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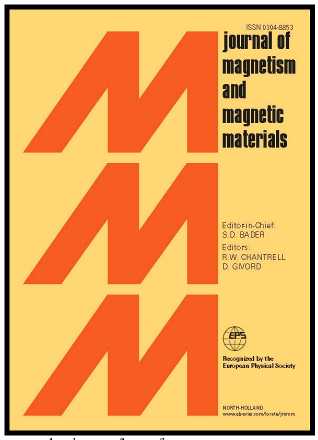

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Interplay of domain walls and magnetization rotation on dynamic magnetization process in iron/polymer–matrix soft magnetic composites

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Abstract

This study sheds light on the dynamic magnetization process in iron/resin soft magnetic composites from the viewpoint of quantitative decomposition of their complex permeability spectra into the viscous domain wall motion and magnetization rotation. We present a comprehensive view on this phenomenon over the broad family of samples with different average particles dimension and dielectric matrix content. The results reveal the pure relaxation nature of magnetization processes without observation of spin resonance. The smaller particles and higher amount of insulating resin result in the prevalence of rotations over domain wall movement. The findings are elucidated in terms of demagnetizing effects rising from the heterogeneity of composite materials.

Keywords: Iron, Polymer–matrix composites, Ferromagnetic, Magnetization process, Complex permeability, Energy loss

1. Introduction

Soft magnetic composites (SMCs) are modern soft magnets designed as compacted heterogeneous conglomerates of ferro- or ferrimagnetic particles coated and bonded together by dielectric layer of appropriate in-/organic substance [1–3]. They have attracted increasing interest owing to the unique conjunction of their physical properties leading to the versatility in applications versus low economic costs and ecological added value. SMCs exhibit a good soft magnetic behavior against AC magnetic field up to frequencies of about 10 kHz [4]. Recent efforts have been devoted to the extension of operating frequency limit toward higher frequencies in MHz band [5, 6]. A significant suppression of core loss during magnetization cycle is obtained due to relatively high electrical resistivity of SMCs. Elimination of long-range eddy currents circulating in cross-section perpendicular to the magnetic flux penetrating a material is the main prerequisite for stable magnetic permeability response up to high frequencies. Moreover, due to the regular structure formed by fine particles embedded in matrix, SMCs offer isotropic magnetic behavior and heat transport properties, which are essential for design of 3D machine components of current demand. Mechanical properties, e.g. high mechanical hardness and flexural strength, can be enhanced by addition of specific binder modifications, e.g. silica [7] or boron [8]. Over the past decade, considerable attention has been paid to find novel ways of composite materials preparation, e.g. by wet chemical methods [9], microwave treatment [10], surface oxidation [11], etc., to meet as suitable physical characteristics in applications as possible. Recently, K.J. Sunday et al. [12] have reported a perspective route to prepare "self-coated" particles in SMCs by mechanical milling of iron powder in an alumina ceramic vial with alumina balls. Such treatment results in a thin Al_2O_3 layer formation on the surface of iron particles. A comprehensive theoretical approach proposed by Y. Pittini-Yamada et al. [13] reveals the important factors at the preparation of high-quality material,

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