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(Invited) Active Molecularization of Terahertz Meta-Atoms for Bio and Medical Sensing Applications

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Abstract

Active control of metamaterial properties is critical for advanced THz applications especially for bio and medical sensors. However, the tunability of THz properties, such as the resonance frequency and phase of the wave, remains challenging. Here, we provide a new device design for extensively tuning the resonance properties of THz metamaterials. Unlike previous approaches, the design is intended to control the electrical interconnections between the metallic unit structures of metamaterials. This strategy is referred to as the molecularization of the meta-atoms and is accomplished by placing graphene bridges between metallic unit structures whose conductivity is modulated by electrolyte gating. Because of the scalable nature of the molecularization, the resonance frequency of the terahertz metamaterials can be tuned as a function of the number of meta-atoms constituting an unit meta-molecule. At the same time, the voltage-controlled molecularization allows delicate control on the phase shift of the transmitted THz, without changing the high transmission of the materials significantly.

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In this study, we propose selectively reconfigurable terahertz meta-molecules by controlling the micro-patterned ion-gel gate structures to change the conductance of graphene bridges between adjacent meta-atoms. Moreover, we experimentally verify that the proposed structures can change the resonance frequency of metamaterial device to define resonance properties from 1.40, 1.10, to 0.74 THz, by changing the metamaterial unit cell from the individual atom to dimeric and tetrameric molecules, respectively.

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