Preface

Scientific investigations to understand the fascinating behavior of thin magnetic films originating from fundamental quantum mechanical properties and particular spin coupling phenomena already started in the 1970s. The exploitation of magnetic films in technologies such as magnetic storage and sensor devices has received enormous boost with the discovery of the giant magnetoresistance effect in 1988. This discovery marks the beginning of the era of spintronics in which, beyond the charge used so far exclusively for conventional electronics, the spin of the electrons plays a dominating role. It also enabled to a large part the tremendous miniaturization of magnetic devices which became requisite for the plethora of magnetic applications, ranging from supercomputers to simulate, for example, climate changes to the zillions of entertainment gadgets allowing, for example, to watch almost anywhere high-quality movies.

In view of the ongoing race to increase the speed and, at the same time, decrease the energy demand for spin-based devices, unconventional spin textures, such as skyrmions, which require broken inversion symmetry such as naturally present in layered thin film systems, have recently attracted enormous attention, indicating that even after nearly 40 years thin film magnetism is still among the most vivid and controversial topics in magnetism.

The success of magnetic thin films particularly in the realm of nanomagnetism was based on major advances in three areas. The first is related to major technological progress in the synthesis of such systems. Thin-film fabrication capabilities have tremendously matured and are widely available, ranging from molecular beam epitaxy with atomic precision to sputter deposition techniques, which enable large-scale production of high quality thin film structures. Beyond the stacking of layered thin films, reaching out into superlattices, where the vertical coupling can be tailored to highest degree, the investigation and the use of effects of confinement and proximity, i.e., reflecting the lateral coupling phenomena, became possible due to advances in nanopatterning capabilities, such as electron-beam lithography, focused ion beam milling, or even the self-assembled rearrangement of structures.

The second is the significant progress in the theoretical description of the magnetic properties of thin films, heterostructures and nanostructures. State-of-the-art density functional theory approaches, again harnessing the computing power of supercomputers, have helped not only to achieve a much deeper understanding, but have also increased the predictive power of theories to guide the experimentalist in the search for better materials. The prediction of a large spin polarization in an Fe/MgO layered system by Butler and Mahon is just one of those hallmarks.

Whereas the synthesis and the theory set the framework, it is the advances in characterization which have ultimately unveiled the properties of thin magnetic films and layered structures. There, an enormous progress has been made over the last two decades, triggered by the need to look deeper and more detailed into those systems, but also enabled by the advent of new instrumentation technologies harnessing the interaction of photons with magnetic thin film materials.

Writing a book on the capabilities of advanced magnetic imaging techniques for thin-film systems, where new developments and achievements are reported almost daily, is not an easy task, but we think worth the effort and hopefully appreciated by our communities. The focus of our book is on those imaging techniques that allow to "see" the magnetic domains or spin textures in different layers separately. The techniques which are laid out in this monograph rely on the interaction of photons with magnetic materials, both of optical photons and of soft X rays. We tried to collect the current state-of-the-art in imaging layered magnetic heterostructures, but also to present the interested reader an up-to-date overview of the research field based on sufficient background information to provide guidance on the choice of the technique that is inherently best suited to solve a certain problem.

In the course of writing the book we were saddened with the passing away of our dear colleague Ulrich Hillebrecht. He has made seminal contributions specifically to the imaging of layered structures containing antiferromagnetic materials, which undoubtedly constitutes an integral part of this endeavor. By adding Uli to the list of coauthors we want to honor him and his contributions posthumously.

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