Rare-earth nitrides: semiconductors, spin/orbit magnetism, tunnelling MRAM, superconductivity

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Controlling the flow of electronic spin in addition to the charge promises speed and power demand advantages. However, there are as yet few “spintronic” devices on the market, in part due to a lack of intrinsic ferromagnetic semiconductors that would permit full exploitation of the coupled spin/charge technology. To date the only full series of such materials are the mononitrides of the lanthanides, the 14 rare-earth elements. Many of the LN (L a lanthanide element) are intrinsic ferromagnetic dopable semiconductors, with strongly contrasting magnetic properties which result from the coupled spin and orbital moments residing in the lanthanide 4*f* shells.[1] We started investigating epitaxial and polycrystalline film growth and electronic-magnetic properties of these compounds a decade ago, motivated by a prediction of half metals among their number,[2] only to discover their semiconducting nature. In the past few years we began work on LN/L’N heterostructures including tunnelling structures.[3] Furthermore we have investigated integration with both the optical III-V semiconductors and superconductors of interest for their potential in central processors. Along the way there have been many surprises, most recently that one of the series, near-zero-magnetisation ferromagnetic SmN, is superconducting below 4 K.[4] Even more recently an investigation of the carrier-concentration dependence of the anomalous Hall effect in these materials has provided a clear quantitative theory of their intrinsic Berry-phase anomalous Hall effect.[5] The talk will cover the lot, the growth conditions and crystal structure, control of their carrier concentration, investigations of their coupled magnetic/electronic properties, tunnelling in device-like structures and the observation of the remarkable superconductivity in doped SmN.

[1] F. Natali et al., Prog. Materials Science **58**, 1316 (2013).

[2] C. M. Aerts et al., Phys. Rev. B **69**, 045115 2004.

[3] H. Warring et al., Phys. Rev. Appl. **6**, 044002 (2016).

[4] E.-M. Anton et al., Phys. Rev. B **94**, 024106 (2016).

[5] H.J. Trodahl et al., Phys. Rev. B **96**, 115309 (2017).