16a-D4-7

Solar cell materials as THz emitters: the THz emission of CZTS

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1. Introduction

One major benchmark for the developed of economic solar cells is the ratio of costs per watt. In this context, due to the low amount of material being used, thin-film solar cells promise to save both material and energy [1].

In this regard, it is a drawback that successful solar thin-film like $Cu(In_xGa_{1-x})Se_2$ CIGS have to use expensive elements like In and Ga. Therefore, research aiming for alternative materials is crucial. Recently, Cu_2ZnSnS_4 (CZTS) is discussed to be a promising candidate for the development of thin-film solar cells [2]. Although, by now, the efficiency compared to CIGS is not as high, rare and costly materials like In and Ga are replaced by abundant materials like Zn and Sn in CZTS. Additionally CZTS is not as toxic as CdTe, which is also used for thin-film solar cell.[3]

2. Results

Here, we show that CZTS emits THz radiation during excitation using a THz time-domain spectrometer. Thereby, the sample was exited using a reflection geometry by a 800 nm fs Ti:Sa laser with a repetition rate of 80 MHz. A photoconductive dipole antenna served as a detector and the probed signal was modulated using an optical chopper with a frequency of 2 kHz. The resulting current modulation was then analyzed using a Lock-in amplifier.

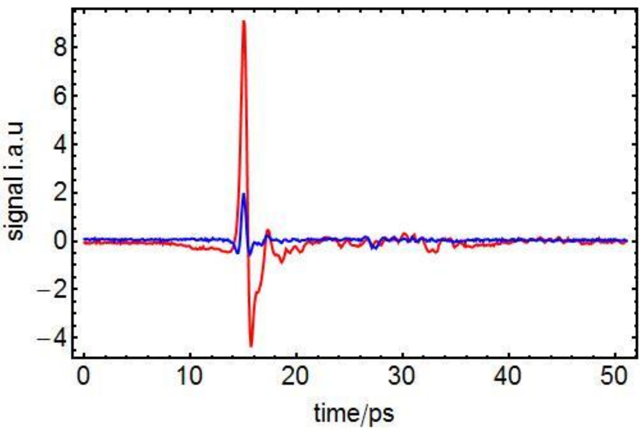

Figure 1 Shown are the THz time domain spectra for CZTS grown on glass(red) and quartz(blue).

The observed samples were grown on two different substrates: glass and quartz. During this process, CZTS crystalizes in grains on the substrate surface. Using SEM technique, it could be shown that the grain size for samples grown on glass exhibits significant larger grains compared to the one grown on quartz.

In the experiment it was observed, that CZTS grown on glass as well as on quartz emits THz radiation while pumped by 800 nm fs pulses. The measured time-domain waveforms are displayed in Fig. 1. The corresponding frequency domain spectra reveal THz emission of the samples higher than 1.5 THz. The intensity of the emitted radiation is smaller for the sample grown on quartz.

Furthermore, we measured the maximum peak intensity of the THz radiation with respect to the azimuthal angle as well as the fluence dependence of the incident pump beam. Surprisingly, for both substrates a single cycle for the azimuthal dependence was observed.

3. Conclusions

We could observe THz emission by the solar cell material CTZS. First measurements are done to determine the underlying process. Due to the low carrier mobility, the photo-Dember effect being the main process is not favorized. Furthermore, magnetic field dependence measurements are planned to gain insides to the emission process. In the future, our findings may help to get a deeper understanding of the charge carrier dynamics while supporting the development thin-film solar cell technology based on CZTS.

Acknowledgements

S. F. likes to grateful acknowledge the Alexander von Humboldt Foundation and the Japan Society for the Promotion of Science (JSPS) for supporting his work through the JSPS postdoctoral fellowships.

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