Terahertz Polarization Imaging using ⟨110⟩ ZnTe Crystal

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Abstract-**We present a method to measure the polarization state of pulsed terahertz wave by using a typical electro-optic sampling setup with <110> ZnTe crystal as sensor. To illustrate that the knowledge of the polarization of the terahertz pulse is essential for interpreting the results, we did terahertz imaging of a plastic plate. We find the terahertz electric field vector is revolved by the scattering at the edge of the sample. Terahertz polarization imaging is sensitive to the edge of the object and therefore can be used to raise the spatial resolution and improve the quality of terahertz images.**

I. Introduction

Terahertz time-domain spectroscopy can measure the time-dependent electric field of a terahertz pulse directly. After the application of the technique to imaging, [1] some of materials have been extracted and visualized by terahertz raster-scan imaging. A characteristic of the imaging technique is that only one component of the electric field vector is measured. Sometimes the images obtained by these methods are difficult to interpret. For example, a decrease in the amplitude of the sample signal field is commonly interpreted as being caused by absorption and scattering. In fact, a rotation of the electric field vector induced by birefringence in the sample also can cause such a decrease. Besides birefringence, the polarization of a terahertz pulse can be changed by various other effects, such as not-normal-incidence reflection and multiple scattering. [2] In an experiment, we observed the terahertz electric field vector was revolved by the reflection and scattering at the edge of a plate. By using a typical raster-scan imaging system with <110> ZnTe crystal as sensor, we measured the two orthogonal components of terahertz field. To demonstrate the potential of this method, we measured terahertz images of a plastic plate in two orthogonal electric field components directions. From comparing the two images, it is shown that the polarization imaging method can be used to raise spatial resolution of terahertz images.

II. Experimental Results

When terahertz polarization is parallel to the (001) axis of ZnTe, the detected terahertz signal shows minor amplitude zero and when terahertz polarization is perpendicular to the (001) axis of ZnTe, the detected terahertz signal shows absolute maximum amplitude. By rotating the (001) axis of ZnTe, we obtained the signal in the two directions, respectively.

The ratio between the peak–peak values of the two electric field components is 0.053 and the ratio between the total power in the two pulses is about 1:2000. The residual field in the parallel direction can easily be attributed to a slight misalignment of the parabolic mirrors.
Since scattering and reflection at the edge of the samples can cause the rotation of the terahertz polarization, our measurement method is applied to raster-scan imaging of a plastic plate with straight edge. The sample is scanned at one dimension with the range of 6mm and the step of 0.2mm.
A series of transmitted terahertz waveforms are obtained while scanning the blade through the focus of the terahertz beam. With the blade inserting the focal plane of terahertz wave, we found, the amplitude of perpendicular component changes from maximum value to zero. However, the amplitude of parallel component has the maximum value while the edge of the blade is at the position of the middle of the terahertz focal plane. The results can be seen in figure 5.

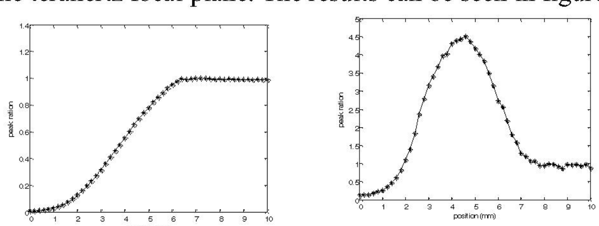

Fig.5. Detected perpendicular (a) and parallel (b) components of the terahertz electric field while scanning the blade through the focus of the terahertz beam. The transverse axis corresponds to the relative position of the edge of the blade. The scan range is 10mm and the step is 0.2mm. The longitudinal axis corresponds to the ratio between the peak-peak value of the scanning signal and reference signal.

In conclusion, we have presented a polarization imaging method to measure the two orthogonal components of the electric field of a terahertz pulse using a typical system with <110> ZnTe as detection crystal. To demonstrate the capability of our method, we performed spectroscopic measurement and raster-scanning imaging in two orthogonal electric field components directions. We found one of the components is sensitive to the edge of the sample and the polarization imaging technique can be used to raise the spatial resolution of terahertz images.

References

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[2] J. Pearce, Z. Jian, and D. M. Mittleman, Opt. Lett. **29**, 2926 (2004).