THz pulse generation by charge density gradients investigated by near-field microscopy

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The processes of generation of THz pulses by optical excitation of semiconductor and metallic surfaces recently attracted renewed attention as novel THz emission mechanisms were discovered [1-2]. Among these mechanisms is the emission due to transient photo-currents in the plane of the optically excited surfaces, which has been considered negligible until recently. Using a THz near-field microscopy system, we correlate the emission of THz pulses with the spatial distribution of photo-excited carriers and demonstrate that the in-plane gradients of the photo-excited charge carrier density can be the dominant source of THz emission in the excitation of semiconductor surfaces.

We investigate the process of THz generation from epitaxial layers of Fe-doped $In_{0.53}Ga_{0.47}As$ excited at various angles of incidence. Figure 1 shows a diagram of the experimental system and the near-field space-time maps of the emitted THz field for two cases: the angle of incidence of 50° (the optimal angle for the process of THz generation) and 0°. The near-field investigations reveal that THz waves of similar amplitudes are generated in both cases. However the asymmetric field distribution for the normal incidence case produces no far-field emission. Remarkably, the generated THz pulses originate not from the whole photo-excited area, but primarily from the edge regions, indicating that the lateral photo-currents produce a dominant contribution to the process of THz pulse generation.

The ability to map the emitted THz wave in the near-field zone of a photo-excited semiconductor surface allows investigations of other THz generation mechanisms. The understanding of the dominant emission mechanism will be used to enhance the optical-to-THz conversion efficiency.

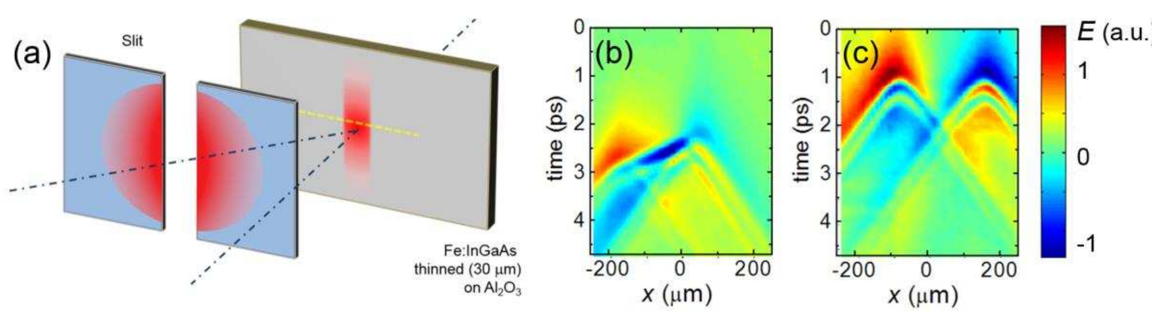

Fig. 1. (a) Schematic diagram of the experimental system, where the semiconductor surface is excited at the angle of incidence of 50°. The emitted THz wave is mapped on the back side of the 30μm thick sample along the yellow dashed line. (b,c) Near-field space-time map of the generated THz wave for the angle of incidence of 50° and 0°.

References

[1] G. Klatt et al., Opt. Express 18(5), 4939-4947 (2010).

[2] G. Ramanandan et al., ACS Photonics 11, (2014).