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Structural and magnetic properties of mechanically alloyed $Fe_{50}Mn_{50}$

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Abstract- $Fe_{50}Mn_{50}$ nano-crystalline alloys are prepared by the mechanical alloying process as a function of milling time. The effect of milling time on structural properties has been investigated by using XRD and EXAFS, which confirmed the alloy after 12 hours**.** The particle size and shape are examined by using SEM. Magnetic properties are examined by using SQUID. Magnetic saturation is decreased due to resulting magnetic dilution and decreasing particles size, and also the coercivity is decreased due to growing single-domain status as the particles size is reduced.

Fe–Mn alloys have been extensively studied for magnetic thin-film device applications. A FeMn thin antiferromagnetic layer has been used to enhance the function of a spin-valve read sensor. The antiparallel alignment of Mn magnetic moment has been observed frequently in magnetic materials. Superparamagnetic behavior has been observed in Fe_xMn_{1-x} ultra thin film. Also, various phenomena such as spin transition and shape-memory effect in Fe–Mn alloy have been reported recently [1].

In this work, $Fe_{100-x}Mn_x$ metastable alloys are prepared by mechanical alloying using a SPEX 8000 mixer with stainless steel ball. The $Fe_{50}Mn_{50}$ alloys are prepared with different milling times (1, 2, 4, 6, 12, and 24 hours). The mechanical alloying is performed in Ar atmosphere to prevent oxidation during the alloying process. The ball to powder weight ratio was 5:1. The variations of structure are examined by XRD and EXAFS. Particle size is calculated using Scherrer formula from XRD data. EXAFS data are analyzed with FEFF software. The nano particles size and shape have examined using SEM. Magnetic moments and coercivities of the samples are measured by using SQUID with the maximum field 5 kOe. The structural properties are discussed in connection with the magnetic properties of the alloys.

Both of XRD and EXAFS patterns showed the alloy formation after 12 hours milling time (Fig. 1 and Fig. 2)**.** The particles size and shape decreased with increasing of milling time, which is examined by using SEM (Fig. 3). Magnetic saturation is decreased due to decrease in particles size and resulting magnetic dilution, and also the coercivity of alloys is decreased due to growing single-domain size as the particles size is reduced (Fig. 4).

The formation of $Fe_{50}Mn_{50}$ metastable alloys were explicitly shown in the XRD pattern by new, shifted and broadened peaks, respectively. EXAFS spectra showed variation in amplitude and phase for 12 and 24 hrs milling times. The significant change in the phase confirmed that new chemical bonding between the central Fe atom and Mn atoms increased during the MA process. Magnetic saturation is decreased due to resulting magnetic dilution and decrease in particles size, and also the coercivity is decreased due to growing single-domain size as the particle size is reduced.

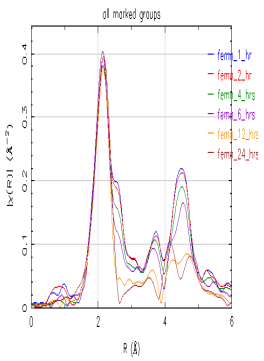

Fig. 1. Fourier transform of EXAFS spectra for $Fe_{50}Mn_{50}$ alloys measured at Ni K edge with indicated milling times.

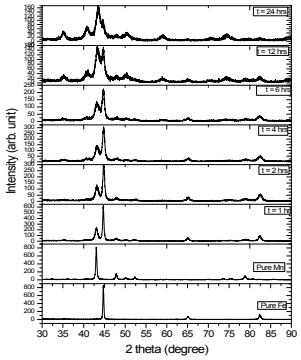

Fig. 2 XRD profiles of $Fe_{50}Mn_{50}$ mechanically alloyed as a function of milling time.

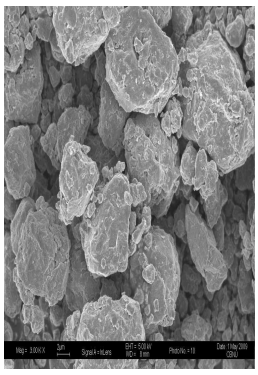

Fig. 3. Typical SEM images of $Fe_{50}Mn_{50}$ mechanically alloyed for 12 hrs milling time.

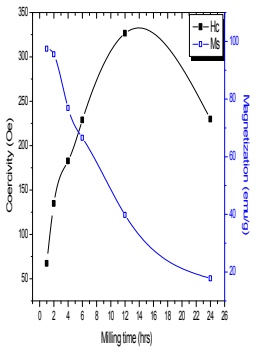

Fig. 4 Variation of magnetization and coercivity for $Fe_{50}Mn_{50}$ alloys as a function of milling time.

[1] Dong-Seok Yang, Nayoung Kim, Yong-Goo Yoo, and Seong-Cho Yu, Phys. Stat. Sol. (a) 205, 1766-1769 (2008)