Terahertz Wave Detection in Metal-GaAs-Metal Structures using Cherenkov-phase-matched Electro-optic Sampling

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The possibility of new and more exciting terahertz (THz) technology impels the development of sensitive but simple detectors. Electro-optic (EO) detection scheme is a viable choice because it does not require micro-fabrication facilities unlike photoconductive antenna and it has been shown to be sensitive to high frequencies by using materials with large electro-optic coefficients. Cherenkov-phase-matched EO detection in GaAs is possible at 1.55 μm optical sampling wavelength because the crystal’s group refractive index, $n_g$, at 1.55 μm is less than its THz refractive index, $n_{THz}$, at 1 THz [1]. In this study, we performed THz wave detection measurements in Cherenkov-phase-matched EO sampling at 1.55 μm by using metal-GaAs-metal samples inserted into a thin metallic parallel-plate waveguide (PPWG). GaAs (100) with aluminum film on its four facets, except on the $<0, -1, -1>$ planes, were used as detectors in a THz time-domain spectroscopy (THz-TDS) system. A spiral antenna was utilized as an emitter, pumped by the 2nd harmonic of the 1.55 μm fs fiber laser. Results indicate that the peak-to-peak EO signal from bare GaAs reference sample was less than that from the metal-GaAs-metal samples. Regardless of the sample thickness, spectral bandwidth of the detected THz signal from metal-GaAs-metal structures was roughly at 1.75 THz while that of the reference sample is at 1.25 THz. The signal-to-noise ratio (SNR) on all samples was 4 orders of magnitude.

Figure 1: (a) EO signal from bare GaAs reference sample and two metal-GaAs-metal structures. (b) The corresponding logarithmic THz intensity of the detected signal.

Reference: