Lasers + NMR to Interrogate Spins in Semiconductors and Interface Structures

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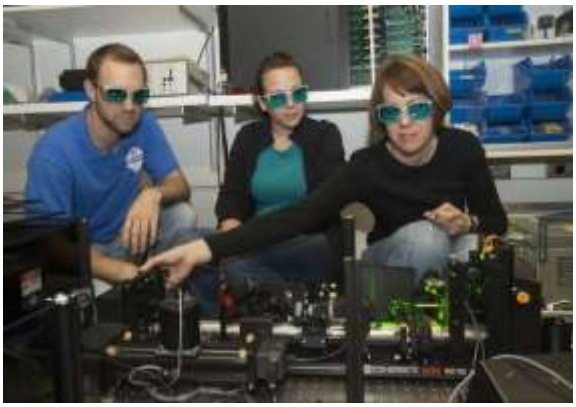
Optical pumping of semiconductors such as GaAs leads to new phenomena in the NMR of these materials. We excite transitions between valence and conduction bands and see coupling of nuclear spins to the spin states in the conduction band. Where this is particularly rich in detail is finding spin-dependent excitations by coupling to light-hole and heavyhole states in the valence band—imparting the intensity and phase of such transition onto surrounding nuclear spins (here probing ^{69}Ga and ^{71}Ga, both).

Using the multiple orders of magnitude enhancement from optical pumping, we have been able to show the structure in the region of a buried interface with OPNMR of ^{75}As in GaAs--revealing strain arising from a disparate material deposited by atomic layer deposition. Using the wavelength-selectivity of optical absorption, the interface region could be discriminated from the crystalline "bulk" of the GaAs. From the ^{75}As quadrupolar satellites, the magnitude of the strain and the depth can be estimated. These results demonstrate the potential application of OPNMR to enhance the small number of spins at the interface, allowing strain-induced defects and dislocations in semiconductor heterostructures to be probed.



Bio: Sophia Hayes is a professor of chemistry at Washington University in St. Louis. Dubbed a “chemicist” (in an accidental mis-translation by a German colleague), she has spent time as a postdoc at Technical Univ. of Dortmund (Germany), a postdoc in a chemical engineering department (jointly at UC Berkeley and LLNL), and was a graduate student at UCSB. She and her group delight in NMR spectroscopy, but have brought lasers into the lab, too, because why should the optics teams have all the fun?

Hayes and her group work on optically-pumped NMR of semiconductors and spin orientation, but also on solid-state NMR studies of the structure of non-crystalline thin metal-oxide films, mesoporous materials for capture of carbon dioxide, and the structure of minerals.