Investigation of In-Gap Field Enhancement at Terahertz Frequencies for a Metasurface Enhanced Sensor

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The arrangements of subwavelength inclusions in a metasurface can serve as an effective absorber for the terahertz region. When such an absorber is combined with a unique material, the absorption can induce effects that can lead to a change in the materials electrical properties. Vanadium dioxide shows a passive and reversible change from monoclinic insulator phase to metallic tetragonal rutile structure by using external stimuli such as temperature (340K), photo excitation, electric field, mechanical strain or magnetic field [1,2]. Upon absorption of the THz radiation, the high electric fields that are generated inside the gaps of the metasurface can serve as trigger points, as was shown previously using kV strength THz E-fields [1]. By designing a better sensor which takes advantage of this non-linear enhancement one can lower this value to more accessible THz electric field strengths. In this work by utilizing various metasurface designs we examined the insulator to metal transition in VO_2 when illuminated by THz radiation. Gaps whose lengths were varied as 0.5, 1, 1.5μm that are oriented perpendicularly to the polarized THz fields served as field enhancement centers. Single and double notched gaps are compared and their respective in-gap field enhancements are calculated. In the single notched structure maximum in gap field enhancement value is obtained as nearly 100 for a 1.0μm gap size. For the double notched structure in gap field enhancement values are almost the same and maximum is obtained for 0.5μm at nearly 180 for both gaps. The change in enhancement shows that the non-linear enhancement is highly dependent on the geometry of the electrodes for a fixed unit cell wall thickness. Such enhancements can be exploited in designing sensitive sensors in the low frequency THz region.

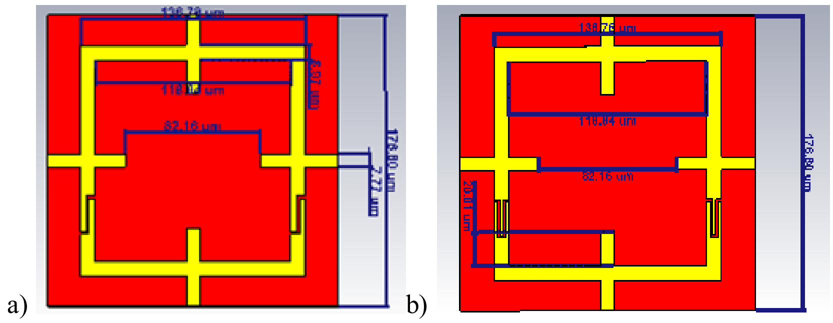

Fig. 1 The metasurface unit cell is comprised of a gold patterned layer deposited on VO_2 and is designed to have a resonant absorption below 1 THz. To explore non-linear enhancement behavior two cases were analyzed: a) single notched b) double notched gap structures.

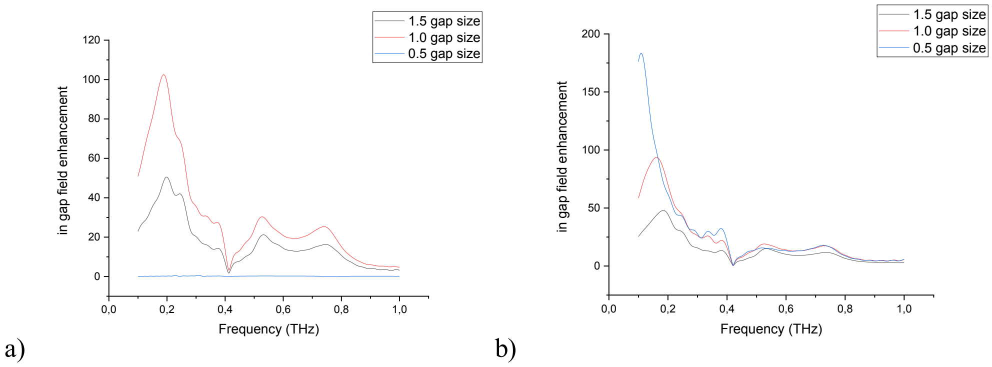

Fig. 2 In gap field enhancement values for a) single notched b) double notched gap structures for different gap lengths in left probe.

References

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