

Contents

List of abbreviations	xv
1 Introduction	1
2 Theory	7
2.1 Energy contributions in a ferromagnet	7
2.1.1 Exchange energy	7
2.1.2 Zeeman energy	7
2.1.3 Demagnetization field	7
2.1.4 Magnetocrystalline anisotropy	8
2.2 Spin-orbit torques	11
2.2.1 Field-like spin-orbit torque	12
2.2.2 Damping-like spin-orbit torque	12
2.2.3 Intrinsic spin-orbit torques	13
2.2.4 Intrinsic torques for the point group $\bar{4}2m$	16
2.2.5 Intrinsic torques for the point group $mm2$	21
2.3 Magnetotransport effects	24
2.3.1 Magnetoresistive effects	24
2.3.2 Magnetothermal effects	28
3 Samples and methods	31
3.1 Sample preparation	31
3.1.1 Optical lithography	31
3.1.2 YIG/Pt samples	32
3.1.3 PtMnSb and PtMnSb/Pt samples	33
3.2 Harmonic magnetotransport measurements	33
3.3 First harmonic effects	37
3.4 Second harmonic effects	38
3.4.1 Field dependence	38
3.4.2 Angular dependence	41
3.4.3 Degeneracy of the lineshape for the $\bar{4}2m$ point group	41
3.4.4 Lineshapes and its degeneracy for the $mm2$ point group	43
3.4.5 Thermal effects	44
3.5 Macrospin simulations	45
	xi

3.6 Spin-orbit torque evaluation procedures	49
3.6.1 Lineshape-independent analysis	49
3.6.2 Lineshape-dependent analysis	50
4 Current-induced effects in PtMnSb	55
4.1 Structural and magnetic characterization of PtMnSb	55
4.2 Saturation magnetization	57
4.3 Magnetoresistance and anisotropy in PtMnSb	58
4.3.1 Longitudinal resistivity	58
4.3.2 Transverse resistivity	60
4.3.3 Magnetic anisotropy	63
4.3.4 Field-dependent planar Hall coefficient	65
4.4 Spin-orbit torque effective fields	66
4.4.1 Symmetry	67
4.4.2 Quantification	68
4.4.3 Thickness dependence	71
4.5 Magnetothermal effects	75
4.6 Conclusions	76
5 Current-induced effects in PtMnSb/Pt	79
5.1 Magnetoresistance and anisotropy in PtMnSb/Pt(t)	79
5.1.1 Longitudinal resistivity	79
5.1.2 Transverse resistivity	82
5.1.3 Magnetic anisotropy	82
5.1.4 Field-dependent planar Hall coefficient	85
5.2 Magnetothermal effects	85
5.3 Spin-orbit torque effective fields	86
5.4 Conclusions	91
6 Magnetic properties and domains of ultrathin YIG/Pt	93
6.1 Background	93
6.2 Experimental details	95
6.2.1 Growth and structural characterization	95
6.2.2 Magnetic measurements	95
6.3 Structural properties	97
6.4 Saturation magnetization	99
6.5 Magnetic anisotropy	101
6.5.1 Easy plane anisotropy	102

6.5.2 In-plane uniaxial anisotropy	102
6.6 Magnetic domains	105
6.6.1 Domain structure in thick and thin YIG	106
6.6.2 Domain walls in thick YIG	107
6.7 Conclusions	109
7 Current-induced effects in YIG/Pt	111
7.1 Background	111
7.2 Samples	112
7.3 Experimental details	112
7.4 Current-induced effective fields	113
7.5 Current-assisted switching	118
7.6 Conclusions	120
8 Conclusions and outlook	121
Appendices	125
A Appendix	126
A.1 Polar and axial tensors for $mm2$	126
A.2 Lineshapes and effective fields for axial tensors of $mm2$	131
A.3 Lineshapes and effective fields for polar tensors of $mm2$	135
A.4 Mathematica script to determine the effective fields	137
A.5 Mathematica script to determine B_1^p from a given axial tensor	139
A.6 Stepwise lineshape-independent evaluation for PtMnSb(10)	141
A.7 PtMnSb effective field fits	143
Bibliography	145