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

Masaki Mizuguchi and Koki Takanashi
(Institute for Materials Research, Tohoku University, Japan)

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 $L1_0$-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 $L1_0$-ordered FeNi phase, so-called “tetrataenite”, which induces unique magnetic properties different from usual Fe-Ni alloys. It has been reported that $L1_0$-ordered FeNi has a large K_u of 1.3×10^7 erg/cm^3 for a bulk sample[1]. However, there have been no studies on the fabrication of $L1_0$-ordered FeNi thin films. We have been trying the fabrication of $L1_0$-ordered FeNi films by alternate monatomic layer deposition or the sputtering method for several years[2-18]. In this talk, we present a review on the recent progress of our study on the synthesis and characterization of $L1_0$-ordered FeNi films. The maximum value of K_u, which was estimated from magnetization curves, reached 9.0×10^6 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 $L1_0$-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 $L1_0$-ordered FeNi bulks by a chemical method will be also presented[19].

This work was partly supported by JST under Collaborative Research Based on Industrial Demand "High Performance Magnets”.

Reference
1) J. Paulevé *et al*., J. Appl. Phys. **39**, 989 (1968).
2) T. Shima *et al*., J. Magn. Magn. Mater. **310**, 2213 (2007).
3) M. Mizuguchi *et al*., J. Appl. Phys. **107**, 09A716 (2010).
4) M. Mizuguchi *et al*., J. Magn. Soc. Jpn. **35**, 370 (2011).
5) T. Kojima, M. Mizuguchi *et al*., J. Phys.: Conf. Ser. **266**, 012119 (2011).
6) M. Kotsugi, M. Mizuguchi *et al*., J. Phys.: Conf. Ser. **266**, 012095 (2011).
7) T. Kojima, M. Mizuguchi *et al*., Jpn. J. Appl. Phys. **51**, 010204 (2012).
8) M. Kotsugi, M. Mizuguchi *et al*., J. Magn. Magn. Mater. **326**, 235 (2013).
9) T. Kojima, M. Mizuguchi *et al*., Surf. Sci. **326**, 235 (2013).
10) M. Ogiwara, M. Mizuguchi *et al*., Appl. Phys. Lett., **103**, 242409 (2013).
11) T. Kojima, M. Mizuguchi *et al*., J. Phys.: Conden. Matter, **26**, 064207 (2014).
12) M. Kotsugi, M. Mizuguchi *et al*., J. Phys.: Conden. Matter, **26**, 064206 (2014).
13) T. Kojima, M. Mizuguchi *et al*., J. Phys. D, **47**, 425001 (2014).
14) T. Tashiro, M. Mizuguchi *et al*., J. Appl. Phys., **117**, 17E309 (2015).
15) K. Mibu, M. Mizuguchi *et al*., J. Phys. D, **48**, 205002 (2015).
16) T. Kojima, M. Mizuguchi *et al*., Thin Solid Films, **603**, 348 (2016).
17) K. Takanashi, M. Mizuguchi *et al*., J. Phys. D, **50**, 483002 (2017).
18) T. Tashiro, M. Mizuguchi *et al*., J. Alloys Compd. **750**, 164 (2018).
19) S. Goto, M. Mizuguchi *et al*., Scientific Reports, **7**, 13216 (2017).