Reponse letter for the manuscript "Enhanced tunability in ferroelectric metamaterials through local field enhancement and the effect of disorder"

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We would like first to thank the reviewers for their constructive comments and remarks that will surely improve the overall quality and clarity of the article. We address here point by point the reviewers concerns and indicate how the manuscript has been revised, with the hope that those changes will satisfy the standards of publication in *Journal of Applied Physics.*

I. REVIEWER #1

A. Evaluations

- Does the manuscript present original and timely results that significantly advance the knowledge in applied physics: Yes
- Does the manuscript report on convincing and rigorous data methods and analysis: Yes
- Is the manuscript clearly written in correct English well organized and free from ambiguities: Yes
- Is the title descriptive of the contents concise interesting and free of acronyms: No
- Does the abstract adequately and clearly describe the contents (problem approach findings) of the paper: No
- Are the figures in the manuscript necessary adequate well presented and clearly labeled: No
- Is the reference list appropriate: No

B. Remarks to author(s)

In this paper the authors present a computational study of dielectric tunability of ferroelectric metamaterials. The authors apply a numerical method to a new system that takes into account the local near-field effects of metamaterial resonators on the dielectric tunability of ferroelectric materials in the metamaterial unit cell.

Overall I found the approach described by the authors to be interesting and I expect it will be useful to introduce this two-scale convergence method to microwave metamaterial engineering and perhaps to metamaterial research in higher frequency ranges as well.

In principle I think this study is publishable, but I would like to see some important clarifying revisions made, all are outlined below. After these revisions are adaquately addressed, I expect to be able to recommend publication in JAP. The authors need to address the following:

1. Title/Abstract/ Introduction of Paper: I think the title/abstract and overall introduction of the paper is somewhat misleading. These sections should be revised to make clear that the authors are presenting a numerical and computational study. As written, it is unclear whether the paper is presenting an experimental observation, or a numerical prediction.

   Reply: It has been clarified in the abstract and introduction that this is a computational and numerical study.

2. In the introduction, please outline the actual ferroelectric composites in common use in this field. It is useful to know what materials this method can be used to model.

3. In the introduction: Local field engineering and field amplification has become more and more useful at other frequency ranges, especially in the THz and near-IR, to control the properties of other materials (eg. Photonics 2019, 6(1), 22). Could the authors expand on some other systems, besides ferro-electric metamaterials, that this method might apply to. For instance maybe tunable GaAs meta-devices.

4. In the introduction: The authors mention that there are generally limitations to the current numerical and theoretical models used in the field, but do not go into any detail. Could the authors expand on this point? What are the limitations?

5. Theory Section, A. In figure 1, are these electrostatics measurements performed by the authors? It is unclear based on the figure and surrounding paragraphs. I assume they are as no citation is provided for the data. Could the authors discuss the details of how these measurements were made? This would be useful for metamaterials researchers who do not work in this frequency range.

6. Theory: Equation 3 is normally referred to as Gauss' Law (or it is at least Gauss' Law written in terms of V).

7. Figure 3 c) It is unclear what is being plotted here. Is this the tunability, n, defined at the beginning

of the introduction? If so, please label using previously defined notation.

8. Overall the English usage is quite good and the paper is very readable. I did find a few typos however and the paper should be proofread again before the next submission. Here are some of the typos I found:

    - Abstract line 7: I believe "wherehas" should be "whereas"
    - Intro par.2 line 5 "ceramics to" should be "ceramics with"
    - Intro par 3 line 13 "litterature" should be "literature".
    - Theory A, last two lines "interrested" should be "interested".

II. REVIEWER #2

A. Evaluations

- Does the manuscript present original and timely results that significantly advance the knowledge in applied physics: Yes
- Does the manuscript report on convincing and rigorous data methods and analysis: Yes
- Is the manuscript clearly written in correct English well organized and free from ambiguities: Yes
- Is the title descriptive of the contents concise interesting and free of acronyms: No
- Does the abstract adequately and clearly describe the contents (problem approach findings) of the paper: Yes
- Are the figures in the manuscript necessary adequate well presented and clearly labeled: Yes
- Is the reference list appropriate: Yes

B. Remarks to author(s)

The paper is interesting and can be published with very small revisions.

1. Although composites are engineered materials, in my opinion, we cannot call "metamaterial" a composite if we do not demonstrate specific frequency-dependent behavior and if the regular repeated units characteristic to the metamaterial are not smaller than the corresponding wavelength where we found the mentioned property. In this paper there is not an analysis vs frequency of the properties, so that your material is a di-phase composite. I suggest to change the title.
2. You gave experimental data for BST ceramics that were used to derive Landau coefficients. It is necessary to give some details of the sample (composition?) and measurements or to cite an experimental work.
3. You may compare the results of your simulations with the results of other studies.