# Contents

## Abstract

1

## Chapter 1: Introduction

1.1 Materials Science 4
1.2 Functional Materials 5
1.3 Smart Materials 5
1.4 Nanomaterials 7
1.5 Magnetism 9
1.6 Spinel Type Ferrites 12
  1.6.1 Crystal Structure of Spinel Ferrites 12
  1.6.2 Magnetic Properties of Spinel Ferrites 14
1.7 Magnetic Anisotropy 15
1.8 Magnetic Domains 18
1.9 Magnetization Process 19
1.10 Magnetic Nanomaterials 20
1.11 Magnetostriction 23
  1.11.1 Mechanism of Magnetostriction 25
  1.11.2 Applications of Magnetostriction 25
  1.11.3 Magnetostrictive Materials 27
  1.11.4 Oxide Based Magnetostrictive Materials 29
  1.11.5 Magnetostriction of Cobalt Ferrite 31
1.12 Scope of the Present Work 35

References 37
Chapter 2: Experimental Methods

2.1 Introduction 44

2.2 Methods of Synthesis 44
  2.2.1 Ceramic Method 45
  2.2.2 Autocombustion Method 46
  2.2.3 Co-precipitation Method 48
  2.2.4 Citrate Method 50

2.3 Compaction 50

2.4 Sintering 51

2.5 Characterization Techniques 52
  2.5.1 Powder X-Ray Diffraction (XRD) 52
  2.5.2 Transmission Electron Microscopy (TEM) 54
  2.5.3 Scanning Electron Microscopy (SEM) 54
  2.5.4 Vibrating Sample Magnetometer (VSM) 55
  2.5.5 Thermo-Mechanical Analysis (TMA) 57
  2.5.6 Density Measurements 59
  2.5.7 Magnetostriction Measurements 61

References 64

Chapter 3: Effect of Particle Size on the Magnetostriction of Sintered Cobalt Ferrite

3.1 Introduction 68

3.2 Synthesis 70

3.3 Studies on As-synthesized Powder Samples 72
  3.3.1 Phase Purity and Structural Characterization 72
  3.3.2 Magnetic Measurements 77
  3.3.3 TMA Analysis 82

3.4 Studies on Sintered Samples 83
  3.4.1 XRD Studies 83
  3.4.2 Density Measurements 85
  3.4.3 Magnetic Measurements 86

References 87
### Chapter 4: Effect of Sintering Conditions on the Magnetostriction of Cobalt Ferrite

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Introduction</td>
<td>114</td>
</tr>
<tr>
<td>4.2</td>
<td>The Sintering Process</td>
<td>117</td>
</tr>
<tr>
<td>4.3</td>
<td>Studies on Sintered Samples</td>
<td>118</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Microstructure and Density</td>
<td>118</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Magnetic Properties</td>
<td>125</td>
</tr>
<tr>
<td>4.3.3</td>
<td>Magnetostriction Studies</td>
<td>128</td>
</tr>
<tr>
<td>4.3.4</td>
<td>Magnetic Field Annealing Studies</td>
<td>134</td>
</tr>
<tr>
<td>4.4</td>
<td>Conclusions</td>
<td>138</td>
</tr>
</tbody>
</table>

References 139

### Chapter 5: Magnetostriction Studies on Self-Composites of Sintered Cobalt Ferrite

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Introduction</td>
<td>141</td>
</tr>
<tr>
<td>5.2</td>
<td>Preparation of Self-Composites</td>
<td>142</td>
</tr>
<tr>
<td>5.3</td>
<td>Magnetostriction Studies on Self-Composites</td>
<td>142</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Two-Component Systems</td>
<td>142</td>
</tr>
<tr>
<td>5.3.2</td>
<td>Three-Component Systems</td>
<td>151</td>
</tr>
<tr>
<td>5.3.3</td>
<td>Effect of Magnetic Field Annealing</td>
<td>153</td>
</tr>
<tr>
<td>5.4</td>
<td>Microstructure</td>
<td>158</td>
</tr>
<tr>
<td>5.5</td>
<td>Discussion</td>
<td>158</td>
</tr>
<tr>
<td>5.6</td>
<td>Conclusions</td>
<td>164</td>
</tr>
</tbody>
</table>

References 165
Chapter 6: Magnetostriction Studies on Mn Substituted Cobalt Ferrite
Derived from Nanocrystalline Powders

6.1 Introduction 166
6.2 Synthesis 168
6.3 Results and Discussion 169
  6.3.1 Powder XRD Analysis 169
  6.3.2 Magnetic Measurements 172
  6.3.3 Microstructure 177
  6.3.4 Magnetostriction Studies 177
  6.3.5 Effect of Sintering Temperature on CoFe1.8Mn0.2O4 182
  6.3.6 Effect of Magnetic Annealing on CoFe1.8Mn0.2O4 184
6.4 Conclusions 186
References 187

Chapter 7: Conclusions and Future Perspectives 189