3D FDTD-LLG modelling of magnetisation dynamics in thin film ferromagnetic structures.

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There is a growing need in high frequency tunable microwave materials for applications in the areas of microwave electronics, transformation optics, photonics. Due to their intrinsic RF phenomena, such as FMR, ferromagnetic thin films have always been of great interest and led to a great amount of experimental research very often supported by numerical simulations. While purely magnetostatic solvers, such as OOMMF or Mumax, have always been the standard benchmark tools and usually provide a precise description of the magnetisation processes in thin-film ferromagnetic structures, these systems are however limited in applications where full electromagnetic solutions are required, especially when the material properties are extremely non-uniform (e.g. dielectric/metal interfaces). In such cases one needs to consider a modelling approach where a full solution of Maxwell equations is needed alongside the materialistic equations, such as e.g. Landau-Lifshits-Gilbert (LLG) providing the relation between the magnetisation and the magnetic field [1]. Here we propose such a model which uses 3D finite-difference-time-domain (FDTD) approach together with LLG to find the exact solutions for magnetisation dynamics in thin film ferromagnetic structures [2]. As a benchmark testing we demonstrate application of such model for different classical phenomena such as Faraday effect, and then explore the dynamic characteristics of thin films in magnetostatic applications. In particular we consider propagation of magnetostatic/spin waves in metallised magneto-dielectric thin films and magnetic structures and demonstrate their dispersion characteristics [3]. The results are compared with the standard analytical solutions and the simulations by using Mumax^3. We also discuss the advantages of the model and its limitations for using in realistic prototype materials.

References

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