Low Temperature-Grown GaAs Carrier Lifetime Measurements Using "Double Optical Pump" Terahertz Time-Domain Emission Spectroscopy

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1. Introduction

Low temperature-grown gallium arsenide (LT-GaAs) has attracted a lot of research interest and is currently the active semiconductor substrate material of choice for photoconductive terahertz emitter and detector devices due to its favorable combination of excellent optoelectronic properties such as relatively high carrier mobility, high dark resistivity, and short carrier lifetimes [1-4].

To measure the photo-excited carrier lifetimes of LT-GaAs and study the carrier dynamics in semiconductors, optical pump-probe experiment using femtosecond time-resolved photo-reflectance is the most commonly applied technique [1-2]. In this work, we propose and demonstrate "*double optical pump*" terahertz time-domain emission spectroscopy (THz-TDES) as an alternative technique to deduce the lifetime of photo-excited carriers in LT-GaAs. In the "*double optical pump*" THz-TDES, photo-excited carriers are generated on the sample by a carrier injection pump pulse and the THz emission by a signal generation pump pulse is observed. Since the surface electric field is screened by optical carriers, the THz emission amplitude is expected to change with the relative time delay between the two optical pump pulses due to carrier decay. The advantage of this proposed technique compared to the transient photo-reflectance technique is the relative ease of the optical alignment.

2. Results

In Fig. 1, we show a comparison of data obtained by *"double optical pump"* THz-TDES and by standard transient photo-reflectance measurements done on the same LT-GaAs sample, which was grown by MBE at 310°C. The carrier lifetimes deduced from exponential curve fittings to the photo-reflectance and THz emission decay curves are 3.5 ps and 3.8 ps, respectively. This good agreement found between the results of the two different techniques is similarly observed for other LT-GaAs samples grown at 200°C to 310°C.

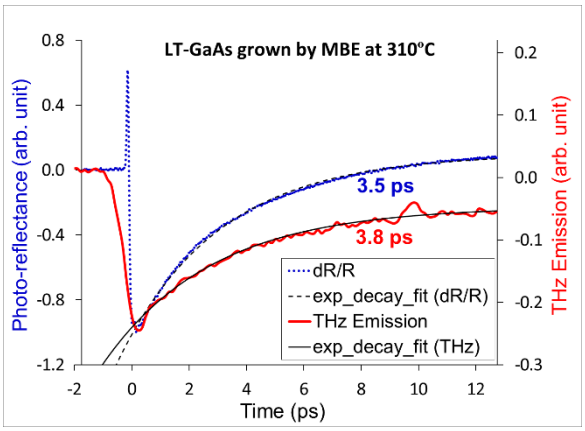

Fig. 1. Comparison of *"double optical pump"* THz emission and transient photo-reflectance data for LT-GaAs.

The results show that the *"double optical pump"* THz-TDES technique can be an alternative method for determining the lifetime of photo-excited carriers in LT-GaAs.

3. Conclusion

We employed *"double optical pump"* THz-TDES measurements for the evaluation of LT-GaAs carrier lifetime. Based on the results, the *"double optical pump"* THz-TDES technique can be an alternative to the more standard transient photo-reflectance. At present, optimization studies of the experimental conditions for this novel approach in carrier lifetime measurements in LT-GaAs and other semiconductors, are being carried out.

References

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