THz Plasmon Emission From an LT-GaAs/GaAs Homojunction

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Few-cycle THz radiation can be generated from semiconductor epilayers by coherent plasma oscillations [1], [2]. Emitters relying on those principles have found wide applications in spectroscopy of semiconductor structures, chemistry, and medical imaging in the frequency range of 0.1 – 10 THz. Output power and long term stability of these emitters are key parameters in such applications.

We have addressed the issue of the terahertz (THz) output power and stability. The standard model of the plasmon emitter relies on the build-in electric field at the surface of the structure. A stronger field leads to a larger emitted power. For the standard emitter the surface states are used to pin the Fermi level which gives rise to the surface field. The surface states arise from the surface imperfection, impurities and the oxide surface layer, hence their concentration and charge state can be modified by the laboratory ambient. To take full control over the built-in electric field we can pin the Fermi level position by deep level defects. Low-temperature grown (LT) GaAs [3] can serve as an efficient pinning medium. Such material possesses a high density of defect states with the energy level close to the GaAs mid-gap [3], hence it firmly pins the Fermi level. A presence of the LT-GaAs in the emitter structure leads to a replacement of the surface field of the emitter with the field at the junction LT-GaAs/GaAs where the THz radiation is now generated.

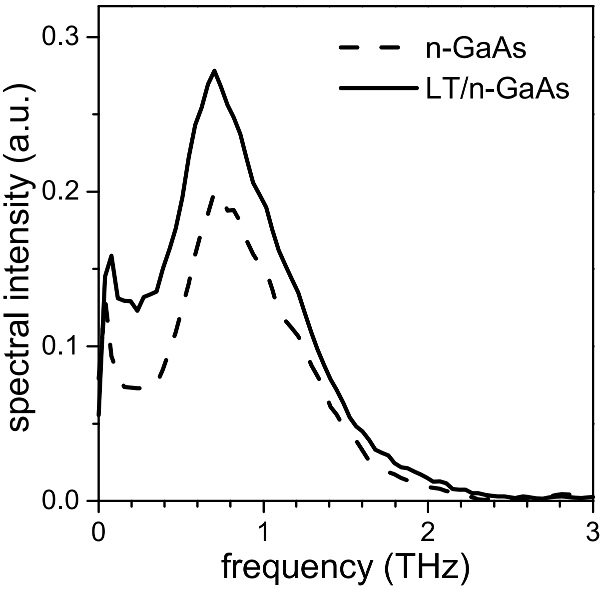

Fig. 1: Power spectra (right panel) of the THz emission from the n-doped GaAs plasmon emitter and from the n-doped GaAs plasmon emitter with LT-GaAs surface layer.

We have grown two structures with an identical n-doped GaAs layer on semi-insulating GaAs substrates, but one with an additional low-temperature grown GaAs surface layer. A mode locked Ti:sapphire laser (12fs pulse width) was used to excite the plasma oscillation and the emitted THz radiation was measured by an autocorrelation technique with a liquid helium cooled silicon bolometer. The autocorrelation technique allows to measure the spectrum of the signal as well as the average power of the radiation. The emission spectra of both samples show the same spectral dependence. However, the emitter with the LT-GaAs surface layer has 1.4x larger output THz power than the emitter without LT-GaAs layer which proves that the improved effective pinning of the Fermi level leads to an increase of the THz generation.

Additionally, we have tested the resistance of the emitters against oxidation. The emitters were oxidized in hot wet air. The LT-GaAs layer revealed an enhanced performance stability since the surface field does not rely on the surface states.

References

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[2] R. Kersting et al., *Phys. Rev. Lett.* 79, 3038 (1997).

[3] D.C. Look, *Thin Solid Films* 231, 61 (1994).