Frequency response engineering of magnetic composite materials

O. Acher

Laboratoire Matériaux Magnétiques et Hyperfréquences
CEA Le Ripault, BP 16, F-37260 MONTS (France)
Fax: + 33 2 47 26 51 79; email : acher@ripault.cea.fr

Abstract

Several attractive composite designs have been proposed recently, that allow the use of ferromagnetic inclusions to manufacture high impedance microwave composites. Laminated Insulator Ferromagnetic on the Edge (LIFE) composites are made of alternated ferromagnetic and insulating materials. LIFE composites with initial permeability times resonance frequency product at least one order of magnitude higher than ferrite materials have been demonstrated [1]. The permeability of the composite can be tuned through an external field trough the conventional Ferromagnetic Resonance effect. The use of LIFE composites to make tunable filters has been reported [2].
Another family of anisotropic high impedance material consists in parallel high permeability wires in an insulating binder. Amorphous glass-covered microwires are attractive for such a configuration. It is shown that the tailoring of the microwire permeability can be achieved through magnetoelastic effect [3]. The resonance frequency can be tuned by adjusting the magnetostriction constant of the ferromagnetic composition, and the level of stress on the metal core.
Powder-based composites have been known for long, but the observation of sharp permeability resonance features is rather recent [4]. These effects have been observed on dispersions of submicronic powders with very narrow size distribution produced by chemical routes. The resonant features have been shown to be attributed to exchange modes.
The understanding of all these composite properties can be carried out only through a suitable definition of the effective permeability and permittivity [5], as several incompatible definitions can be found in the literature. Though a huge variety of magnetic responses are accessible through the optimization of the composite topology and of the intrinsic magnetic parameters, some first-principle bounds apply. In particular, it has been derived recently that the integral of the imaginary permeability times the frequency integrated over the whole frequency range is bounded by a simple expression [6].
More recently, magnetic inclusions have shown to be attractive to engineer the frequency response not only of the permeability, but also of the permittivity of composite materials [7].

References

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