A New Route to Synthesize $L1_0$-type FeNi Alloy Powder

S. Goto[1], Y. Hayashi[1], E. Watanabe[1], H. Kura[1], H. Yanagihara[2], M. Mizuguchi[3], K. Takanashi[3], E. Kita[4]
[1]Research Laboratories, DENSO CORPORATION, Aichi 470-0111, Japan
[2]Institute of Applied Physics University of Tsukuba, Ibaraki 305-8573, Japan
[3]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
[4]National Institute of Technology, Ibaraki College, Ibaraki 312-8508, Japan

$L1_0$-FeNi is a potential candidate for use in high performance magnets free of rare earth elements because of their high magnetic anisotropy. Various synthesis processes such as neutron irradiation[1)], alternate monoatomic layer deposition[2)] and chloride complex reduction[3)] have been carried out. However, a technique for obtaining a large content of this material has not yet succeeded. In this paper, we propose a route of large scale synthesis of $L1_0$-FeNi alloy in powder form by successive nitriding and denitriding of FeNi alloys.

We first optimized the nitriding conditions of FeNi alloy powders such as the process temperature, flow rate of NH_3 gas, and so on. Then a denitriding technique was developed to obtain $L1_0$-FeNi alloys by hydrogen gas treatment. In order to characterize the nitride and the reduced alloys, transmission electron microscope (TEM), scanning electron microscope combined with energy dispersive x-ray spectroscope (SEM-EDS) and x-ray diffraction (XRD) were employed. We also performed magnetization measurements at room temperature.

XRD results indicate coexistence of $(Fe,Ni)_2N$ as the main phase with $(Fe,Ni)_4N$ as the second phase (Fig.1). We also found that the iron and nickel atom positions of the $(Fe,Ni)_2N$ alloy are almost ordered. The estimated volume of the $(Fe,Ni)_2N$ phase was at least 85%. The denitrided FeNi alloy was mainly composed of the ordered phase of $L1_0$. We observed a correlation between the two order parameters of the FeNi nitrided alloy and the FeNi denitrided alloy. The order parameter and the magnetic coercivity of the $L1_0$-FeNi compound were S = 0.67 and H_c = 815 Oe, respectively (Fig.2).

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Reference

1) L. Neel et al., J. Appl. Phys., 35(1964) 873.
2) M. Mizuguchi et al., J. Magn. Soc. Jpn., 35(2011) 370.
3) Y. Hayashi et al., J. Magn. Soc. Jpn., 37(2013) 198.

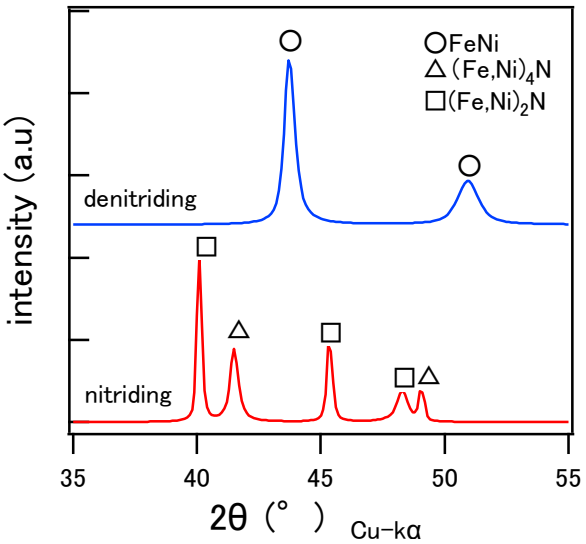

Fig1. Experimental x-ray diffraction patterns of the nitride FeNi (lower) and $L1_0$ phase (upper)

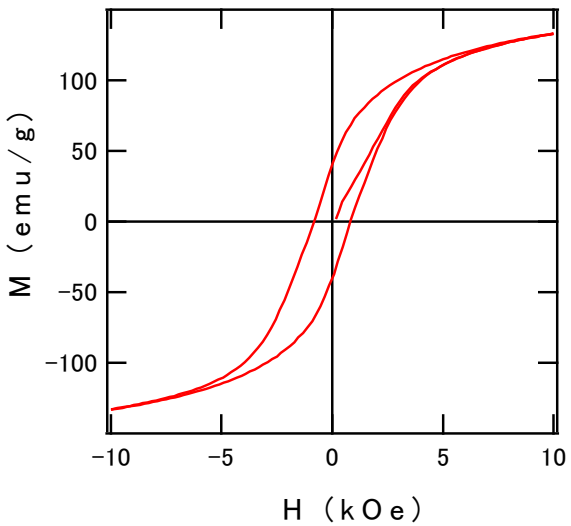

Fig.2 Magnetization curve at room temperature for a $L1_0$-FeNi powder