A novel multiplexed THz spatial modulator for fast, sub-wavelength imaging and spectroscopy

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We report on the current state of the development of a sub-wavelength THz spatial modulator array – a multi-pixel THz imaging device. The modulator allows fast image acquisition and spectroscopy with greatly improved spatial resolution.

Current THz sub-wavelength imaging techniques require mechanical (raster, point-by-point) scanning of a THz imaging complex over the sample area for image composition. This results in long acquisition times. Therefore, in order to increase the speed of acquisition, a THz imaging device consisting of multiple sub-wavelength apertures (an imaging array) for THz radiation was developed. The need for X-Y mechanical scanning of the apertures across the sample is minimized depending on the pixel array dimensions (number of sub-wavelength apertures) with respect to the sample area. The THz spatial modulator concept was first proposed by Rutt et al in [1]. In this paper we report on the design and characterization of a fully functional THz spatial modulator.

The transmission factor of each of the sub-wavelength apertures can be varied (modulated) electronically at a given modulation frequency. Thus, each of the apertures can perform independent amplitude modulation of the THz radiation. These apertures are then multiplexed in the frequency domain. The received signal – a bundle of frequency components – is processed which permits the photodetector system to differentiate between the adjacent holes. This is done by transforming the received signal (modulated optical signal, time signal) into the frequency domain by virtue of the FFT. The amplitude modulation is revealed in the output spectrum as a row of uniformly spaced modulation peaks separated by a fixed frequency interval. The position of a modulation peak on the frequency axis corresponds to the aperture's modulation frequency. If the amplitude modulation depth factor is constant and known for each of the apertures, the amplitude of a single modulation peak yields information about the sample's THz attenuation – THz absorption image.

Additionally, if combined with a broadband, coherently enhanced synchrotron radiation source and scanning Fabry-Perot interferometer, the modulator can be used for THz Fourier Transform Spectroscopy.

[1] Harvey Rutt and Mohammad M Al Hakim – "A proposed novel multiplexed near field Terahertz microscope" - University of Southampton e-prints, ORC Colloqulum, 5th of April 2006.