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February 26-29, 2024

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Upgraded Recycling of Cast-Iron Scrap Chips towards Fe-based Thermoelectric Materials for Waste-heat Energy Harvesting

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ABSTRACT

In this research, an environmentally friendly and cost-effective production process involving the upgraded recycling of cast-iron scrap chips into thermoelectric materials based on iron (Fe) was proposed. The thermoelectric performance of Fe-based materials, including iron-silicide (β-$FeSi_2$) and Heusler alloys (Fe_2VAl), utilizing cast-iron scrap chips was thoroughly examined across temperatures ranging from room temperature to 800°C. The study identified an optimal dimensionless figure of merit, ZT (0.22 for n-type at 700°C and 0.17 for p-type at 700°C), making it a favourable starting material for producing β-$FeSi_2$ thermoelectric materials [1]. The development of n-type and p-type β-$FeSi_2$ modules was achieved, and the coefficient of thermal expansion was evaluated. Isothermal oxidation tests were conducted at 800°C in air for 14 days using an electric furnace to assess the oxidation behaviour of β-$FeSi_2$ prepared from cast-iron scrap chips [2]. The results indicated that β-$FeSi_2$ derived from cast-iron scrap chips exhibited a promising long lifetime at high temperatures (around 800°C) in air, showcasing excellent potential for stability in high-temperature thermoelectric devices when utilizing cast-iron scrap chips as a starting material. Furthermore, the thermoelectric performance of Fe_2VAl, prepared using cast-iron scrap chips, demonstrated positive outcomes. The p-type Fe_2VAl exhibited the highest power factor (PF) value of 1604$\mu Wm^{-1}K^{-2}$ at 200°C. Additionally, undoped Fe_2VAl, prepared from cast-iron scrap chips, showed a substantial improvement, with a PF value of 967$\mu Wm^{-1}K^{-2}$ at 200°C, approximately twice that of previously reported values [3]. Unfortunately, the fabrication of n-type Fe_2VAl specimens from cast-iron scrap chips was hindered by impurities present in the scrap chips' composition [4]. Despite this limitation, the use of cast-iron scrap chips for producing undoped and p-type Fe_2VAl alloys holds potential for contributing to eco-friendly and cost-effective production processes. Ultimately, the research delves into comprehensive guidelines aimed at enhancing recycling processes, with a specific emphasis on esteemed intermetallic compounds. This exploration occurs within the broader framework of elevating the recycling of cast-iron scrap chips, representing a significant endeavour to mitigate the abundance of waste and advance toward a more environmentally friendly and cost-effective production paradigm.

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