Chapter I

Introduction

Thermoelectric or Thomson effect devices are solid-state devices that generate electricity from a heat source. The Thomson effect is the phenomenon where thermoelectric power generation results from the electricity that is induced in particular materials by temperature differential. In the early 1800s Seebeck observed that if two dissimilar materials were joined together and the junctions were held at different temperatures (T and T+ΔT), a voltage difference (ΔV) was developed, that was proportional to the temperature difference (ΔT). The ratio of the voltage developed to the temperature gradient ($\Delta V/\Delta T$) is called the Seebeck coefficient (α) or thermopower. The thermopower is very low for metal material (only a few μVK^{-1}) because they have a large electronic contribution to thermal conductivity. Semiconductor materials have a high thermopower typically a few 100 μVK^{-1}.

Semiconducting phase β-$FeSi_2$ is one of the promising materials useful for energy conversion in the temperature range 200-900°C. The material is nonpoisonous, good resistant against oxidation and can be operated in air without any protection. It exhibits high electrical conductivity and large thermoelectric power. A great advantage is that both p-type and n-type of the β-phase can be obtained by doping with Mn or Al and Co respectively. Solid state of iron silicide exists in three phases, which are β-$FeSi_2$, ε-FeSi and α-Fe_2Si_5. According to the phase diagram of the binary system Fe-Si, the stoichiometric $FeSi_2$ solidifies at 1220°C as a eutectic structure composed of α-Fe_2Si_5 and ε-FeSi, the metallic phase with poor thermoelectric properties. The β-$FeSi_2$ phase formation is either through the peritectoid reaction between α-Fe_2Si_5 and ε-FeSi or the eutectoid decomposition of α-Fe_2Si_5 to β-$FeSi_2$ and Si. β-$FeSi_2$ is not practically grown from melt. So far three types of β-$FeSi_2$ samples have been prepared [1].

- Tiny single crystals grown from the vapor phase.

- Thin polycrystalline layers by electron beam evaporation or plasma ion processing.

- Polycrystalline bulk material by powder metallurgical method.

In this thesis only the properties of polycrystalline bulk material will be discussed. The material is grown by mechanical alloying (MA) technique. MA is a solid state alloying process which is suitable for the production a very fine microstructure. The objective of this thesis is to synthesize $Fe_{1-x}Co_xSi_2$ (x = 0, 0.01, 0.03, 0.05) by mechanical alloying, cold-press and heat-treatment to induce β-$FeSi_2$. Thermopower (α) is determined by temperature gradient method in which one end of sample is a low temperature and the other end is heated by a hot probe. Electron transport parameters, electron concentration (n) and mobility (μ), are measured by the van der Pauw method to yield the electrical conductivity. Thermoelectric power factor ($\alpha^2\sigma$) is obtained from thermopower and electrical conductivity.