Creating Double Negative Index Metallic Materials for HPM Applications

H. S. Faraji, G. Atmatzakis, M. F. Su, and C. G. Christodoulou
Electrical and Computer Engineering Department, University of New Mexico
Albuquerque, NM, USA
hsfaraji@ece.unm.edu

***Abstract*— In this paper we introduce a new metamaterial unit-cell we name "Complementary Zia Metamaterial (C-Zia)". A Zia structure is a metamaterial unit cell structure which is based on inductive and capacitive regions similar to the well-known split-ring resonators (SRR) but it provides a greater design flexibility and frequency tunability. Also Zia metamaterial was adapted to show bianisotropic, chiral, and biaxial behavior. C-Zia structure is a complementary form of a previously published Zia structure, which is completely metallic and easy to mount. As such it is expected to be more compatible with high power microwave applications, in which traditional SRRs and other forms cannot be used due to dielectric breakdown.**

Keywords: Metamaterial; Zia; HPM

I. INTRODUCTION

Metamaterials are periodic arrays of subwavelength structures which provide an electromagnetic response not typically available in nature. They exhibit many interesting properties for high power microwave (HPM) applications, such as (i) the ability to get dielectric properties out of all-metallic structures, (ii) enablement of operational characteristics not attainable with conventional matarials, and (iii) reduction of physical component sizes.

Some well-known metamaterial structures are split-ring resonators (SRRs) and electric coupled resonators (ELCs). They typically possess a resonant response to the incident electric or magnetic fields and accordingly provide an effective permittivity or permeability. The resonance is closely tied into the few structural parameters of the metamaterial, such as gap widths and ring radii. This, combined with ad-hoc design rules and use of subcomponents made of dielectrics, render such metamaterials impractical in HPM applications.

A recent study in metamaterials research [1] resulted in a new type of structure dubbed the Zia metamaterial. This structure is all-metallic and has more degrees of freedom for tunability compared to other types metamaterial structures. More importantly, the study applied group theory concepts to metamaterials research to come up with Zia-based designs that effectively exhibit biaxial, bianisotropic and chiral material properties. Conventional Zia structures need a dielectric substrate in order to be mechanically mountable. This is a disadvantage for HPM applications, because dielectrics tend to build charge and break down in such environments. In this paper we introduce a complementary form of the Zia structure ("C-Zia") to address this issue. Preliminary results show that a "C-Zia" structure can couple into incident electric and magnetic fields simultaneously to provide concurrent effective negative permittivity and permeability. Such double behavior is not observed in other types of structures such as SRRs without ancillary structures such as rods, strips, or a waveguide.

II. RESULTS

The single-layer-thick C-Zia structure is shown in Fig. 1 (r_w = 0.2mm, r_{ir} = 4mm, r_h = 2mm and fg = 0.1mm). Fig. 2 shows the retrieved permeability and permittivity of the structure. There is a frequency range between 19.1 GHz to 20 GHz in which both permittivity and permeability are negative, hence a "metamaterial" behavior is observed.

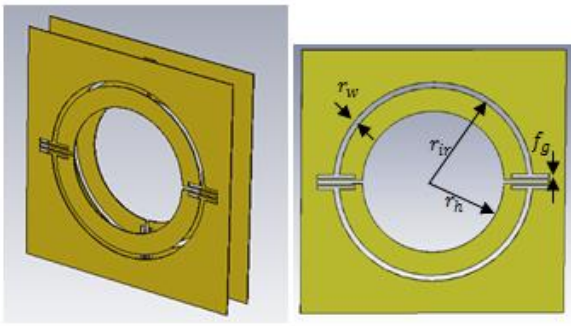

Figure 1. C-Zia unit cell

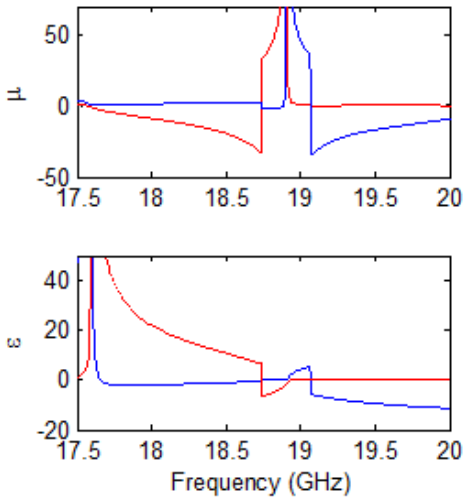

Figure 2. C-Zia magnetic permeability and electric permittivity (real part in blue and imaginary part in red)

REFERENCES

[1] C. M. Reinke, T. M. De la Mata Luque, M. F. Su, M. B. Sinclair, and I. El-Kady, "Group-theory approach to tailored electromagnetic properties of metamaterials:An inverse-problem solution," *Physical Review E* **83**, 066603, 2011.