High target utilisation sputtering for the development of advanced materials for magnetic data storage applications

Submitted by Denh Tran to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Engineering, June 2012

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Abstract

High target utilisation sputtering (HiTUS) is a relatively new thin film deposition technique that generates a high density plasma remotely from the sputter target. This method has been employed firstly to investigate FePt and FePtN thin films for high density data storage media applications and secondly to investigate the production of a GMR/PZT hybrid structure (multi-ferroism) for improvements to magneto-resistive read-sensor devices in hard disk drives and potentially for other novel multi-ferroic applications.

The magnetic and structural properties of FePt and FePtN films, prepared by the HiTUS method, on both silicon and glass substrates have been investigated before and after annealing at temperatures in the range of 300 to 800 °C. It is shown that during thermal annealing there is a degradation in magnetic properties of the FePt films at around 400 °C due to the formation of silicides as the thermal processing promotes the reaction of the film with the substrate. However, in the FePtN samples coercivity values continue to rise with annealing temperatures above 400 °C. XRD analysis confirms that silicide formation is suppressed in films containing nitrogen up to 800 °C. Using the HiTUS technique, there is evidence that $L_1_0$ ordering of FePt has occurred at annealing temperature of 400 °C with in plane and out of plane coercivities of 7180 Oe and 6300 Oe respectively.

Finally, it is shown that HiTUS is capable of depositing ultra thin multilayer GMR structures onto a variety of substrates; silicon, glass, flexible kapton film and PZT. It is interesting to find that the GMR ratio obtained on kapton film (14.39 %) is almost as high as that on silicon (16.15 %), with much scope for improvement. Multi-ferroic composite films consisting of the GMR multilayer structure $[\text{Co}(8 \, \text{Å})/\text{Cu}(21 \, \text{Å})]_{20}/\text{Co}(12 \, \text{Å})$ on PZT substrates were fabricated and magneto-electric coupling effects explored. It was found that AC voltages applied across the composite GMR/PZT structure produced a marked decrease in the coercivity of the GMR layer. However, DC voltages did not produce any measurable magnetic effects. Careful investigation revealed that the reduction in coercivity observed during AC measurements was, in fact, due to sample heating effects.
## Contents

1 Introduction 12

1.1 Overview of thesis ........................................... 14

2 Thin film fabrication 16

2.1 Introduction ...................................................... 16
2.2 Vacuum Evaporation .......................................... 18
2.3 Sputtering ......................................................... 19
   2.3.1 Glow discharges .......................................... 20
   2.3.2 DC cathode sputtering ................................... 22
   2.3.3 Magnetron sputtering .................................... 24
2.4 High target utilisation sputtering ............................ 27
   2.4.1 System overview ........................................... 29
   2.4.2 Plasma generation and HiTUS process ................... 30
   2.4.3 Sputtering of magnetic materials ....................... 39

3 Magnetic materials 45

3.1 Magnetism ....................................................... 45
3.2 Classification of magnetic materials .......................... 46
3.3 Characteristics of ferromagnetic materials .................... 48
   3.3.1 Ferromagnetic domains ................................... 48
   3.3.2 Magnetostatic energy .................................... 49
   3.3.3 Magnetic anisotropy ..................................... 50
   3.3.4 Magnetocrystalline anisotropy .......................... 51
   3.3.5 Stress anisotropy ........................................ 53
   3.3.6 Domain walls ............................................. 54
   3.3.7 Shape anisotropy and inter-particle interactions ........ 55
   3.3.8 Hysteresis loops ......................................... 56
4 Magnetic data storage

4.1 The basic hard disk drive ........................................ 58
4.1.1 The recording process ........................................ 58

4.2 Data read out ....................................................... 61
4.2.1 Magneto-resistive Effect ....................................... 61
4.2.2 Giant Magneto-resistive Effect ................................. 62
4.2.3 Giant magneto-resistance in multilayers ...................... 63
4.2.4 Basic principles of the reading process using GMR spin valves 63

4.3 Exchange coupling .................................................. 65

4.4 Magnetic Tunnel Junctions ......................................... 66

4.5 Data storage media ................................................ 68
4.5.1 Important magnetic properties of magnetic recording media 71
4.5.2 Recording media challenges ................................... 72

4.6 High $K_u$ materials ............................................... 74

4.7 Crystal structures .................................................. 76
4.7.1 Miller System .................................................... 78

4.8 $L1_0$ FePt structure and phases ................................ 79

4.9 Challenges for FePt ................................................ 81
4.9.1 Controlling the easy axis ...................................... 81
4.9.2 Reduction of ordering temperature ............................ 84
4.9.3 Reduction of grain size ......................................... 85

5 Multi-ferroism ......................................................... 86

5.1 Ferroelectricity ...................................................... 86

5.2 Ferroelasticity ....................................................... 88

5.3 The piezoelectric effect ........................................... 90

5.4 Lead zirconate titanate ............................................ 92

5.5 Combining ferromagnetism and ferroelectricity .................. 94

5.6 Magneto-electric coupling mechanisms ........................... 97
5.6.1 Interface charge mediated coupling ........................... 97
5.6.2 Exchange bias mediated coupling ............................... 97
5.6.3 Strain mediated coupling ....................................... 98
6 Characterisation techniques

6.1 Vibrating sample magnetometry .................................. 100
  6.1.1 Theory of VSM ............................................. 101
6.2 Magneto-optical Kerr effect magnetometry ......................... 103
  6.2.1 Magneto-optic effect ...................................... 103
  6.2.2 Magneto-optic Kerr effect ................................ 104
  6.2.3 Operating geometries ..................................... 105
6.3 X-ray diffractometry .............................................. 107
  6.3.1 Theory .................................................... 107
  6.3.2 Diffraction measurements .................................. 110
  6.3.3 Crystallite size .......................................... 111
6.4 Atomic force microscopy .......................................... 112
  6.4.1 Optical lever detection ................................... 112
  6.4.2 AFM modes ............................................... 113
6.5 Magneto-resistivity measurements .................................. 115

7 Fabrication and characterisation of annealed FePt thin films 118

7.1 Introduction .................................................... 118
7.2 Sputtering with nitrogen ........................................ 119
  7.2.1 Silicon nitride ........................................... 121
7.3 Project Introduction ............................................ 123
7.4 Experimental ................................................... 124
7.5 Results ........................................................ 126
  7.5.1 Magnetic properties ....................................... 126
  7.5.2 X-Ray diffractometry ..................................... 134
  7.5.3 Electrical properties ..................................... 143
  7.5.4 Surface morphology ....................................... 146
  7.5.5 Crystallite size .......................................... 147
  7.5.6 High coercivity FePt ...................................... 147
7.6 Summary and conclusions ......................................... 153

8 Multi-ferroics for future data read sensors 156

8.1 ME for data storage read out applications ........................ 157
8.2 The GMR effect on ferroelectric PZT ............................... 159