

Dual dynamically tunable terahertz graphene-based plasmonic induced transparency and slow light effects

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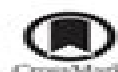
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Abstract

A novel single-layer graphene-based structure is designed in this article. This structure consists of two graphene strips and two graphene blocks. The components of this structure generate two bright modes and one dark mode in the terahertz region, and these three modes undergo destructive interference, leading to the phenomenon of double plasmonic induced transparency. The graphene of this structure has continuity, and the Fermi level can be adjusted by adjusting the bias voltage applied to the structure. Compared with those discontinuous structures, it is easier to achieve tuning function. The structure uses the finite-difference time-domain for data simulation, uses the coupled mode theory for theoretic calculation, and compares the transmission spectra obtained by the two methods. Through observation, it can be found that the frequency positions of the peaks and dips of the simulated transmission spectrum increase with the increase of the Fermi level, showing a perfect linear relationship, which indicates that this structure has great prospects in the modulator. In addition, the structure has achieved good results in the slow light effect, and after measurement, the peak values of group index and group delay can reach up to 380 and 0.241 ps, respectively. By utilizing these advantages, this structure can provide more possibilities for the development and research of slow light fields.

Keywords: plasmonics, metamaterials, integrated optics devices

1. Introduction

In recent years, with the increasing attention and understanding of researchers on metamaterial, graphene has entered the vision of researchers [1–4]. Graphene has the advantages of high electrical conductivity, long lifetime plasmon excitation, low loss, and easy modulation [5, 6], thus is widely used in optics [7–10], materials science [11–13], micro/nano processing [14, 15], energy [16] and other fields. With the

deepening of research, scientists have found that single-layer graphene exhibits similar properties to metals in the terahertz band, and can successfully excite surface plasmons polaritons. Graphene-based metasurfaces can also achieve plasmonic induced transparency (PIT) phenomena. The traditional electromagnetic induced transparency (EIT) [17] effect is a typical quantum coherent effect, which essentially prevents atoms at the atomic level from participating in the coupling of light under the action of the coupling field, thereby gradually reducing the absorption of weak probe light by the medium and even making it completely transparent. And PIT is a phenomenon similar to EIT that occurs at the resonant frequency

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Slow Transparency

Jacob B. Khurgin, Rodney S. Tucker



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Slow Light Jacob B. Khurgin, Rodney S. Tucker, 2018-10-08 One of the Top Selling Physics Books according to YBP Library Services The exotic effects of slow light have been widely observed in the laboratory However current literature fails to explore the wider field of slow light in photonic structures and optical fibers Reflecting recent research Slow Light Science and Applications presents a comprehensive introduction to slow light and its potential applications including storage switching DOD applications and nonlinear optics The book covers fundamentals of slow light in various media including atomic media semiconductors fibers and photonic structures Leading authorities in such diverse fields as atomic vapor spectroscopy fiber amplifiers and integrated optics provide an interdisciplinary perspective They uncover potential applications in both linear and nonlinear optics While it is impossible to account for all the captivating developments that have occurred in the last few years this book provides an exceptional survey of the current state of the slow light field

New Horizon of Plasmonics and Metamaterials Masafumi Kimata, Shinpei Ogawa, 2020-06-25 Plasmonics and metamaterials are growing fields that consistently produce new technologies for controlling electromagnetic waves Many important advances in both fundamental knowledge and practical applications have been achieved in conjunction with a wide range of materials structures and wavelengths from the ultraviolet to the microwave regions of the spectrum In addition to this remarkable progress across many different fields much of this research shares many of the same underlying principles and therefore significant synergy is expected This Special Issue introduces the recent advances in plasmonics and metamaterials and discusses various applications while addressing a wide range of topics in order to explore the new horizons emerging for such research Camera, 1915 Frontier Research and Innovation in Optoelectronics Technology and Industry Khaled Habib, Elfed Lewis, 2018-11-15 This book provides an overview of research achievements by industry experts and academic scientists in the subject area of Optoelectronics Technology and Industry It covers a broad field ranging from Laser Technology and Applications Optical Communications Optoelectronic Devices and Integration Energy Harvesting to Medical and Biological Applications Authored by highly regarded researchers contributing a wealth of knowledge on Photonics and Optoelectronics this comprehensive collection of papers offers insight into innovative technologies recent advances and future trends needed to develop effective research and manage projects Researchers will benefit considerably when applying the technical information covered in this book Generalized Optomechanics And Its Applications: Quantum Optical Properties Of Generalized Optomechanical System Jin-jin Li, Ka-di Zhu, 2013-03-07 A mechanical oscillator coupled to the optical field in a cavity is a typical cavity optomechanical system In our textbook we prepare to introduce the quantum optical properties of optomechanical system i e linear and nonlinear effects Some quantum optical devices based on optomechanical system are also presented in the monograph such as the Kerr modulator quantum optical transistor optomechanical mass sensor and so on But most importantly we extend the idea of typical optomechanical

system to coupled mechanical resonator system and demonstrate that the combined two level structure and resonator system can serve as a generalized optomechanical system The quantum optical properties which exist in typical system are also presented in the combined two level structure and resonator system *Western Camera Notes* ,1901 *Photonics* Léonard Dobrzyński,Yabin Jin,Abdellatif Akjouj,El Houssaine El Boudouti,Gaetan Leveque,Housni Al-Wahsh,Yan Pennec,Cecile Ghouila-Houri,Abdelkrim Talbi,Bahram Djafari-Rouhani,2020-11-28 *Photonics* a volume in the Interface Transmission Tutorial Book series describes the science of photonic transmission properties of the interfaces of composite materials systems and devices The book s authors review the general analysis methods of interface transmission give many examples and apply these methods to photonic applications Applications discussed include photonic crystals materials devices and circuits Offers a unique approach on photonics from the interfacial transmission point of view Reviews the interface transmission properties of composite materials for photonics applications Authored by world leading experts on interface transmission

Handbook of Water and Wastewater Treatment Plant Operations, Second Edition Frank R. Spellman,2008-11-18 Hailed on its initial publication as a real world practical handbook the second edition of Handbook of Water and Wastewater Treatment Plant Operations continues to make the same basic point water and wastewater operators must have a basic skill set that is both wide and deep They must be generalists well rounded in the sciences cyber operations math operations mechanics technical concepts and common sense With coverage that spans the breadth and depth of the field the handbook explores the latest principles and technologies and provides information necessary to prepare for licensure exams Expanded from beginning to end this second edition provides a no holds barred look at current management issues and includes the latest security information for protecting public assets It presents in depth coverage of management aspects and security needs and a new chapter covering the basics of blueprint reading The chapter on water and wastewater mathematics has tripled in size and now contains an additional 200 problems and 350 math system operational problems with solutions The manual examines numerous real world operating scenarios such as the intake of raw sewage and the treatment of water via residual management and each scenario includes a comprehensive problem solving practice set The text follows a non traditional paradigm based on real world experience and proven parameters Clearly written and user friendly this revision of a bestseller builds on the remarkable success of the first edition This book is a thorough compilation of water science treatment information process control procedures problem solving techniques safety and health information and administrative and technological trends *Popular Astronomy* ,1905 [The Routledge Companion to Journalism Ethics](#) Lada Trifonova Price,Karen Sanders,Wendy N. Wyatt,2021-08-24 This volume provides a comprehensive discussion of enduring and emerging challenges to ethical journalism worldwide The collection highlights journalism practice that makes a positive contribution to people s lives investigates the link between institutional power and ethical practices in journalism and explores the relationship between ethical standards and journalistic practice Chapters in the volume represent three key

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Recent Advances in Nanotechnology Zishan Husain Khan, Mark Jackson, Numan A. Salah, 2023-09-07 This volume comprises the select peer reviewed proceedings of the International Conference on Nanotechnology Opportunities and Challenges ICNOC22 It aims to provide a comprehensive and broad spectrum picture of the state of the art research and development in nanomaterials nanocomposites nanobiosensors nanochemistry renewable energy nanochemistry in medicine batteries and supercapacitors targeted cellular therapies among others This volume will be useful for researchers and professionals working in nanotechnology and allied fields *Pictorial Photography* Paul Anderson, 1917 **The American Stationer**, 1889 Freedom in the World 2019 Freedom House, 2020-01-25 Freedom in the World the Freedom House flagship survey whose findings have been published annually since 1972 is the standard setting comparative assessment of global political rights and civil liberties The survey ratings and narrative reports on 195 countries and fifteen territories are used by policymakers the media international corporations civic activists and human rights defenders to monitor trends in democracy and track improvements and setbacks in freedom worldwide The Freedom in the World political rights and civil liberties ratings are determined through a multi layered process of research and evaluation by a team of regional analysts and eminent scholars The analysts used a broad range of sources of information including foreign and domestic news reports academic studies nongovernmental organizations think tanks individual professional contacts and visits to the region in conducting their research The methodology of the survey is derived in large measure from the Universal Declaration of Human Rights and these standards are applied to all countries and territories irrespective of geographical location ethnic or religious composition or level of economic development Freedom in the World 2018 Freedom House, 2019-01-31 Freedom in the World the Freedom House flagship survey whose findings have been published annually since 1972 is the standard setting comparative assessment of global political rights and civil liberties The survey ratings and narrative reports on 195 countries and fifteen territories are used by policymakers the media international corporations civic activists and human rights defenders to monitor trends in democracy and track improvements and setbacks in freedom worldwide The Freedom in the World political rights and civil liberties ratings are determined through a multi layered process of research and evaluation by a team of regional analysts and eminent scholars The analysts used a broad range of sources of information

including foreign and domestic news reports academic studies nongovernmental organizations think tanks individual professional contacts and visits to the region in conducting their research The methodology of the survey is derived in large measure from the Universal Declaration of Human Rights and these standards are applied to all countries and territories irrespective of geographical location ethnic or religious composition or level of economic development *Practical Color Photography* Edward John Wall,1922 Electron Liquid Theory of Normal Metals Viktor Pavlovich Silin,1988 *Complete Self-instructing Library of Practical Photography: At home portraiture: flashlight, interiors, copying, enlarging, lantern slides* James Boniface Schriever,Thomas Harrison Cummings,1908 *Camera Craft* ,1905

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