Magneto-Photo-Luminescence and Time resolved Photo-Luminescence spectroscopy of $InAs_xP_{1-x}$ alloys

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Introduction

Photo-luminescence (PL) spectroscopy, especially in the time domain, is a powerful method to study optical properties of semiconductors. By tuning experimental parameters such as optical excitation energy and intensity, sample temperature, and polarization of absorbed and emitted photons, PL can be employed to study a variety of material properties. In this project, we used the time resolved optical facility at the NHMFL in collaboration with Dr. McGill, to probe the dynamical response of $InAs_xP_{1-x}$ structures. Recently, g-factor engineering has attracted much attention for potential applications in spintronics. In the case of $InAs_xP_{1-x}$ alloys, a wide range of g-factors, including g=0, can be achieved [1]. In order to probe the band-structure and the dynamics of photo-excited carriers in $InAs_xP_{1-x}$ epitaxial films with x=0.13, 0.4, we measured NIR absorption spectra at 4 K and 300 K, as well as magneto- photoluminescence spectra in both the time and frequency domain for magnetic fields in the range of 0-15T and temperatures in the range of 4-90 K. From the temporal measurements, we observed strong tunability in the relaxation dynamics as a function of excitation wavelength and external magnetic fields.

Experimental

During the visit, we employed several magneto-photo-luminescence and time-resolved schemes at different external magnetic fields, laser excitations, and sample temperature. We used several femtosecond lasers with the wavelengths ranging from 400 nm-1.3 microns. The streak camera and regular spectrometer were used during the measurements. The collection was thru fibers inside the superconducting magnet.

Results and Discussion

As the switching rates in electronic and optoelectronic devices are pushed to higher frequencies, it is important to understand and tune carrier dynamic phenomena in semiconductors on femtosecond time-scales.

During the two weeks of the experimental efforts, we were able to demonstrate the tunabilty of the carrier dynamics as a function of several external parameters including the applied magnetic field and the laser power. The results shown in Fig.1, are the examples of our measurements using the streak camera. In this case for the InA_xsP_{1-x} with x=0.13%, the excitation wavelength was fixed at 800 nm and the magnetic field was tuned from 0-15 Tesla, for a fixed laser power of 60 mW. The relaxation dynamic was compared with a measurement at 15 Tesla and the laser power of 5 mW. We observe an increase in the relaxation time when the magnetic field is increased from zero to 15 Tesla as well as when the excitation power is decreased.

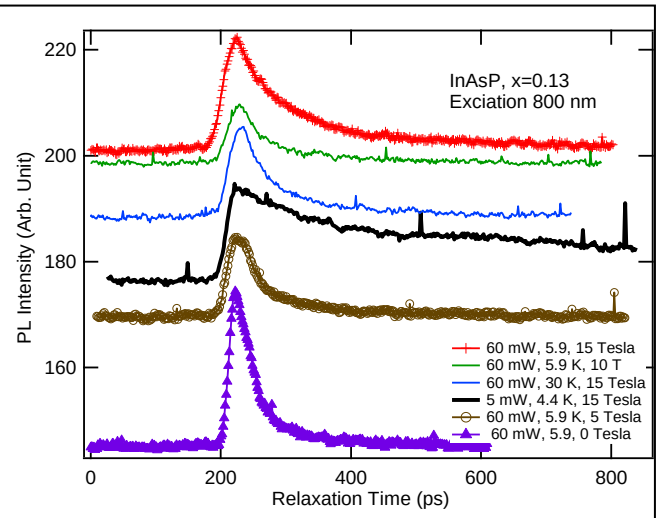

Fig 1: Time resolved Magneto-PL of InAsP as a function of external magnetic fields and the laser power. We observe the tunability of the relaxations as a function both parameters.

Conclusions

Our results demonstrate the unique and complex dynamics in this material system that can be important for electronic and optoelectronic devices. Our results will be presented in the APS March meeting and a publication is in preparation.

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