Preface

Since the discovery of Cu_2MnSn by Friedrich Heusler in 1903, this type of ternary alloys has been intensively investigated due to its ferromagnetism without containing any ferromagnetic elements, such as Fe, Co, Ni and Gd. Such an alloy, known as Heusler alloy, has been demonstrated to form thermal antiphase boundaries, which can be utilised for shape-memory materials and magnetic refrigeration. The Heusler alloys have then attracted more attention from the spintronics community since the first prediction of the half-metallicity on a half-Heusler alloy, NiMnSb, by de Groot et al. in 1983. The Heusler alloys are therefore known to be one of the best half-metallic ferromagnets to achieve 100 % spin polarisation at room temperature due to their high Curie temperature and large intrinsic magnetic moments. In order to implement the Heusler alloys into spintronic devices, the half-metallicity needs to be maintained in their thin film form. This requires to overcome major challenges; the formation of fully-ordered phase, the avoidance of atomic disorder at surfaces and the interfaces and introduction of strong magnetic anisotropy.

These three challenges have been initially discussed from the theoretical point of view, followed by experimental analysis on the properties of the Heusler alloys in a bulk form. Based on the technical advancement in growth, these alloys have been grown in a thin-film form over the last decades. These films have recently patterned into a nanometre-scale junction for their device implementation. In such a nano-junction, the surface contributions dominate the overall properties and hence emphasise the above challenges even more than ever. It is therefore a good time to overview the development of the theory of the Heusler alloys as well as understanding and improvement of the properties of the alloys.

This book consists of seven parts from fundamental theory to device applications. The first part focuses on the theory of Heusler compounds, including two chapters by the pioneering research groups on half-metallic Heusler alloys; theory of Heusler and full-Heusler compounds by Galanakis and basics and perspectives of magnetic Heusler compounds by Felser. The properties of the alloys are described in the following part. Two techniques are used to characterise the alloys, i.e., spin-resolved photoemission (Aeschlimann) and nuclear magnetic resonance

(Wurmehl) in the first two chapters. Their properties in nanometric scale (Hütten) as well as their atomic interactions (Grin) are shown afterwards. The magnetic and electric properties of binary-form Heusler alloys (Coey) are then discussed. Their off-stoichiometric properties (Leighton) are also discussed at the end of the part.

The third part highlights three major applications of the Heusler alloys; spintronics (Hirohata), thermoelectrics (Balke) and thermodynamics (James). These chapters refer to the advantages of the usage of these alloys as well as the obstacles for their applications as related to the above challenges. Such applications rely on the two-dimensional form of the alloys, which is covered by the following part (Hono). The evaluation of the magnetic properties of these films is reviewed in Part V, including ultrafast optics (Hillebrands), Mössbauer spectroscopy (Mibu) and X-ray magnetic circular dichroism (Elmer). In the next part, further evaluation of these films in multilayered junctions is shown to study their giant magnetoresistive (Takanashi) and tunnelling magnetoresistive behaviours (Mitani). The influence of their interfacial disorder (Yamamoto) and exchange coupling (O'Grady) onto their behaviours are also explained in the latter half of this part. At the end of this book, new emerging applications of the Heusler alloys are discussed, especially topological insulators (Chadov).

On behalf of the authors, we sincerely wish this book serves as a comprehensive handbook of Heusler alloys in a timely manner and contributes to further development in this exciting research field. We are grateful to all the authors who spent their precious time and knowledge to realise this book. We also thank the tremendous technical support from Springer.

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