P-01

열전재료 $FeSi_2$의 기계적 합금화에 의한 제조 및 특성

Processing and properties of thermoelectric $FeSi_2$ materials fabricated by mechanical alloying

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$FeSi_2$ has a great potential for thermoelectric energy conversion devices utilizing simple temperature difference effectively at medium temperature range(~900K) without additional driving mechanisms. The high temperature phase of $FeSi_2$ is a eutectic structure consisting of tetragonal α-Fe_2Si_5 and cubic ε-FeSi, and low temperature phase is orthorhombic β-$FeSi_2$ which is known to be an intrinsic semiconducting phase. The β-$FeSi_2$, which is of our interests, have received great attention in a thermoelectric material because of its relatively low cost, the possibility of the improved thermoelectric efficiency, the thermal stability at high temperature and a chemical stability. However, the conventional ingot iron-silicide is composed of α-Fe_2Si_5, which is known as α-$FeSi_2$, and cubic ε-FeSi, at even low temperature due to the slower cooling rate and the phases can not be engaged in thermoelectric application. Thus, certain isothermal annealing is thought to be inevitable to induce a peritectoid reaction from α and ε phases to β phase.

In an effort to produce fine grain size, which might provide short diffusion path to enhance phase transformation and phase homogenization, mechanical alloying(MA) of elemental Fe and Si powders is considered in this study. In this work, MA followed by hot pressing have been conducted in the Fe-Si system near the composition of $FeSi_2$. The effect of milling time, hot pressing and heat treatment condition on the formation of $FeSi_2$ phase was investigated in this study. Thermoelectric and mechanical properties of β-$FeSi_2$ doped with Co(n-type semiconductor) prepared from MA process were presented, discussed and contrasted with the results of analogous studies of the conventionally processed counterparts.

Iron-silicide was successfully produced by mechanical alloying process and consolidated by vacuum hot pressing. It was shown that isothermal annealing under vacuum atmosphere below the critical temperature for 24 hours led to thermoelectric semiconducting β-$FeSi_2$ phase transformation. The mechanical properties were improved during isothermal annealing presumably due to the phase stabilization or the additional sintering effect. Thermoelectric properties of $FeSi_2$ materials were also remarkably improved during isothermal annealing due to β phase transformation.