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Ultrafast Terahertz modulation with nonlinear metamaterials

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In recent years, metamaterials have drawn great attention as they can be engineered to achieve electromagnetic properties that are not available in natural materials. Thermal, electrical, and optical schemes have been proposed to achieve some degree of active control. However, the effective parameters in the aforementioned devices do not depend on the intensity of the applied field and they are typically quite slow processes. Obviously, the ability to dynamically control the response of such devices on the time scale of the light cycle is highly desirable. The nonlinear effects induced by an intense THz field on the transmission response of double concentric ring metamaterial resonators (CRRs) on optically-pumped silicon are investigated in this work. The THz electric field exhibits high confinement due to the CRRs, and hence modifies the transmission response. We show experimentally that the transmission amplitude depends strongly on the intensity of the THz field. The photoexcited layer is modeled as a multilayer where the phase is included in order to compute the transmission and extract the corresponding complex conductivity. In order to get more insight about the physical mechanism of the measured response, 3D numerical simulations have been carried out and compared to the experimental results. The comparison revealed that the non-linearity depends critically on the THz-induced reduction of the conductivity of the photoexcited silicon as a result of the high confinement of the THz field near the resonators. The proposed concept holds promise for future active Terahertz metamaterials, as well as for ultrafast Terahertz devices.

Biography

Ibraheem Al-Naib has received Dr.-Ing. PhD in Electrical Engineering from the TU Braunschweig, Braunschweig, Germany in 2009. He has held teaching university appointments in the United Arab Emirates. From 2010 to 2013, he was a Postdoctoral Research Fellow with the Institut National de la Recherche Scientifique, Varennes, QC, Canada. Since July 2013, he is a Postdoctoral Fellow at Queen's University, Kingston, ON, Canada. He has authored and coauthored more than 30 journal papers, over 45 conference papers, and one book chapter. His research interests include Terahertz spectroscopy, thin-film sensing, metamaterials, and the study of semiconductors with intense THz field.

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