Improving the Sensitivity of Terahertz Spectrometer by Implementing a New THz Spectroscopy Set-up

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Introduction:

Solar energy is converted into electricity when sunlight strikes a solar cell. How electrons transport through a solar cell material has a large impact on the efficiency of a solar cell. Terahertz wave (THz) is a type of radiation that can be used to study electron transport in a material. Conductivity of a material after optical light excitation is determined by THz absorption. The more conductive a sample is, the more THz is absorbed. Our research will provide insight on electron conduction mechanism in solar energy materials.

In the current set-up, we use a laser amplifier to generate THz pulses. In this work, instead of a laser amplifier, we use the seed laser pulses and a large-area-photoconductive THz emitter to generate THz. The new system emits 100,000 times more THz pulses per second, which improves the sensitivity of the THz spectrometer. The new system is used to study conductivity of samples.

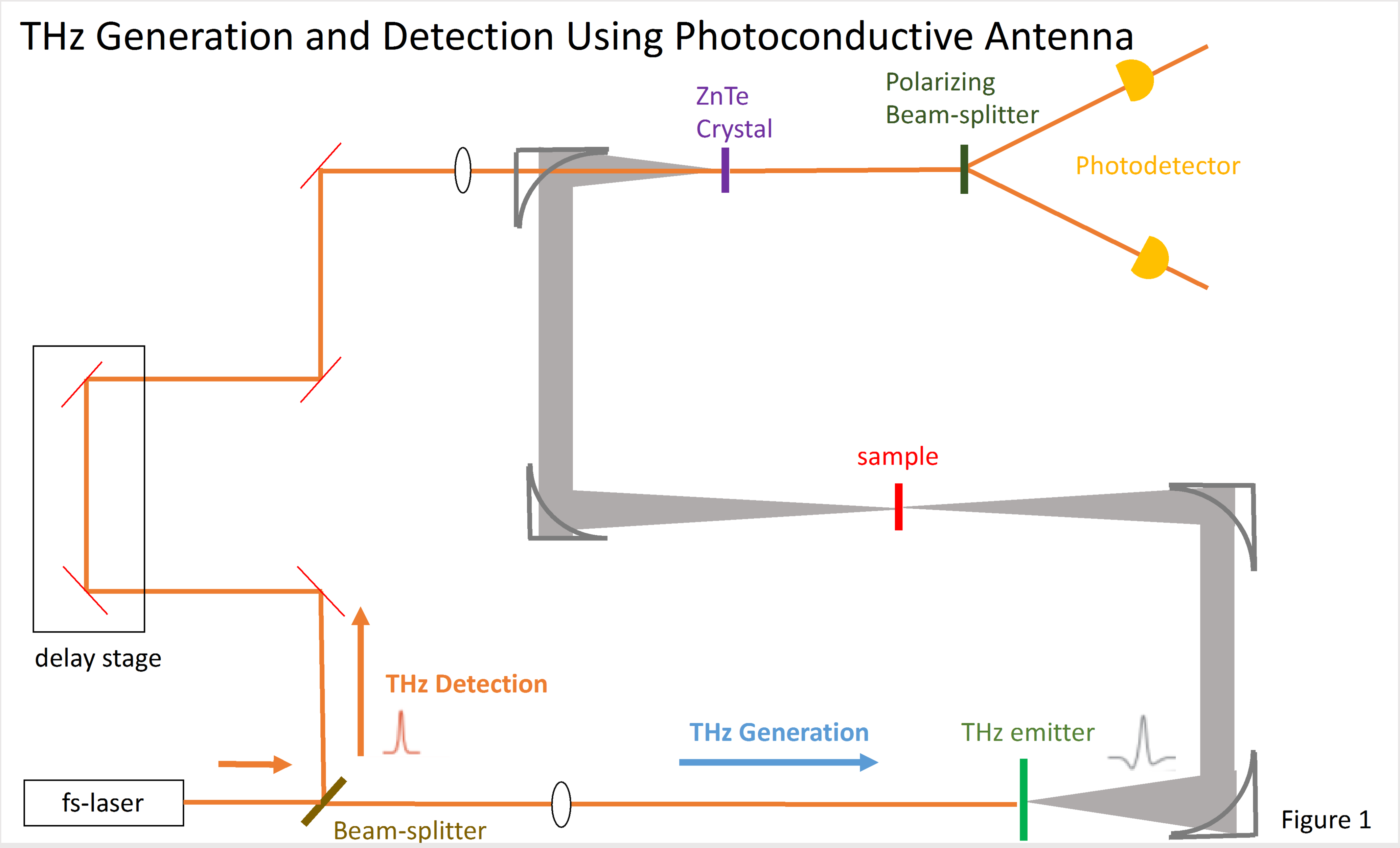

Figure 1

THz Generation and Detection:

Incident laser generate laser pulses that splits into two paths: THz generation path and THz detection path (Figure 1). A THz pulse is generated when a laser hits the THz emitter. The laser pulse excites electrons in the emitter, and the electrons move under an external bias. The movement of electrons generates a THz pulse. We use ZnTe crystal and optical laser pulse to detect THz wave. When THz wave is incident on the ZnTe crystal, the polarization of the laser pulse is modified, and the change in polarization is detected by the photodetectors. THz pulses are detected when the delay stage is set at a position where the THz pulse and detection pulse arrive at the ZnTe crystal a the same time.

Results:

Main THz pulses were found at where delay stage is at X=7.2, 8.5, 9.0 mm, for THz generation with amplified laser pulses, THz emitter, and THz emitter with a silicon sample in the set-up, respectively. We found by scanning a larger delay stage range, extra pulses were detected relative to the main pulse, which impact the sensitivity of the THz spectrometer. We identify the cause of the extra THz pulses detected (Table 1). For each element in the beam path (Figure 1) a small amount of light is reflected at the back surface of the element, introducing pulses with small amplitudes (Figure 2). The signal to noise ratio is 500 when laser amplifier is used, and 166 when the THz emitter is used. This shows that the sensitivity of the THz spectrometer still needs to be improved. Future work will involve improving the performance by increasing bias voltage, increasing excitation density, and optimizing laser spot size.

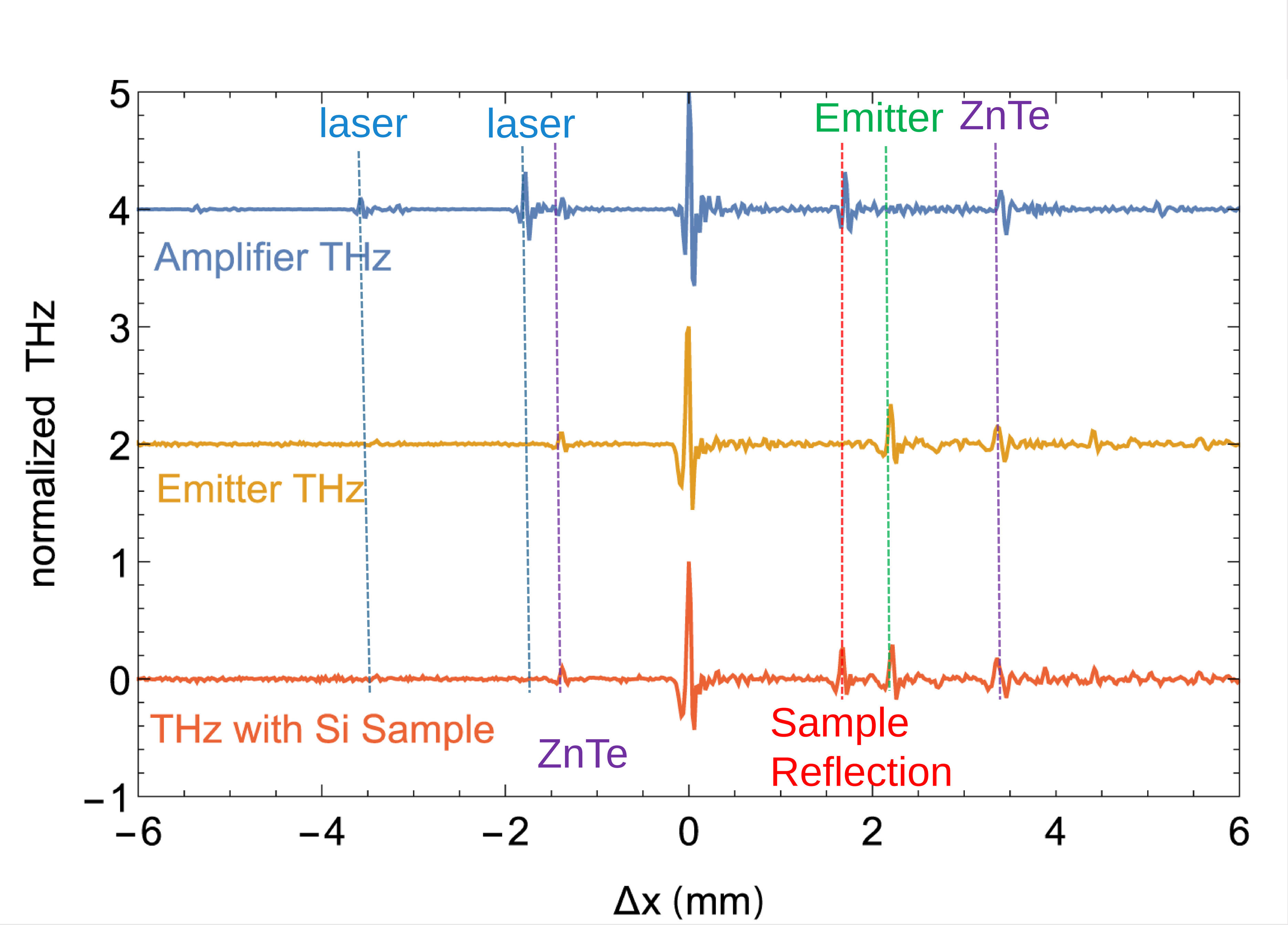

Figure 2

Causes of Extra Pulses

ΔX (mm)	Relative Amplitudes	Causes
-3.58	0.095	Laser Amplifier
-3.19	0.012	Beam-Splitter
-1.78	0.284	Laser Amplifier
-1.34	0.095	ZnTe Crystal
1.66	0.344	Sample Reflection
2.18	0.291	THz Emitter
3.34	0.178	ZnTe Crystal

Table 1