論 文 内 容 の 要 旨

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In this work, the upgrade recycling of cast iron scrap chips toward iron-based thermoelectric materials was proposed as an eco-friendly and cost-effective production process. Because cast iron consists mainly of iron with carbon and silicon, scrap chips of cast iron are expected to be a proper starting material for preparing iron-based intermetallic compound with good thermoelectric properties such as β-$FeSi_2$ and Fe_2VAl. The thermoelectric properties of undoped, p- and n-type β-$FeSi_2$, prepared utilizing cast iron scrap chips, have been characterized by measuring the Seebeck coefficient, electrical conductivity and thermal conductivity at temperatures ranging from room temperatures to 800°C. By doping with different substitution concentrations of Co, Mn and Al, the conduction type and properties of β-$FeSi_2$ can be modified and improved using cast iron scrap chips as a starting material. The effects of the doping elements are discussed for preparing β-$FeSi_2$ utilizing cast iron scrap chips. Cast iron scrap chips could be preferable as a starting material to replace pure Fe for n-type and p-type β-$FeSi_2$ thermoelectric materials. The optimum value of *ZT* obtained in the present study is preferable for use as a starting material to produce β-$FeSi_2$ thermoelectric materials and showed promise as an eco-friendly and cost-effective production process for thermoelectric materials. As well as the fabrication of the module of n-type and p-type β-$FeSi_2$ was developed and coefficient thermal expansion was evaluated. In this study, the isothermal oxidation tests were carried out at 800°C in air for 14 d by using an electric furnace and the oxidation behavior of β-$FeSi_2$ prepared from cast iron scrap chips was reported. Based on the results, β-$FeSi_2$ prepared from cast iron scrap chips has probably a long lifetime at high temperature around 800°C in air and has excellent potential in high temperature stability for high temperature thermoelectric devices even when using cast iron scrap chips as a starting material. Furthermore, in this present study, the development of eco-friendly Heusler alloy Fe_2VAl made from cast iron scrap chips is investigated, in which the microstructure and the thermoelectric performance of the product were mainly examined. The thermoelectric performance shows positive impact as the maximum power factor, *PF*. Meanwhile, the power factor value, *PF* of the undoped Fe_2VAl prepared using cast iron scrap chips was prevailed approximately twice improved and p-type Fe_2VAl prepared using cast iron scrap chips was about 10% smaller as compared than those previously reported. The possibility of cast iron scrap chips for producing undoped and p-type Fe_2VAl alloys obtain towards eco-friendly and cost effective production process. However, the n-type Fe_2VAl specimen made from cast iron scrap chips could not possible to fabricate due to the small difference in the off-stoichiometric of the specimen since the compositions of cast iron scrap chips contain some impurities such as Mn, C and Si. Based on the XRD results and thermoelectric performance of n-type Fe_2VAl made from pure Fe and added with 2, 4, 6% mass C, the results showed that samples have similar behavior with 2C.I -V-0.9Al-0.1Si sample. It means the C impurity contains in cast iron scrap chips has influence on conduction type. Hence, it is further necessary to investigate the effect of impurities contains in cast iron scrap chips on

the development of n-type Fe_2VAl alloy and further improvements in the thermoelectric performance are desired. Ultimately, the general guidelines to highly valued intermetallic compounds toward upgrade recycling of cast iron scrap chips is discussed to achieve better upgrade recycling process. In the future study, the guideline could be applied to fabricate another intermetallic compound made from cast iron scrap chips. From the above statements we can conclude that iron-based thermoelectric β-$FeSi_2$ and Fe_2VAl are successfully fabricated by using cast iron scrap chips. This upgrade recycling material is considerable effort to reducing the abundant waste towards eco-friendly and cost effective production process. Thus, this present study revealed that the cast iron scrap chips can be optimum utilize as a starting material for fabricating iron based materials and prevailed comparable thermoelectric performance to that previously reported.