

Table of contents

Introduction	1
1 Fundamentals	5
1.1 Ferroic properties	5
1.2 Magnetoelectric effect	7
1.3 Symmetry considerations	10
1.4 Curie-Weiss extrapolation	11
1.5 Nonlinear optics: Second Harmonic Generation	11
2 Hexagonal rare-earth manganites, HoMnO₃	15
2.1 Crystal structure	16
2.1.1 Influence of RE ³⁺ radius on crystal structure	16
2.1.2 Hexagonal HoMnO ₃	17
2.1.3 Ferroelectricity in hexagonal REMnO ₃	18
2.2 Magnetic structure	19
2.2.1 Spin arrangements	21
2.2.2 Magnetic interactions	22
2.3 Phase diagrams	24
2.4 Magnetoelectric coupling	26
3 Experimental methods	29
3.1 Sample preparation	29
3.2 Sample characterization	32
4 Epitaxially grown HoMnO₃ thin films and capacitor layers	39
4.1 Crystal structure	39
4.2 Lattice parameters	42
4.3 HoMnO ₃ /YMnO ₃ superlattices	43

4.4	Capacitor trilayer	46
4.5	Summary	48
5	Magnetic properties and phase diagram of films and single-crystals	49
5.1	Temperature dependence of magnetization	49
5.1.1	Curie-Weiss law	49
5.1.2	Spin reorientation temperature, T_{SR}	51
5.1.3	Low temperature anomalies	53
5.2	Magnetic field dependence of the magnetization	60
5.2.1	Magnetic field-induced phase transition	60
5.2.2	High-field transition of single-crystals	64
5.3	The HoMnO_3 phase diagram	65
5.4	Summary	67
6	Characterization by SHG	69
6.1	Electric polar order	69
6.2	Magnetic order	72
6.3	Summary	76
7	Electrical properties	79
7.1	Ferroelectric polarization	79
7.2	Experimental difficulties with leakage current	80
7.3	Summary	82
8	Conclusions and outlook	83
	References	86