Magnetostatic-Magnon Sensors for Microwave Microscopy of Biological Structures

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Abstract

The detection of biological structures in microwave frequencies and understanding of the molecular mechanisms of microwave effects is considered as a problem of a great importance. Nowadays, however, most microwave techniques for biosensing are based on resonance structures, which can be used for measuring dielectric and conductivity properties of materials. In optics, special electrostatic-plasmon structures with optical superchiral fields are effectively used for subwavelength chiral biological and chemical structures characterization. However such plasmonic structures are ineffective in microwaves. To create superchiral fields for microwave biosensing, recently magnetostatic-magnon (MS-magnon) sensors have been proposed [1]. Multi-resonance spectra, strong energy concentration and unique topological (chirality) structures of the near fields originated from the MS-magnon resonators allow effective measuring material parameters in microwaves, both for ordinary structures and objects with chiral properties. These sensors can be effectively used for the near-field scanning microwave microscopy of chemical and biological objects.

The MS-magnon spectral characteristics of small ferrite-disk resonators are well studied in microwave experiments [1-3], can be analyzed theoretically [4-7], and are well illustrated by numerical results based on the ANSYS® HFSS™[1, 8]. Nevertheless, for studies of interaction between the superchiral fields, originated from the MS-magnon resonator, and a biological sample, COMSOL Multiphysics® has to be used.

Based on the COMSOL Multiphysics®, in our present studies, we show the MS-magnon spectral characteristics of small ferrite-disk resonators and field structures of these oscillations. Figure 1 shows the numerically simulated spectral characteristic for a small ferrite disk (diameter of D=3mm and thickness of h=50um) placed in microstrip structure. The disk is normally magnetized by a bias magnetic field Ho=4900 Oe. Figure 2 shows the intensity of the power flow distribution at first resonance mode. One can see the strong subwavelength localization of energy and vortex behavior of microwave near fields. Such a topology cannot be observed at non resonance frequencies. Figure 3 shows microwave microstrip structure with ferrite disk (sensor) and a sample under investigation.

Microwave sensing and monitoring is very attractive for biological applications because of their sensitivity to water and dielectric contrast. Direct detection of biological structures in microwave

frequencies and understanding of the molecular mechanisms of microwave effects is considered as a problem of a great importance. Nowadays, however, microwave technique for localized testing biological objects is at a rudimentary level. In contrast, optical biosensing has benefited from in a large variety of specialized tools. The proposed chiral field microwave biosensors will open an entirely new field of microwave biomedical diagnostics and pathogen detection. For realization of such microwave biosensors the COMSOL Multiphysics® software should be used.

Reference

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Figures used in the abstract

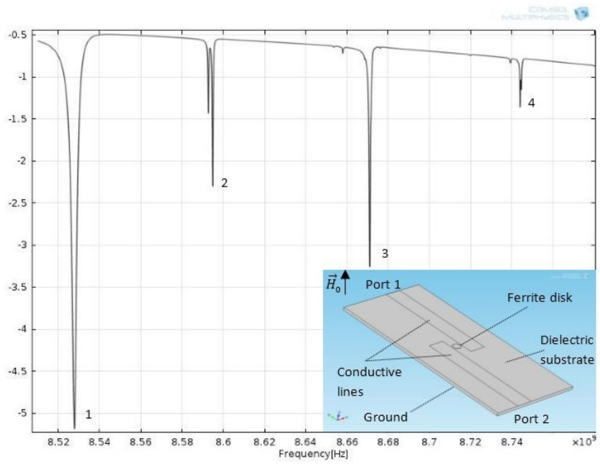

Figure 1: Frequency characteristics of a module of the reflection coefficient for a microstrip structure with a small ferrite disk. The resonance modes are marked by numbers n=1, 2, 3, 4.

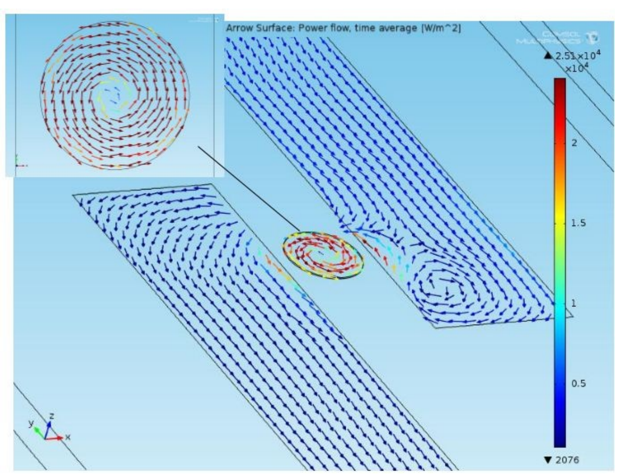

Figure 2: Intensity of the power flow distribution at first resonance mode.

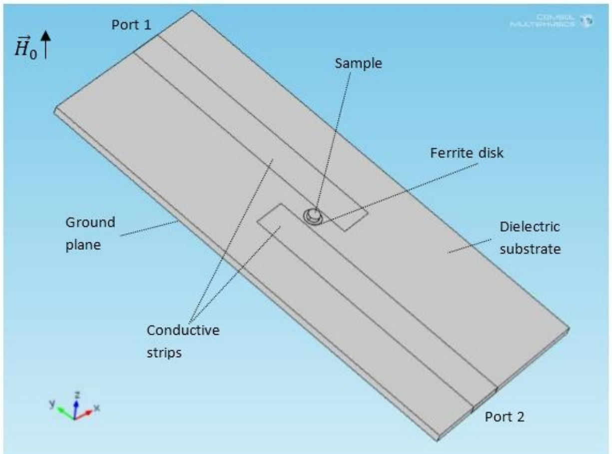

Figure 3: Microwave microstrip structure with ferrite disk (sensor) and a sample under investigation.