Teraherz pulse emission from InGaAs and GaMnAs nanowires

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Over the last years, terahertz (THz) radiation from semiconductor surfaces illuminated by femtosecond laser pulses is finding multiple application areas. It has recently been reported that nanowires (NWs) and nanorods structures in comparison with bulk semiconductors are able to enhance THz emission from optically excited surfaces. Despite the increase of the efficiency of optical–terahertz radiation conversion, vertically aligned nanowire arrays have the same limitation (i. e. the main part of the radiation propagates in parallel to the surface resulting the low THz emissivity outside the sample) as bulk semiconductors. This problem could be solved using non-vertically aligned NWs.

In this work THz emission of the oblique nanowires was investigated for the first time. Samples of GaAs NWs were grown by molecular beam epitaxy (MBE) on high temperature (550°C) GaAs (111) and (110) substrates. NWs grown on GaAs (110) substrate forms $\sim$ 55° angle between the NWs and the surface [1]. Experiments were done using Ti:sapphire oscillator generating 150 fs, 800 nm pulses at the repetition rate of 76 MHz. THz electric field transients were detected with a low temperature grown GaAs antenna.

The amplitude of the THz signal obtained from NW arrays was from 2 to 4 times stronger than from GaAs substrate. Furthermore, THz emission azimuthal dependencies of the oblique NW layers was observed for the first time (Fig. 1). Also, in contrast to a bulk GaAs, tilted NW layer emits the THz radiation well enough when the laser beam falls perpendicularly to the surface (Fig. 2). These results could be explained by photoexcited carriers moving along the NWs.

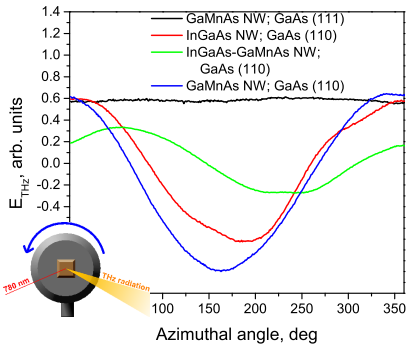

Figure 1: THz emission azimuthal dependencies of the GaAs NW layers grown on GaAs (110) and GaAs (111) substrates

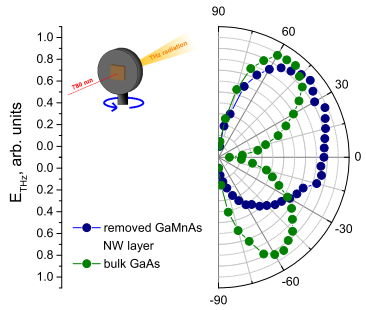

Figure 2: THz pulse amplitude dependencies on an angle between the incident laser beam and a normal to the sample surface for the removed GaMnAs substrate.

Non-vertically aligned NW layers can be used in polarization rotating THz emitters. This application is very important because the principle of half wave plate can not be used due to a wide spectrum of THz pulses.

[1] R. S. Dowdy, D. A. Walko and X. Li, *Nanotechnology*, **24**, 035304(1-6) (2013)