

β -FeSi₂ の熱電特性向上の為の Co 添加量の最適化

Optimization of Co addition amount to enhance thermoelectric properties of β -FeSi₂

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β -FeSi₂, having orthorhombic crystalline structure with *Cmca* space group, has been classified as a potential candidate for thermoelectric (TE) application due to its environmental friendliness, good thermal stability, and low cost [1]. Ur and Redzuan *et al.* reported that the maximum the *ZT* of Co-doped β -FeSi₂ was 0.06 at 600 K and 0.085 at 1073 K, respectively, [2,3]. In this work, we study on the effect of Co doping on the scattering mechanism and the optimization of its concentration to the TE performance of β -FeSi₂. β -Fe_{1-x}Co_xSi₂ ($0 \leq x \leq 0.06$) samples were fabricated by arc-melting and followed by heat treatment at 1423 K for 3 hours and annealing at 1113 K for 20 hours. The Seebeck coefficient and electrical resistivity was measured by ResiTest-8300 and homemade measurement system. The thermal conductivity was measured by power conversion efficiency measurement system (PEM-2, ULVAC-RIKO). At 300 K, as shown in Fig.1, with increasing *x* from 0 to 0.06 in β -Fe_{1-x}Co_xSi₂, the electrical resistivity (ρ) decreases from 7.23(7) to 0.008 Ω .cm due the increase in carrier concentration (n_H) from $6.3(9) \times 10^{16} \text{ cm}^{-3}$ to $1.0(0) \times 10^{19} - 3.8(8) \times 10^{20} \text{ cm}^{-3}$, respectively. The highest value of carrier concentration is found in $x=0.02$ sample and it is saturated at this point. In addition, the Seebeck coefficient $|S|$ of the non-doped sample is 127 $\mu\text{V/K}$ and that of Co-doped samples decrease from 371 to 145 $\mu\text{V/K}$ as increasing Co, due to the increase in carrier mobility (μ_H). As a result, the highest $ZT = 0.087$ at 670 K is achieved in $x = 0.03$ owing to the significant enhancement in power factor and the slight reduction in thermal conductivity, where its optimum n_H at 300 K is about $1.0(4) \times 10^{20} \text{ cm}^{-3}$. Therefore, the thermoelectric properties of β -Fe_{1-x}Co_xSi₂ can be optimized at $x=0.03$ and carrier concentration about $1.0(4) \times 10^{20} \text{ cm}^{-3}$ with the maximum $ZT = 0.087$ at 670 K owing to the improvement in power.

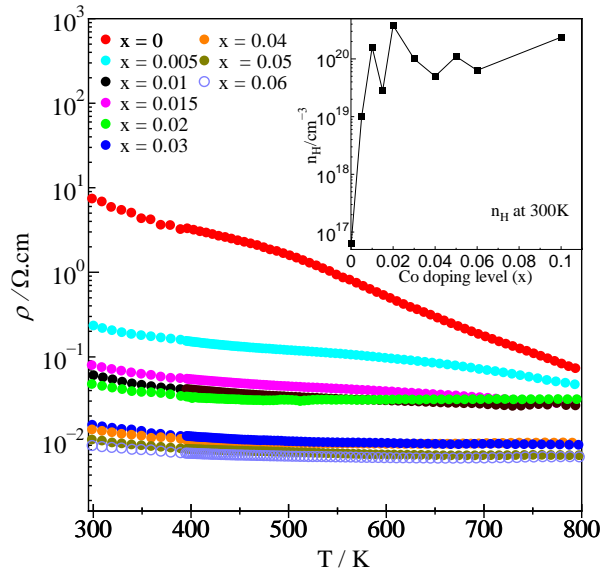


Fig.1 Temperature dependence of ρ

References

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