Nanomagnets in a semiconductor environment: materials challenges and device perspectives (invited).

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With the successful realisation of magnetic/semiconductor heterostructures comes the prospect of building semiconductor devices with spin-dependent characteristics. The set of magnetic materials that are part of such a spintronic heterostructure has grown rapidly over the past years.
The well known magnetic metals (Fe, Co, NiFe, ⋯) and some less standard magnetic alloys (e.g. MnAs, MnGa, ⋯) can serve as Schottky contacts to a semiconductor. Besides these, there is a need for half-metallic metals with ' perfect' interfaces to the semiconductor. Epitaxial growth techniques seem to provide the most reliable route to achieve the required degree of interface control. Preserving the correct magnetic properties at the metal/semiconductor interface in direct-contact devices remains an issue during device manufacturing and operation.
A promising approach is the use of Ferromagnetic / Insulator / Semiconductor (FM/I/S) structures, building on the expertise in e.g. Al2O3 barriers in magnetic tunnel junctions and MIS structures for electronic devices. The physical separation of the magnetic and semiconductor material by an insulator is interesting from both the electronic transport and device stability points of view.
Besides the use of (half-)metallic contacts, a very intruiging challenge is to embed the magnetic properties into the semiconductor lattice, in such a way that the resulting room-temperature magnetic semicondutor is compatible with the standard semiconductor device fabrication process. This would enable to use the all the bandgap engineering tricks of advanced semiconductor devices to exploit and enhance spin-dependent effects.
The above materials options to build spintronic devices will be illustrated by our recent experimental findings in fabricating and assessing spin injection in spin-LEDs with (Ni)MnSb, MnAs, FM/I and GaMnAs spin-injectors.