Non-linear Detection of THz radiation using 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. Furthermore, depending on the geometry such structures can lead to strong field confinement effects. When such an absorber that has such inclusions which exhibit field confinement is combined with a unique material, the absorption can induce effects that can lead to a change in the materials electrical properties. The optimization of such structures is key to the development of a new class of sensors and detectors in the THz region. To realize such a vision, the use of materials which exhibit conductive changes necessary. 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. Utilizing various metasurface designs we examined the insulator to metal transition in VO2 when illuminated by THz radiation. For a unique unit-cell design based on a SRR-like structure we found that field enhancement is not necessarily related to the resonant frequency of the unit cell structure. The inclusion of 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. Comparisons are made for single and double notched gaps. Typically, we found maximum in gap field enhancement values near 100 for a 1.0µm gap sizes. The multiplication 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 detectors in the sub-1 THz region where many applications from communications to sensing are taking place.

a) b) 

Figure 1. The metasurface unit cell is comprised of a gold patterned layer deposited on VO2 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) In gap field enhancement values

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