Electrically Detected Magnetic Resonance Spectroscopy of Impurity Doped Semiconductors

Meenu Maria Solly,[1,2] Nicholas Collins,[1,2] Janet Jacobs,[1,2] Floriana Tuna,[2,3] and Richard Curry[1,2]

[1] *Department of Electrical and Electronics Engineering , University of Manchester*
[2] *Photon Science Institute, University of Manchetser*
[3] *Department of Chemistry, University of Manchester*

The biggest challenge faced in the field of quantum information processing (QIP) is the loss of information in the spin system due to the interaction with the paramagnetic defects and impurities. Electron spin coherence is shortened by two principal factors, electron spin-spin interactions and electron nuclear spin interactions. Researchers are able to isotopically enrich silicon(Si) to remove Si-29 that possesses an unpaired nuclear spin, thereby creating a noise free environment which would help remove electron nuclear spin interactions[1].
Electrically detected magnetic resonance (EDMR) spectroscopy is a sensitive spectroscopic tool to study the paramagnetic defects in the system. Here, the magnetic resonance of the system is studied with the change in the conductivity of the syetem. Compared to conventional Electron Paramagnetic Resonance/Electron Spin Resonance (EPR/ESR) in which the sensitivity is limited to 1010 paramagnetic defects, EDMR can readout few to single spin signals from semiconductor materials. Here, we establish a cavity EDMR and a stripline EDMR system to measure the spin signal from implanted group V donors in Si.
An EDMR spectra on the background doped Fz-Si was obtained at 1.9 K with a Q-band microwave frequency using a TE011 resonant cavity. At higher frequency the Zeeman term in the hamiltonian dominates giving two ^{31}P peaks in the spectra separated by 4 mT, agreeing with the literature[2]. A continous waveguide device was made on a Si sample implanted with Antimony and Phosphorous as dopants and Arsenic as contact leads. EDMR spectra with ^{31}P, ^{75}As, was obtained at low field regime (100MHz-800MHz) where the hyperfine term dominates in the hamiltonian. The spin dependant recombination in the device occur through the Pb_0 defect in the Si/SiO_2 interface. This was evident from the Pb_0 peak in the spectrum.
Both the systems being established and optimised, the next step is to study the coherence time of the group V ions implanted on enriched Si, by measuring the T_1 and T_2 relaxation times.

References:

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