Far-Field and Near Field Performance Characterization of a THz Imaging System

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Terahertz time-domain spectroscopy (THz-TDS) has been a very powerful tool in various applications such as material characterization and identification, biomedical imaging and nondestructive detection. Photoconductive antenna (PCA) is one of the most commonly used THz pulsed sources. THz far field emitters made of a butterfly-shaped antenna structure on different substrates including low-temperature-grown GaAs (LT-GaAs), semi-insulating GaAs (SI-GaAs) and molecular beam epitaxy (MBE) grown GaAs-on-Sapphire, are characterized. THz radiation dependence on parameters such as DC bias voltage, laser power, etc., is investigated. The radiation mechanism is further studied by considering the polarization effect and cancellation effect of the antenna. The performances of some other antenna structures, such as stripline antenna will be compared as well.

For a conventional far field THz-TDS imaging setup, the resolution is restricted by the diffraction limit. To overcome this constraint, near field setup can be applied to obtain resolution smaller than wavelength. Near field scanning is implemented based on an array of emitting antennas on laser-transparent sapphire substrate with MBE-grown GaAs active layer. The back-side illumination mode ensures the sample to be in the near field regime of the emitting antennas. Thin gold film deposited on top of quartz substrate (providing a metal-dielectric boundary) is used as samples for near field scanning test. The polarization dependent resolution is experimentally characterized, showing that better resolution can be obtained when the metal-dielectric boundary is parallel to the antenna polarization. Moreover, a Hadamard multiplexing method incorporating a 2×2 PCA emitter array is proposed to improve the system SNR. A preliminary study shows that a factor of 2 SNR improvement is achieved by using the Hadamard multiplexing method compared to single antenna measurement under the same amount of measurement time.