defects was analyzed using electroluminescence with 3 A forward current (Fig.3). Subsequently this solar cell was analyzed with the THz TD system in reflection mode with a forward current of 3 A. The reflected THz signal of defect and defect-free regions is shown in Fig 4.

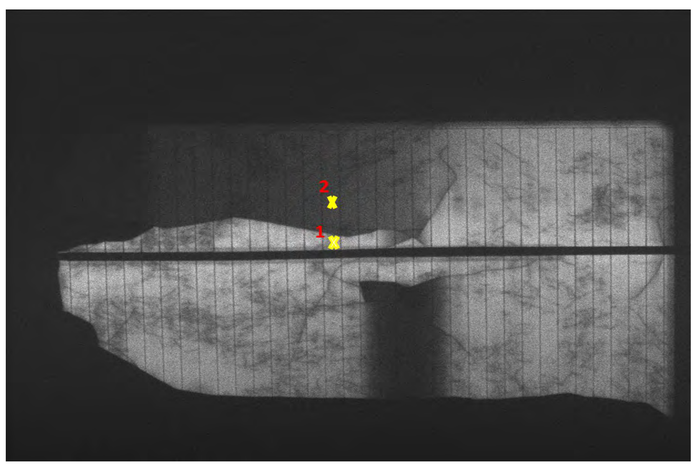

Fig. 3: Electroluminescence image of the Si solar cell. The emitted photons under forward bias were captured with a EMCCD camera to obtain an image of the distribution of radiative recombination in the cell. Dark areas indicate lower emission intensity caused by cracks or defects in the cell.

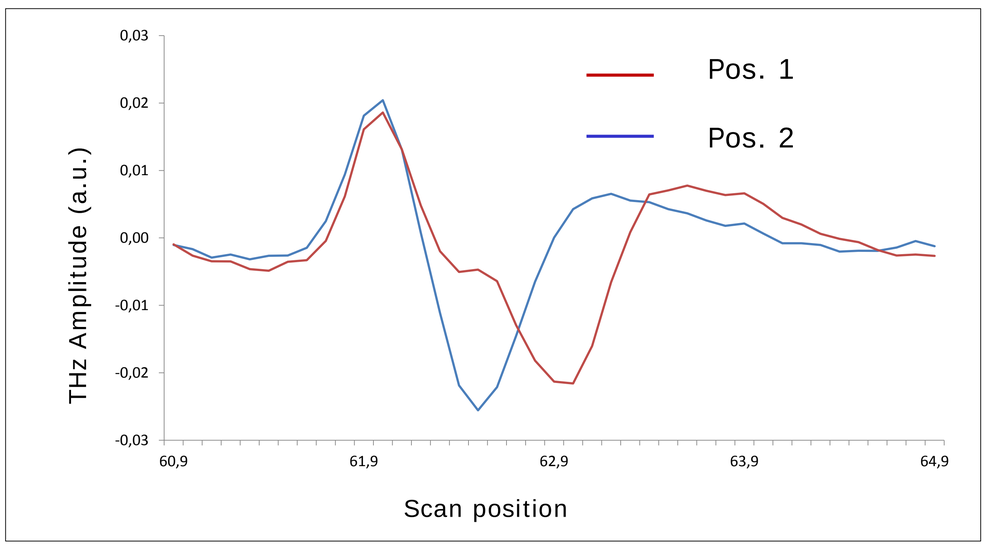

Fig.4: THz reflected signal of Si- solar cell from two different measurement positions (pos. 1, and pos. 2, see Fig. 3) under forward bias with 3A load current were detected. A significant shift of the negative peak between defect and defect-free positions is examined.

Conclusion

The THz response from different position on the surface of a solar cell under forward bias in reflection mode was measured. A comparison of the detected signals from different regions on the Si cell showed a time shift in the negative peak. The potential of these effects to the characterise solar cells is being investigated further .

References

- M. Tounouchi, Cutting-edge THz technology, nature photonics, Vol. 1, 2007
- A.Tae, et al., Characterization of optically dense, doped semiconductors by reflection THz TDS, Appl. Phys. Lett., Vol.2, No. 23, 1998
- M. Yamashita, et al., Conf. Optical Science and Technology, Florida, 2005

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