OPTICALLY-PUMPED NMR IN QUANTUM WELLS REVEALING LIGHT HOLE-TO-CONDUCTION BAND TRANSITIONS AND BULK SEMICONDUCTORS SELECTING SPIN PAIRS

Matt Willmering,[1] Zayd Ma,[1] Erika Sesti,[1] Ryan Wood,[2] C. Russell Bowers,[2] Chris Stanton,[3] Arneil Reyes,[4] Phil Kuhns,[4] Stephen McGill,[4] and Sophia E. Hayes[1]

[1]*Dept. of Chemistry, Washington University, St. Louis, MO;* [2]*Dept. of Chemistry, University of Florida, Gainesville, FL;* [3]*Dept. of Physics, University of Florida, Gainesville, FL;* [4]*National High Magnetic Field Laboratory, Tallahassee, FL*

Optically Pumped NMR (OPNMR)[1] of semiconductors transfers angular momentum from spin polarized conduction electrons to surrounding nuclei. This is accomplished by irradiating a sample with a continuous wave laser at the band-edge that is polarized (π, σ+, or σ-) and will impart selection rules to excited electrons. Hence, the conduction electron spin orientation can be manipulated, which couples to nuclei via a hyperfine interaction, and can spin-flip nuclei, resulting in an enhanced nuclear polarization. typical OPNMR experiments measure the NMR response as a function of excitation energy. OPNMR "profiles" of signal intensity versus photon energy have been reported on several semiconductors (si-GaAs, Be-GaAs, InP, and Si)[1] and provide insight into the nuclear polarization, electron polarization, and physical properties of a semiconductor such as band gap, absorption features and Landau levels[2,3].

We present OPNMR profiles on two separate groups of semiconductor samples. CdTe samples with different resistivities, crystallinities, and an addition of a dopant (Zn). CdTe is a II-VI direct gap semiconductor with the zincblende crystal structure and three NMR active nuclei (^{125}Te, 111Cd, and ^{113}Cd). In k-space, the energy of the light hole (mj=±1/2) and heavy hole (mj=±3/2) in bulk CdTe are degenerate in energy at k=0. Therefore, by exciting with photon energy at or near the band gap, the ^{113}Cd and ^{125}Te spins can become polarized. NMR signal enhancements, and spin-spin couplings will be discussed.

One sample is a multiple GaAs/AlGaAs quantum well sample with a well width of 16.9 nm. The quantum confinement in one direction lifts the light hole (LH) and heavy hole (HH) degeneracy at k=0. Due to the breaking of the degeneracy, a specific electron spin can be selected by changing the wavelength of the laser. This electron spin orientation can be transferred to the nuclei and is observed in the OPNMR profile by a phase inversion of the $^{69/71}$Ga NMR signal as the laser becomes resonant with the LH transition (Figure 1). Observation of the phase inversion in the OPNMR profile provides a precise measurement of this LH to conduction band transition energy which can be studied as a function of magnetic field using OPNMR. This study, in collaboration with the National High Magnetic Field Lab (NHMFL), will also be presented.

[1.] Hayes, S. E., Mui, S. & Ramaswamy, K. Optically Pumped Nuclear Magnetic Resonance of Semiconductors. J. Chem. Phys. 128, 052203 (2008).
[2.] Sesti, E. L et al. Magnetic Field Dependence of the Light Hole-to-Conduction Band Transition in GaAs/AlGaAs Quantum Wells from Optically-Pumped NMR and Hanle Curve Measurements Article. J. Magn. Reson. 246, 130–135 (2014).
[3.] Sesti, E. L. et al. Assignments of Transitions in the OPNMR of GaAs / AlGaAs Quantum Wells on a Bulk GaAs Substrate. Phys. Rev. B 90, 125301 (2014).

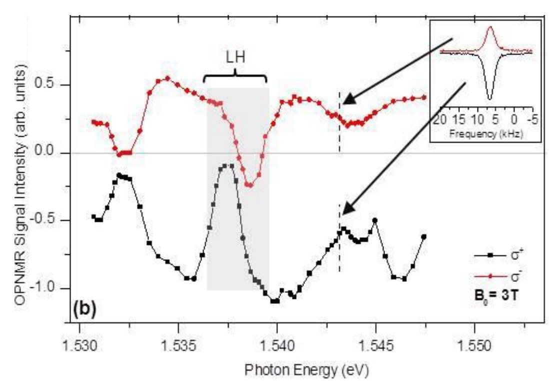

Figure 1: OPNMR profile showing the inversion of the nuclear spins when exciting at an energy equal to the light hole transition for σ + and σ - light.

Category: MO Magneto Optics
Email: hayes@wustl.edu