Synthesis and spectroscopic analysis of novel ordered alloy with large uniaxial magnetic anisotropy

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A large uniaxial magnetic anisotropy is a fascinating feature for magnetic materials because it gives birth to various intelligent functions. For instance, materials with a large uniaxial magnetic anisotropy are promising for the application to high-density magnetic storage devices since the thermal stability of magnetization is kept even in a nanometer scale. Furthermore, large uniaxial magnetic anisotropy energy ($K_u$) is one of the crucial matters to realize next-generation strong hard magnets. It is well known that L10-ordered alloys such as FePt, CoPt, and FePd show considerably large $K_u$. However, they include noble metals, thus it is an indispensable subject to find a noble metal-free large magnetic anisotropy ferromagnet. It is known that iron meteorites contain L10-ordered FeNi phase, so-called “tetrataenite”, which induces unique magnetic properties different from usual Fe-Ni alloys. It has been reported that L10-ordered FeNi has a large $K_u$ of $1.3 \times 10^7$ erg/cm$^3$ for a bulk sample). However, there have been no studies on the fabrication of L10-ordered FeNi thin films. We have been trying the fabrication of L10-ordered FeNi films by alternate monatomic layer deposition or the sputtering method for several years. In this talk, we present a review on the recent progress of our study on the synthesis and characterization of L10-ordered FeNi films. The maximum value of $K_u$, which was estimated from magnetization curves, reached $9.0 \times 10^6$ erg/cm$^3$. The largest order parameter, which was estimated from XRD spectra, was 0.48. $K_u$ monotonously increased with the order parameter. We also fabricated Ni/Fe superlattices with different layer thickness and investigated their magnetic properties to understand magnetic anisotropy in Ni/Fe system including L10-ordered FeNi. The spectroscopic analysis of the electronic structures of these films by the photoemission spectroscopy (PES) and the magnetic circular dichroism (MCD) measurements were made using a synchrotron radiation. The origin of the large uniaxial magnetic anisotropy will be discussed. In addition, recent progress on the synthesis of L10-ordered FeNi bulks by a chemical method will be also presented.

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Reference