Title: Novel Synthetic Magnetic Structures for All-Optical Magnetic Recording

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Other staff associated with project: Dr Jade Scott

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Summary:
Magnetic data storage is central to societal exploitation of information technology. Bulk data storage is by hard disk drives in the 'Cloud'. Currently, these drives use magnetic writing (electromagnetic) and reading (spintronics). Heat Assisted Magnetic Recording (HAMR) drives are just entering the market and they replace the purely electromagnetic writing with heat applied via a near-field plasmonic interaction on the disk surface [1]. Beyond HAMR, a decade from now, there is the potential to do away with the energy consuming electromagnetic writing process and use an all-optical means to switch and encode magnetic data on the disk. This requires convergence of three new research challenges 1. New materials that exhibit helicity independent, deterministic, magnetic switching, 2. Superior near field irradiation schemes and 3. The use/development of microscale picosecond (ps) laser sources. This project will address aspects 1 and 3.

We are currently engaged in a collaboration to explore the materials and the physical mechanisms that could be used in all-optical switching (AOS). To date we have demonstrated the effects with thin synthetic ferrimagnets comprised of multilayers such as Ni_3Pt (7nm) / Ir (0.5nm) / Co (1nm) [2] and Ni/Pt superlattices [3]. We now wish to converge towards conventional HAMR based magnetic media based on the FePt alloy. This will involve the synthesis of new synthetic magnetic multilayers and their magnetic characterisation (magnetometry, ferromagnetic resonance etc). The materials development work may also involve a session/s at the DIAMOND synchrotron facility, using XMCD [4] to probe switching dynamics of constituent atoms/layers [2]. It will also interact closely with potential modelling initiatives in a parallel PhD project whereby we foresee the exchange of empirical data informing the development of models of materials the underpinning switching mechanisms that will also include quantum effects [5]. Secondly, to allow us to screen newly developed materials for the desirable AOS behaviour ahead of more intensive characterisation with collaborators at Exeter University we aim to create a small integrated photonic test bed system that uses new ps lasers [6] to do basic far field laser excitation of AOS materials to demonstrate use of microscale ps lasers in AOS.

There is the scope for undertaking computer based simulations using ab-initio code [http://vampire.york.ac.uk] and/or packages such as OOMMF [https://math.nist.gov/oommf/] or mumax3 [https://mumax.github.io] depending upon student interests. You will also get training & exposure to equipment for materials processing & characterisation including deposition systems & electron & focused ion beam microscopes.

Key Skills: An interest in applying some fundamental physics to applied problems, developing yourself through exposure to scientific equipment used in leading industries.

Contact details to discuss project:
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Background Reading:

[1] Seagate "Just" a Hard Drive - https://www.youtube.com/watch?v=NNzlxhDOhfs
[2] 'Transition Metal Synthetic Ferrimagnets: Tunable Media for All-Optical Switching Driven by Nanoscale Spin Current', Maciej Dąbrowski et al Nano Lett. **21**, 9210–921 (2021). https://pubs.acs.org/doi/abs/10.1021/acs.nanolett.1c03081
[3] 'Unidirectional multi-pulse helicity-independent all-optical switching in [Ni/Pt] based synthetic ferrimagnets', Connor R. J. Sait et al to be published Phys. Rev B.
[4] https://www.diamond.ac.uk/Instruments/Magnetic-Materials/I10.html
[5] See a project offered by Myrta Gruening/Gabriele de Chiara
[6] 'Mode-Locked Laser Diodes and Their Monolithic Integration', J.H. Marsh & L. Hou IEEE Journal of Selected Topics in Quantum Electronics, **23,** 1100611 (2017) http://eprints.gla.ac.uk/139388/7/139388.pdf