プラズマ導入によるマイクロ波アンテナの高機能化検討 (II)

Advanced Microwave Antenna by Addition of Plasma Components (II)

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1. Introduction

After the theoretical analyses of Veselago in 60's [1] on negative index material, and more recently researches including experimental results, we are able to create negative permittivity or permeability with a new material named as metamaterial. Furthermore, with anisotropic and spatially gradient refractive index, it is possible to achieve cloaking effect [2]. Our proposal is to use the properties of plasma to obtain flexible cloaking. In particular, when we use such flexible cloaking effects for microwave antenna, we can reduce interferences among various propagating microwaves for telecommunication. To do that, we have generated a plasma cylinder (Fig 1) and currently design installation of anisotropic negative permeability metamaterial. We demonstrated here the numerical method and initial results.

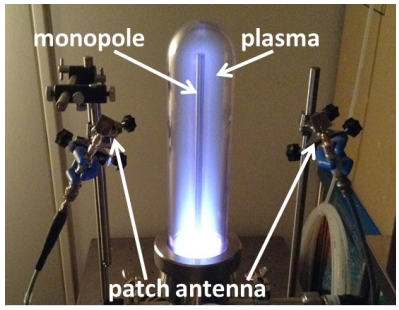

Fig 1: Experimental setup and generated plasma around metallic monopole.[4]

2. Numerical model and method

By the use of the numerical method named as Finite-Difference Time-Domaine (FDTD) [3], we calculate the response of the electromagnetic field against plasma antenna composed of plasma with electron density (maximum value:$1x10^{12}$ cm^{-3}) with spatial gradient according to the Bessel function. We also introduce likewise anisotropic negative permeability between radial (relative permeability: 1.0) and rotational directions (-0.5) in cylindrical coordinates.

3. Numerical results

Results (shown in Fig.2,3) give us very weak phase shift of the electromagnetic wave after through our plasma antenna, with no significant wave scattering; these features belongs to the properties of the cloaking. However, here we observe attenuation due to our plasma antenna, and further calculations are now ongoing to design spatial configurations of permittivity and permeability to have optimized condition of cloaking. Also the experimentation will let us know some degree of freedom with the plasma permittivity.

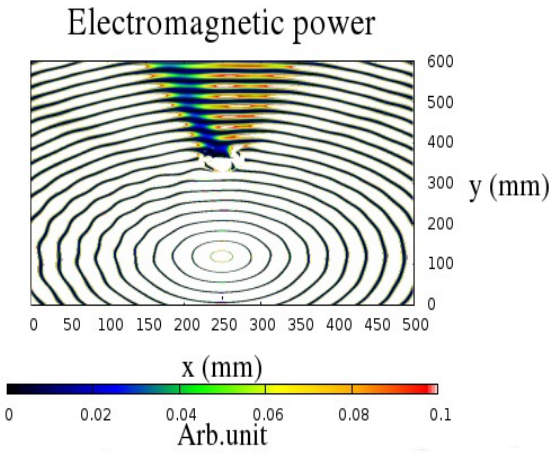

Fig 2: Numerical result of the electric field in the electromagnetic wave with a circular anisotropic medium (plasma antenna)

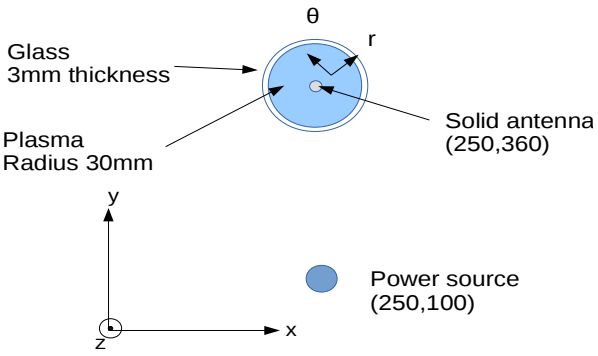

Fig 3: Cross section of the plasma antenna calculated in our numerical code.

References .

[1]V.G. Veselago, Soviet Physics Uspekhi,**10**,509 (1968).[2]. D. Schurig et al. Science **314** , 977 (2006);[3] O. Sakai *et al.*, Plasma Sources Sci. Technol. **21**, 013001 (2012);[4] 酒井道、岩井亮憲、齋藤啓子、第 62 回応用物理学会春季学術講演会講演予稿集、12a-D14-6 (2015)。