Time-Resolved Pump Probe Spectroscopy of (100)-GaAs to ±25 T

J.A. Curtis, T. Tokumoto, N. Nolan (UAB Physics); J.G. Cherian, S.A. McGill (NHMFL, FSU); D.J. Hilton (UAB Physics)

Introduction and Experimental

We report the development of a new ultrafast optical experiment that uses the new Florida Split Helix 25 T magnet system. Our experiments use the new Split Helix magnet, which enables a new generation of magnetic field dependent ultrafast measurement. Our nondegenerate pump-probe spectrometer uses an amplified titanium:sapphire laser (Coherent Legend, 2 mJ per pulse, 1 kHz, <150 fs pulses) located in Cell 3. We frequency double a portion of the pump beam and probe with a linearly polarized probe field to study the time-resolved reflected amplitude using a biased photodiode detection scheme and a lock-in amplifier. Representative pump probe data are shown in the figure. Photoexcitation at 400 nm results in rapid intervalley scattering (k_{32}) to the zone center and results in the formation of a coherent phonon wave packet, discussed in a subsequent section. Thermalization of holes within the valance subband to zone center has been previously measured to proceed on a ≤0.5 ps time scale [1]. Once electrons and holes are at zone center, carrier recombination typically occurs across the band gap with a characteristic time scale of ≥500 ps [2].

Results and Discussion

Figure 1 shows representative differential reflection data of our (100)-GaAs sample and shows a transient increase in reflection due to femtosecond pulse generated free carriers that initially result from the optical excitation to the L-valley in GaAs. Rapid scattering of photoexcited carriers to the zone center results in the formation of a coherent phonon wave packet [3], which travels from the surface at the speed of sound and explains the existence of oscillations in the differential reflection due to the interference between the probe pulse reflecting off the front surface of the sample with a second probe reflection from the coherent phonon packet. Scattering of the photogenerated holes in the valence subband to zone center also proceeds on a subpicosecond time scale [4]. We observe a small increase in the oscillation frequency as magnetic field is increased, which is currently under further investigation.

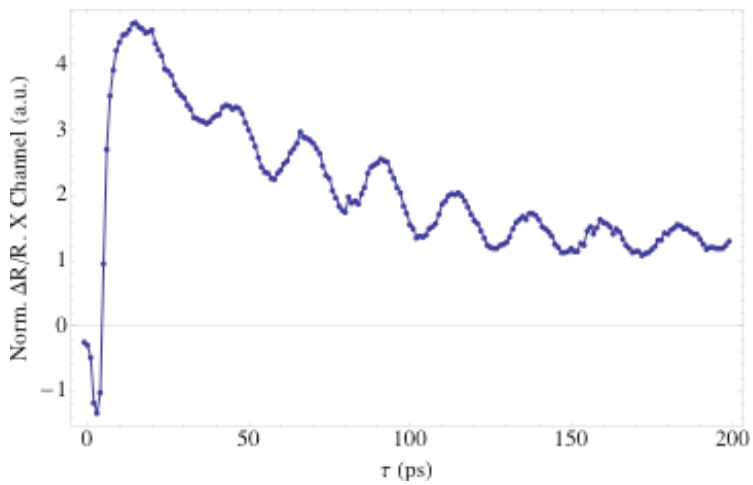

Figure 1: Time resolved nondegenerate differential reflection in (100)-GaAs at 25 T using the Florida Split Helix Magnet.

Acknowledgements

This research is based on work supported by the National Science Foundation under Grant No. DMR-1229217 (JGC, SAC, and DJH) and Grant No. DMR-1056827 (TT). Additional support from the US Department of Education under Grant No. P200A090143 (JAC) is gratefully acknowledged. Work at the NHMFL is performed under NSF Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy.

References

[1] Ganikhanov, F., Burr, K., Hilton, D. J., and Tang, C. L., Phys. Rev. B **60**, 8890–8896 (1999).
[2] Adachi, S., J. Appl. Phys. **58**, R1 (1985).
[3] Scholz, R., Pfeifer, T., and Kurz, H., Phys. Rev. B **47**, 16229–16236 (1993).
[4] Burr, K. C. and Tang, C. L., Appl. Phys. Lett. **74**, 1734–1736 (1999).