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Numerical Analysis of Electromagnetic Field in ESR Resonator Cavity

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1. Introduction

Recent biological application calls for electron spin resonance (ESR) spectrometer with the high sensitivity [1]. Since the signal to noise ratio of the ESR spectrometer heavily depends upon the resonator cavity, it is necessary to increase the local magnetic field strength in the ESR cavity [2]. We analyzed the electromagnetic field in a resonant cavity for ESR spectroscopy based upon the Maxwell's equations. Though the analytical solutions can roughly estimate the overall electromagnetic field, the detailed field strength can not be obtained. Thus, we employed the numerical simulation. In the present study, we will report on the electromagnetic field analysis in a cylindrical cavity which is connected to import wave guide, and the effects of dielectric materials used for the cavity.

2. Numerical Analysis

We carried out the numerical calculation employing the Finite Difference Time Domain (FDTD) algorism. We coded a simulation program in C language. For the output of calculated results, we used the illustration modules of MATHEMATICA as well as EXCEL. We varied the cavity size and the dielectric material size in the cavity. We used a dielectric material with the dielectric constant of 4.0. Figure 1 shows a model diagram for the simulation.

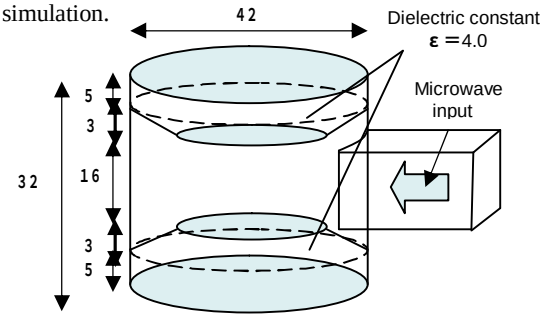

Fig. 1 A model of a resonator cavity for the simulation. The dielectric disks are located at the top and bottom of the cavity.

3. Results and discussion

We obtained the greatest strength of magnetic field in the central part of the cavity. Figures 2 depicted a distribution map of magnetic field strength and values at the central cross section of cavity. We observed that the strength of magnetic field increased at the central part of the cavity. These values are 2 times larger than the cases without usage of dielectric materials. The increment of magnetic field strength is explained by the stronger displacement current of Ampere's law in the dielectric materials.

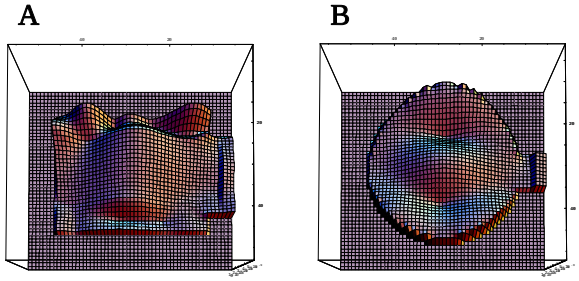

Fig. 2 The magnetic field map in the cavity. Magnetic fields are shown at the A) vertical and B)horizontal center planes.

4. Conclusion

Usage of dielectric materials in the cavity, we could increase the magnetic field strength of ca. 2 times stronger than without dielectric materials.

References

[1] C.G. Montgomery Ed. Technique of Microwave Measurements (vol. 11, Radiation Lab. Series) McGraw-Hill, New York, 1947.

[2] R. S. Alger, Electron Paramagnetic Resonance: Techniques and Applications, John Wiley & Sons (1968)