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Editorial

Advances in Soft Magnetic Materials

Kaixuan Li and Zhaoyang Wu *

Anhui International Joint Research Center for Metallurgical Processes and Systems Science, Anhui University of Technology, Ma'anshan 243002, China; lkx@ahut.edu.cn
* Correspondence: ahutwzy@ahut.edu.cn

Soft magnetic materials have emerged as promising candidates due to their high power density in diverse magnetic components utilized for energy conversion, filtering, resonance, and isolation [1–10]. As the volume and weight of power electronic systems continue to decrease, there is an escalating demand for soft magnetic materials featuring low core loss and high electrical conductivity [11–22]. This Special Issue aims to spotlight the advancements and fundamental aspects related to the synthesis, characterization, properties, and applications of soft magnetic materials. In this Special Issue, researchers concentrate on aspects including insulating layer coating, powder molding, and annealing heat treatment during the preparation process of soft magnetic materials. The Special Issue comprises five research papers.

The study conducted by Lin et al. [23] centers on optimizing the properties of Fe–Si/SiO_2 soft magnetic materials. The core aspect of the study is to substantially enhance the permeability and resistivity of the material while minimizing its core loss through precise control of the SiO_2 insulating layer and its interfacial structure. The study entails an analysis of the formation and action mechanism of SiO_2 on the surface of Fe–Si alloy particles and investigates the impact of chemical vapor deposition on the formation of the coating layer. The study validates that effective control of the SiO_2 insulating layer is one of the crucial technical approaches for attaining high-performance (high resistivity, low loss) iron–silicon soft magnetic materials. This work holds significant importance for the development of soft magnetic materials used in high-efficiency and low-energy-consumption electromagnetic devices.

Huang et al. [24] investigated Fe–Si–Cr soft magnetic materials suitable for high-frequency power supply applications, concentrating on the development and analysis of materials featuring a double-insulating layer structure (Cr_2O_3/SiO_2). The key approach is to initially construct a SiO_2 insulating layer on the surface of Fe–Si–Cr alloy particles via chemical vapor deposition and subsequently combine it with a water-glass-based organic coating. This combination remarkably enhances the resistivity and effective permeability of the material while substantially reducing its core loss, particularly under high-frequency operating conditions. The research indicates that this double-insulating layer structure can effectively suppress high-frequency eddy-current loss, demonstrating the strong application potential of this type of material in high-efficiency and miniaturized power electronic converters.

Xu et al. [25] focused on the synthesis and performance optimization of low-loss Mn–Zn ferrites for power applications. By incorporating different additives, they explored the influence on the loss characteristics of the ferrites and employed techniques such as Fourier transform infrared-Raman spectroscopy and transmission electron microscopy to analyze the impact of metal cations on the oxygen–acid structure. The research findings indicate that the optimized Mn–Zn ferrites exhibit significantly reduced magnetic losses and are

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suitable for high-efficiency power conversion equipment. Their findings offer an important theoretical and experimental foundation for the development of high-performance magnetic materials and facilitate the advancement of power electronics technology.

Liu et al. [26] optimized the preparation strategy of the insulating layer based on the solid-phase interface reaction by utilizing the thermal decomposition of similar compounds in conjunction with the doping of carbonyl iron powders. Oxygen generated during the thermal decomposition of $ZnSO_4$ initiates the solid-phase reaction, causing non-magnetic Si and Cr atoms to migrate from the interior of the Fe–Si–Cr soft magnetic powder to the surface insulating layer, ultimately forming a composite insulating layer composed of $ZnO{\cdot}SiO_2{\cdot}Cr_2O_3$. Simultaneously, the doped carbonyl iron powders possess good plasticity. When combined with the coating layer, they can not only fill the pores within the soft magnetic materials, but their higher specific surface area due to their small particle size can also offer more reaction sites for the decomposition of $ZnSO_4$ and the growth of the composite insulating layer. This promotes the uniform distribution of the insulating layer on the surfaces of the soft magnetic powder and carbonyl iron powders, enabling effective doping of carbonyl iron powders within the insulating layer and precise control over the magnetic properties of the SMCs.

Li et al. [27] further optimized the heat-treatment duration and temperature for Fe–Si/SiO_2 soft magnetic materials and verified the correlation between the heat-treatment process and the internal pores, defects, and magnetic properties of the material. By refining the heat-treatment duration and temperature, internal stress and dislocation density can be effectively diminished, leading to lower coercivity. Simultaneously, this research presents a quantitative analysis of the relationship among the microstructure, magnetic properties, and heat-treatment parameters of the material, which is vital for expanding the application potential of the soft magnetic material preparation process.

This Special Issue comprises five research papers, all of which have made significant contributions to enhancing the properties of magnetic materials by optimizing their microstructure and preparation process. We extend our sincere gratitude to all the contributors for their enthusiastic participation in this Special Issue. We believe it offers valuable insights into current topics in magnetic materials and will inspire further interest among researchers in the fields of materials science and magnetism. We deeply appreciate all the authors for submitting high-quality work, which has enabled the successful publication of this Special Issue.

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