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# Fabrication of Nanocomposite Powders by Mechanical Alloying of $Fe_3O_4$-M (M=Ti, Al) Systems

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Mechanical alloying (MA) has been used in the formation of a metastable phase, especially for amorphous and nanostructured materials. The ease of interdiffusion between different atomic species has been considered to be an indispensable factor for amorphization [1,2]. Also, it has been found that MA facilitates the nanocomposite formation of metal-metal oxide systems through solid-state reduction during mechanical alloying [3,4]. The system we chose is the $Fe_3O_4$-M (M=Al, Ti), where pure metals are used as reducing agent. The effects of mechanical alloying and kind of pure metals on the solid-state reduction of magnetite have been investigated.

The mechanical alloying has been carried out under argon atmosphere using a Fritsch P-5 mill. The compositions of the starting powder mixture corresponded to the stoichiometry of the displacement reactions in $Fe_3O_4$-M (M=Al, Ti). The thermal properties and structural change of ball-milled powders have been studied by differential scanning calorimetry (DSC) in combination with ordinary X-ray diffraction with Cu-K$\alpha$ radiation. Magnetic measurement using a vibrating sample magnetometer (VSM) and SEM observation were also carried out.

It is found that nanocomposite powders in which $Al_2O_3$ and $TiO_2$ are dispersed in Fe matrix with nano-sized grains are obtained by mechanical alloying of $Fe_3O_4$ with Al and Ti for 25 and 75 hours, respectively. It is suggested that the large negative heat associated with the chemical reduction of magnetite by aluminum is responsible for the shorter MA time for nanocomposite formation in $Fe_3O_4$-Al system. X-ray diffraction spectra show that the reduction of magnetite by Al and Ti is a relatively simple reaction, involving one intermediate phase of $FeAl_2O_4$ and $Fe_3Ti_3O_{10}$, respectively. From magnetic measurement, we can obtain more indirect information about the details of the solid-state reduction during MA, as well as magnetic particle size distribution and microstructures. In this way, we can point out what is the uniqueness in the solid-state reduction by MA in the $Fe_3O_4$-M (M=Al, Ti) systems.

## References

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