Polarization information for terahertz imaging

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***Abstract*—A method to analyze the variety of the polarization state of terahertz (THz) wave by using a typical electro-optic sampling setup with <110> zinc-blende (ZnTe) crystal as a sensor is presented. To illustrate the knowledge of polarization of the THz pulse, the function of THz detect in ZnTe crystal is interpreted. Two kinds of Jones matrixes, birefringence device and polarizer device, are used to analyses the polarization change of the THz electric field vector caused by the sample. It was found that the THz polarization imaging is sensitive to the edge of the samples.**

I. Introduction And Background

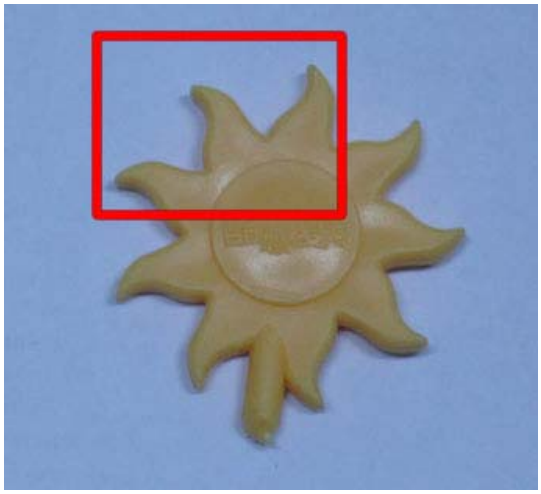
Terahertz (THz) waves, sandwiched between the microwaves and far infrared waves, exhibit properties of both sides of the electromagnetic spectrum. They have many advantages: They can transmit a variety of substances such as cloth, plastic, wood, paper, dried food, and so on. They are nonionizing and nondestructive and hence are relatively safe. Furthermore, most molecules have characteristic absorption in the THz spectra region. By combining this technique to imaging [1], a variety of related imaging techniques, such as real-time imaging with a CCD camera [2], computed tomography [3], single-shot imaging [4], and near-field imaging [5] have been proposed. The short wavelength of the THz waves (much shorter than that of microwave waves) allows a relatively high spatial resolution which is sufficient in many imaging applications.

However, most of the THz imaging techniques achieve only one component of the THz electric field vector and impute the decrease of signal to the absorption and scattering of the sample. In fact, a rotation of the electric field vector induced by birefringence of the sample can also cause such a decrease. Besides the birefringence, the polarization of a terahertz pulse can be changed by various other effects, such as not-normal-incidence reflection and multiple scattering [6]. Therefore, the polarization information of the THz signal contains also characterizes of the example and can be used to exhibit the structure and/or image of the sample. Some works have been carried out to utilize the polarization information of the THz signal to image the object [7]. In this presentation, a new method to analyze the variety of polarization of the THz wave is presented. Two kinds of Jones matrixes, the birefringence and polarization models, are used to generate the image of the object and good results are obtained.

II. Results

The THz wave with arbitrary polarization direction can be measured via twice measurements. Firstly, the polarization of the probe beam is set to parallel to the <110> axis of the ZnTe crystal [8], thus the measured signal is proportion to $E_{THz}\sin\alpha$, E_{THz} is complex amplitude of THz wave and α is the angle between the polarization of THz wave and the direction of <110> axis of the ZnTe crystal. Then the crystal is rotated by 90 degree, the measured signal in this case is proportion to $E_{THz}\cos\alpha$, thus the polarization direction can be achieved.

The plastic sample with thickness of 4.0mm is used to demonstrate our method. Following figure is the visible image of the sample, due to the limitation of the raster scanning system, only the part in rectangle is scanned.



The images of the different components of the 0.2THz electric field are shown in the following figures. Although the illuming light is horizontally polarized, due to the scattering and diffraction at the edge of the sample, the perpendicular component can also be measured. The top image shows the amplitude of horizontal component at 0.2THz, which has shown the edge of the sample. The bottom image describes the amplitude of the perpendicular component. Comparing with the horizontal component, the perpendicular component shows more detail information about the object. The ununiform of the sample has been clearly seen. Three facets of the object are clearer.

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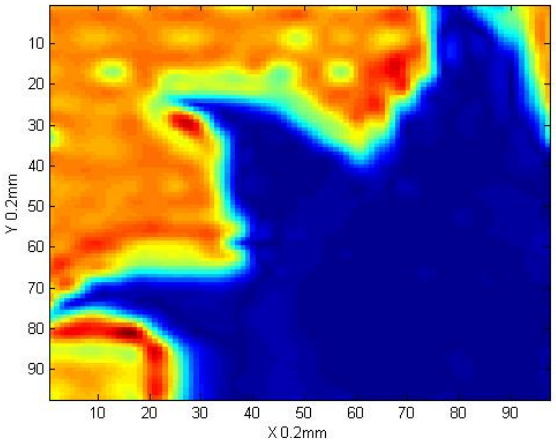
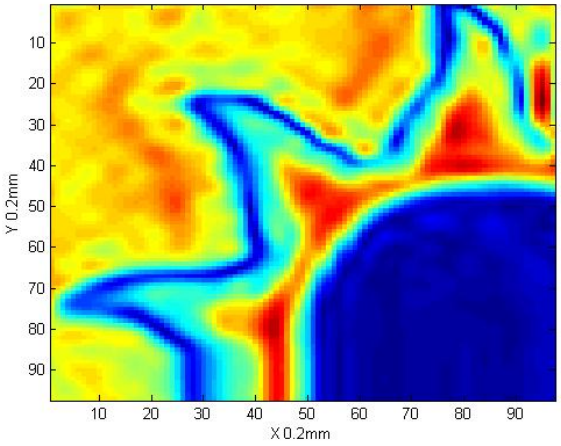
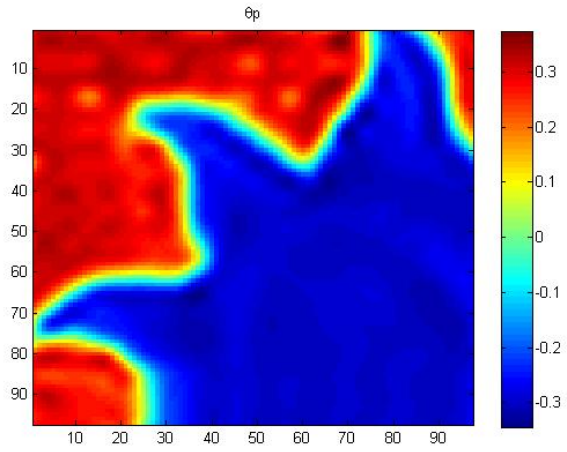




Jones matrix is a powerful method to analyses the polarization variety in optical system. It can easily depict the change of polarization state inducing in optical device. To analyze how the sample changes the polarization, Jones matrixes of the birefringence device and polarizer are introduced to describe the result [9]. The following figure shows the change of θ_p, which is the polarizer orientation angle respect to the x axis of the experimental coordinates. It can be seen that the detail of the sample has been clearly shown.



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