THz near-field microscopy – A review

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***Abstract*— One of the major limitations of THz imaging is low spatial resolution. Consequently, various techniques have been proposed in the literature to break the diffraction limit. Many of the existing techniques draw inspiration from near-field scanning optical microscopy, while other techniques tightly focus optical beams to reduce the size of the generated THz beams. This paper reviews briefly the existing THz near-field methods and recent developments for identifying possible areas of research potential.**

I. Introduction

THz imaging offers many attractive advantages over existing modalities. One of the major limitations of THz images is low spatial resolution as determined by Rayleigh's criterion with a comparatively longer wavelength (0.3 mm at 1 THz). Various techniques have been proposed in the literature to break the diffraction limit. A review on pulsed THz near-field methods is presented in [1] that encompasses the operation, the development to date and resolutions achieved. Pulsed THz near-field imaging is a rapid growing area and some work has been conducted since. This paper presents a brief update of the recent development along with the existing work.

II. Review

A. Aperture

Pulsed THz near-field imaging is first demonstrated in [2] with an elliptical sub-wavelength aperture to achieve a resolution approximately 50 μm (λ/4) in illumination mode. A collection mode probe using a metallic aperture is demonstrated to give a resolution of 7 μm (λ/86) [3]. Dynamic apertures are also presented in [4]. Recent work on a low-loss dielectric material waveguide with sharpened pyramidal tip has been proposed to demonstrate a resolution of about 20 μm (λ/200) [5].

B. Tip

The first THz tip method is demonstrated in [6] with a resolution of approximately 18 μm (λ/110). THz pulses are focused onto a sharpened tip placed near a GaP detection crystal, and through electro-optic effect, the polarization of the opposing synchronised probe pulse is changed by the tip THz electric field. The resolution is determined by the spot size of the probe laser. Another a similar tip method with a resolution of 150 nm (λ/1000) is presented in [7] and [8]. Scattered THz radiation is detected near the sample surface using a photoconductive dipole antenna [7], [1] or electro-optic sampling [8]. The work demonstrated the need to further refine the existing spherical scatter model for the imaging tip [9] and the inclusion of antenna properties for the probe which, are discussed in [10] and [11].

C. Electro-optic

An alternative apertureless near-field technique exploits the comparative smaller THz emission point than the wavelength. An optical beam is tightly focused to a small spot in an optical rectification crystal for the generation of a sub-wavelength diameter THz beam in the near-field [12]. Thin crystals are experimented in [13] and a resolution of 20 μm is reported in [1]. Similar work is presented recently in [14], where a 500 μm thick crystal (ZnTe) is used for a resolution of approximately 75 μm in imaging a sharpened tungsten wire. The resolution is equal to the pump beam focal size. This technique promises to be a potential area of investigation.

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1-4244-0400-2/06/$20.00 ©2006 IEEE