ELECTRON MOMENTUM RELAXATION TIME INFLUENCE ON THE TERAHERTZ EMISSION ENHANCEMENT IN MAGNETIC FIELD

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In 1993 it was discovered [1], that terahertz (THz) emission varies greatly by applying external magnetic field close to semiconductor surface. It was suggested [2] that THz emission enhancement depends on the effective mass of electrons in a semiconductor, thus different materials have varying enhancement coefficients. Research in our laboratory suggests that this coefficient also depend on electron momentum relaxation time, given different enhancement coefficients in same type of semiconductor.

A novel method for determination of the terahertz pulse emitting dipole orientation by terahertz emission was developed. The method is based on the measurements of THz emission in reflection geometry, allowing for the determination of electric dipole tilt angle, θ. In small magnetic fields, photoexcited electrons move perpendicular and parallel to the surface, where the forces responsible for the movement are due to electric field force and Lorentz force, respectively. Thus, the magnetic field induced change of dipole tilt angle, $d\theta$:

$$\frac{d\theta}{dB} \approx \frac{F_{\parallel}}{F_{\perp}} \approx \frac{e v_{\perp} B}{eE} = \frac{e\tau B}{m} \tag{1}$$

Since majority of THz energy is emitted during ballistic movement of electrons [3], τ is electron momentum relaxation time, and equation (1) can be simplified:

$$\frac{d\theta}{dB} = \mu B \tag{2}$$

A series of high-resistance semiconductor substrates were measured to determine this relationship. The determinated values were compared with electron mobility values obtained by already established Optical Pump – THz Probe (OPTP) method. A strong correlation was found between both methods. There are two advantages to the determination of THz pulse emitting dipole orientation by THz emission method compared to OPTP method. First, a fast and easier to implement measurement of samples was achieved. Second, greater stability to fluctuations in laser radiation was observed. We conclude, that determination of THz pulse emitting dipole orientation by THz emission method is a viable tool for the investigation of electron mobility in semiconductor substrates and epitaxial layers on top of them.

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