

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

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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 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

Well Oiled Alex Vines, Human Rights Watch (Organization), 2009 This 102 page report details how the dictatorship under President Teodoro Obiang Nguema Mbasogo has used an oil boom to entrench and enrich itself further at the expense of the country's people Since oil was discovered there in the early 1990s Equatorial Guinea's gross domestic product GDP has increased more than 5 000 percent and the country has become the fourth largest oil producer in sub Saharan Africa At the same time living standards for the country's 500 000 people have not substantially improved Publisher description

Relationship Randy M. Clendenin, Martha W. Homme, 2002-07 **Pictorial**

Photography Paul Anderson, 1917 *The American Stationer*, 1889 *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 **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 **International**

Anti-Corruption Norms Cecily Rose,2015-08-13 This book traces the creation of international anti corruption norms by states and other actors through four markedly different institutions the Organisation for Economic Co operation and Development the United Nations the Extractive Industries Transparency Initiative and the Financial Action Task Force Each of these institutions oversees an international instrument that requires states to combat corruption Yet only the United Nations oversees anti corruption norms that take the sole form of a binding multilateral treaty The OECD has by contrast fostered the development of the binding 1997 OECD Anti Bribery Convention as well as non binding recommendations and guidance associated with treaty itself In addition the revenue transparency and anti money laundering norms developed through the Extractive Industries Transparency Initiative and the Financial Action Task Force respectively take the form of non binding instruments that have no relationship with multilateral treaties The creation of international anti corruption norms through non binding instruments and informal institutions has the potential to privilege the interests of powerful states in ways that raise questions about the normative legitimacy of these institutions and the instruments they produce At the same time the anti corruption instruments created under the auspices of these institutions also show that non binding instruments and informal institutions carry significant advantages The non binding instruments in the anti corruption field have demonstrated a capacity to influence domestic legal systems that is comparable to if not greater than that of binding treaties With corruption and money laundering at the forefront of political debate International Anti Corruption Norms

provides timely expertise on how states and international institutions grapple with these global problems **The Complete Oil Painter** Brian Gorst,2004-01-01 Oils are perhaps the most versatile of all paint mediums Yet for many artists oil painting is either shrouded in mystique or considered very difficult Filled with clear step by step instructions and surefire strategies The Complete Oil Painter is an essential one stop guide to becoming an expert in every aspect of this medium Artists will discover everything they need to know about materials pigments supports canvases tools and equipment palettes brushes paint application wet into wet alla prima glazing impasto form and color light and dark expression color mixing exploring themes still life portraiture figure painting and much more *Camera* ,1916 Anti-individualism and Knowledge Jessica Brown,2004 A persuasive monograph that answers the keyepistemological arguments against anti individualism in thephilosophy of mind **Semantic Externalism** Jesper Kallestrup,2013-03 Semantic externalism is the view that the meanings of referring terms and the contents of beliefs that are expressed by those terms are not fully determined by factors internal to the speaker but are instead bound up with the environment The debate about semantic externalism is one of the most important but difficult topics in philosophy of mind and language and has consequences for our understanding of the role of social institutions and the physical environment in constituting language and the mind In this long needed book Jesper Kallestrup provides an invaluable map of the problem Beginning with a thorough introduction to the theories of descriptivism and referentialism and the work of Frege and Kripke Kallestrup moves on to analyse Putnam s Twin Earth argument Burge s arthritis argument and Davidson s Swampman argument He also discusses how semantic externalism is at the heart of important topics such as indexical thoughts epistemological skepticism self knowledge and mental causation Including chapter summaries a glossary of terms and an annotated guide to further reading **Semantic Externalism** an ideal guide for students studying philosophy of language and philosophy of mind Camera Craft ,1905 **Encyclopedia of American Poetry: The Twentieth Century** Eric L. Haralson,2014-01-21 The Encyclopedia of American Poetry The Twentieth Century contains over 400 entries that treat a broad range of individual poets and poems along with many articles devoted to topics schools or periods of American verse in the century Entries fall into three main categories poet entries which provide biographical and cultural contexts for the author s career entries on individual works which offer closer explication of the most resonant poems in the 20th century canon and topical entries which offer analyses of a given period of literary production school thematically constructed category or other verse tradition that historically has been in dialogue with the poetry of the United States The Wesleyan Tradition Michael Collier,2012-08-22 Since issuing its first volumes in 1959 the Wesleyan poetry program has challenged the reigning aesthetic of the time and profoundly influenced the development of American poetry One of the country s oldest programs its greatest achievement has been the publication of early works by yet undiscovered poetry who have since become major awarded Pulitzer and Bollingen prizes National Book Awards and many other honors At a time when other programs are being phased out Wesleyan takes this opportunity to celebrate its

distinguished history and reaffirm its commitment to poetry with publication of *The Wesleyan Tradition* Drawing from some 250 volumes editor Michael Collier documents the wide ranging impact of these works In his introduction he describes the literary and cultural context of American poetics in more recent decades tracing the evolution of the Deep Image and Confessional movements of the 50s and 60s and exploring the emergence of the prose lyric style Although the success of the Wesleyan program has inspired its share of imitators no other program has had such a fundamental impact Works by the eighty six poets included here both document and celebrate that contribution *The Photographic Journal of America ...*,1888 *The Encyclopaedia Britannica* ,1902 *Living in the Comfort Zone* Rokelle Lerner,2010-04-12 Here is one of the most useful books on relationships you will ever read This book challenges you to explore the unknown depths of the soul and claim your individuality while learning to connect with others in a healthy way The term comfort zone describes the internal sanctuary you create by developing and maintaining your boundaries Only through conscious creation of your comfort zone can you develop the ability to be present in body mind and spirit in order to create healthy relationships Only by defining yourself can you connect with others Rokelle Lerner addresses the practical issues of maintaining both your separateness and your sacred domain of connection she explains how you can walk a spiritual path with practical feet Lerner has filled this book with her clients personal stories modeling potential problems that can arise in relationships due to unformed or violated boundaries You will learn how to stop boundary intruders and boundary distancers mend the body and soul deal with shame heal emotional intellectual and spiritual boundaries set limits unlock bonding patterns and sustain your comfort zones while you do the soul work required for further personal growth

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Table of Contents Slow Transparency

1. Understanding the eBook Slow Transparency
 - The Rise of Digital Reading Slow Transparency
 - Advantages of eBooks Over Traditional Books
2. Identifying Slow Transparency
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Slow Transparency
 - User-Friendly Interface
4. Exploring eBook Recommendations from Slow Transparency
 - Personalized Recommendations

- Slow Transparency User Reviews and Ratings
- Slow Transparency and Bestseller Lists
- 5. Accessing Slow Transparency Free and Paid eBooks
 - Slow Transparency Public Domain eBooks
 - Slow Transparency eBook Subscription Services
 - Slow Transparency Budget-Friendly Options
- 6. Navigating Slow Transparency eBook Formats
 - ePub, PDF, MOBI, and More
 - Slow Transparency Compatibility with Devices
 - Slow Transparency Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Slow Transparency
 - Highlighting and Note-Taking Slow Transparency
 - Interactive Elements Slow Transparency
- 8. Staying Engaged with Slow Transparency
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Slow Transparency
- 9. Balancing eBooks and Physical Books Slow Transparency
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Slow Transparency
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Slow Transparency
 - Setting Reading Goals Slow Transparency
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Slow Transparency
 - Fact-Checking eBook Content of Slow Transparency

- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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