Dilute Magnetic Semiconductors for Spintronics: Mn:GaN

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Harnessing electron spins from metals into semiconductors is crucial for the development of new quantum spin semiconductor technology, from spin transistors to quantum sensors and quantum computing. The realisation of spintronic applications relies heavily on magnetic semiconductor materials with suitable properties. In particular, dilute magnetic semiconductors, such as Mn doped GaN, have shown the great promise of a high Curie temperature (220K-370K), exceeding room temperature, and a large concentration of holes.

Recent success in implementing a realistic device simulator to explore spin transport in a compound semiconductor transistor with magnetic gates shows non-uniform decay of the net magnetisation between source and gate and a magnetisation recovery effect due to spin refocusing. Moreover, magnetisation of the drain current is strain-sensitive and the spin polarisation of the drain current can be coherently controlled via source-drain and gate voltages.

These results have prompted exploration of dilute magnetic semiconductor materials, specifically Mn doped GaN, for devices operating at room temperature. Simulation results and progress are reported on the fabrication and experimental characterisation, including XPS, SEM, MRI and Hall measurements, of Mn:GaN wafers at the Centre of Nanohealth of Swansea University in collaboration with Cardiff University and the Compound Semiconductor Centre supported by the EPSRC Compound Semiconductor Manufacturing Hub.

[1] B Thorpe, K Kalna, FC Langbein, SG Schirmer. Monte Carlo Simulations of Spin Transport in Nanoscale InGaAs Field Effect Transistors. J Appl Phys, 122, 223903, 2017.
[2] B. Thorpe, K. Kalna, F. C. Langbein, S. G. Schirmer. Spin Recovery in the 25nm Gate Length InGaAs Field Effect Transistor. Int. Workshop Comp. Nanotech, 168 2017.