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Numerical simulation of vertical tunneling transistor with bilayer graphene as source and drain regions

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In this paper, the electrical characteristics of vertical tunneling bilayer graphene field effect transistor (VTBGFET) are theoretically investigated. We evaluate the device behavior using nonequilibrium Green's function (NEGF) formalism combined with an atomistic tight binding model. By using this method, we extract the most significant figures of merit such as ON/OFF current ratio, subthreshold swing, and intrinsic gate-delay time. The results indicate that using a bilayer graphene instead of a monolayer graphene as the base material for the source and drain regions leads to a larger ON/OFF current ratio due to the presence of an energy bandgap in biased bilayer graphene. Also, the subthreshold swing of VTBGFET can be much lower than that of vertical tunneling monolayer graphene field-effect transistor (VTMGFET). We find that the increase of the number of hBN layers enhances the ON/OFF current ratio but degrades the intrinsic gate-delay time.

1 Introduction Graphene has attracted significant interest due to its extraordinary properties such as high carrier mobility, high thermal conductivity, and strong break strength [1, 2]. However, native graphene has a zero bandgap and it is not suitable as a transistor channel for digital applications [1, 2]. Several methods have been proposed for opening a bandgap in graphene for increasing the transistor switching ratio such as imposing lateral quantum confinement by using graphene nanoribbon (GNR), applying an electrical field across bilayer graphene, using quantum dots, or chemical derivates [3–6]. These techniques are likely to entail a degradation of graphene mobility. Also, the performance of GNR as transistor channel is limited due to the undesirable line-edge disorder [7]. An alternative approach to increasing the switching ratio of graphene-based devices is to utilize tunneling based device architecture. Recently, vertical tunneling monolayer graphene field effect transistors (VTMGFETs) have been proposed and fabricated by Britnell et al. [8]. Also, several studies about simulation of VTMGFETs have been reported [9–11]. In these transistors, graphene electrodes act as the source and drain regions separated by a 2D tunneling barrier, such as hBN. The performance of VTMGFETs relies on the tunneling barrier height tunability via a shift in the Fermi level of graphene. VTMGFETs exhibit room temperature switching ratio of 30, which is not sufficient for digital applications [10]. One of the possible routes to increase the switching ratio of this device is to induce an energy bandgap in source and drain graphene electrodes. Spatial confinement in GNR leads to the opening of a bandgap [11]. In order to obtain a suitable bandgap, the width of GNRs must be scaled to extremely small values. The presence of the line-edge disorder in narrow GNRs is the critical problem that can degrade the electrical characteristics of the device [7, 11]. The novelty of this paper is to use bilayer graphene with a tunable bandgap as the source and drain regions. Infinite bilayer graphene in A–B (Bernal) stacking provides bandgap without suffering from line-edge disorder [12]. In this paper, we present a numerical simulation based on nonequilibrium Green's function (NEGF) formalism to describe the electrical characteristics of vertical tunneling bilayer graphene field effect transistor (VTBGFET) such as I_{ON}/I_{OFF} ratio, subthreshold swing, and intrinsic gate-delay time. Also, the electrical characteristics of VTBGFET and VTMGFET

Numerical Simulation In Tunneling

Yun Bo Huang

Numerical Simulation In Tunneling:

Numerical Simulation in Tunnelling Gernot Beer,2012-12-06 For many years the Austrian tunneling industry has demanded that research is urgently required to establish a theoretical basis for the New Austrian TUnneling Method and to assist site engineers in the often difficult day to day decisions In particular it was felt that numerical models need to be improved considerably in order to be able to act as useful tools in predicting soil rock mass behavior during tunneling The required improvement not only refers to the quality of the models but also to their ease of use As long as an experienced modeler is required to spend days in preparing the input and in interpreting the results the models will not be useful at the tunnel site It is heartening therefore that a group of scientists in Austria has come together to attempt to tackle this challenging task The initiative has been supported in a number of ways by the Austrian tunneling industry All Aus trian companies associated with tunneling sent representatives to the man agement advisory board which ensured that the research carried out in the project was of benefit to the industry The Austrian Geomechanics Society sponsored the project with a considerable amount which was mainly used to cover site costs HL AG and OSAG as well as the joint ventures allowed access to tunnel sites thereby making it possible to test new developments **Application of numerical simulation in the tunnel sealing experiment** R. Guo,2004 **Numerical Simulation of Segmental Tunnel Lining** Raja Nurul Afiqah Raja Zulkefli,2015 *Numerical Simulation of the Howard Street Tunnel Fire, Baltimore, Maryland, July 2001* ,2003

Wind-induced Vibration of Long Span Suspension Bridges Yang Yang,Bo Wu,Long Li,2025-12-23 Wind induced Vibration of Long Span Suspension Bridges in mountainous areas includes the author s research on such bridges and adopts a combination of on site measurements wind tunnel tests theoretical analyses and numerical calculations to discuss the characteristics and parameters of the wind environment at bridge sites the buffeting response of bridges under the effect of winds on bridges in mountainous areas the vortex response of wide bodied flat steel box girders chattering characteristics i e noise characteristics and the vibration characteristics of the wind vehicle bridge system Includes detailed analyses of complex wind environments at bridge sites along with the impact of pulsating wind on such bridges Describes how to reduce fatigue damage caused by buffeting in bridge design and operation Proposes a new wind speed calculation system and its impact on vibration Helps bridge builders and civil and structural engineers design bridges for operation in mountainous areas **Sustainable Tunneling and Underground Use** Mona Badr,Ayman Lotfy,2018-10-31 This volume comprises a set of high quality refereed papers that address the different aspects related to the geotechnical and structural design and construction of deep excavations tunnels and underground space facilities as well as the effect of their construction on the surroundings The papers cover planning design modeling monitoring and construction aspects of these essential structures The utilization of underground space using tunneling and deep excavations has become much needed to support the increasing needs of urban environments and to allow for functional extensions and sustainable developments in heavily

congested areas Recently more utilities and transportation transit systems have been relocated underground because of scarcity of surface space The growing interest in the use of underground space has necessitated commensurate advancements in related fields geotechnical engineering engineering geology and structural engineering design tools construction techniques and analytical and interpretation methods The volume is based on the best contributions to the 2nd GeoMEast International Congress and Exhibition on Sustainable Civil Infrastructures Egypt 2018 The official international congress of the Soil Structure Interaction Group in Egypt SSIGE *A Numerical Simulation in Longitudinal Ventilation System of Long Highway Tunnel* Wenchin Lin,1995 **Modeling, Numerical Simulation and Experimental Study of a Wireless Link in a Tunnel** Yun Bo Huang,2001 **Numerical Simulation of Two Opposing High-speed Trains in a Tunnel** S. V. Ramakrishnan,1995 Advanced Research in Civil Engineering, Materials, Machinery and Applied Technologies M. Han,X.S. Tai,2015-01-08 Selected peer reviewed papers from the 2014 3rd International Conference on Civil Engineering and Material Engineering CEME 2014 December 27 28 2014 Changsha China *Proceedings of the 10th International Conference on Civil Engineering* Guangliang Feng,2024-07-19 This open access book is a compilation of selected papers from the 10th International Conference on Civil Engineering ICCE2023 The work focuses on novel research findings on seismic technology of civil engineering structures High tech construction materials digitalization of civil engineering urban underground space development The contents make valuable contributions to academic researchers and engineers **Numerical Simulation of the Howard Street Tunnel Fire, Baltimore, Maryland, July 2001** K. B. McGrattan,2003-03-01 Numerical Simulation of the NASA-Ames 11 Ft. Transonic Wind Tunnel by a Panel Method Code Trong Tri Bui,1989 A Numerical Simulation of Three-dimensional Flow in an Adaptive Wall Wind Tunnel J. P. Mendoza,1984 **Numerical Simulation of Resonant Tunneling Devices Described by the Wigner-Poisson Equations** Anne Stefanie Costolanski,2013 **Centrifuge Modeling of the BART Transbay Tube and Numerical Simulation of Tunnels in Liquefying Ground** Jui-Ching Chou,2010 This thesis describes centrifuge model tests and numerical analyses of tunnels in liquefiable soil The prototype of the centrifuge tests was the Bay Area Rapid Transit BART Transbay Tube TBT that connects Oakland to San Francisco CA USA During the tunnel construction much of the gravelly backfill material around this tunnel was placed loosely under water at a relative density less than 50% Because of the low relative density of the backfill material around the tube and low unit weight of the tube there were concerns that tube might suffer large deformation due to buoyancy forces if the backfill material liquefied in an earthquake BART engaged Fugro West Inc Oakland CA to assess the need for ground improvement to mitigate seismically induced deformations of the tunnel in particular the deformations due to uplift of the tunnel in the liquefied backfill Fugro recommended that their numerical analyses and deformation mechanisms should be further verified using centrifuge model tests Centrifuge model tests were performed 1 to assess the stability of the BART Transbay Tube 2 to confirm the uplift mechanisms of the BART Transbay

Tube and 3 to verify numerical methods Test results indicated that the anticipated uplift during the design earthquake would be acceptable less than about 0 25 m Three uplift mechanisms were observed in the centrifuge model tests 1 a cyclic ratcheting mechanism of sand moving under the tunnel associated with cyclic lateral deformations of the tunnel 2 seepage of water under the tunnel and 3 heave of soft clay around the trench Flow of the sand as a viscous liquid was not observed Two approaches were used to record subsurface movements in the centrifuge experiments The traditional approach used data from accelerometers and displacement transducers to determine the trajectory of the tunnel A new approach Electric Field Displacement Sensors EFDS involves installation of source and ground electrodes in the specimen through which well defined multi directional electric fields can be set up in the specimen The movement of measurement electrode which can be attached to an object of interest can then be determined simply by measuring its voltage Li 2006 was the first to use this approach but she used an electrode switching system to sequentially excite multidirectional electric fields A new contribution of this thesis was the idea that independent electric fields data from different sources can be excited simultaneously at different frequencies elimination of the need for the switching system has saved a lot of complexity in the equipment and also allowed much improved temporal resolution After comparing the processed data from the EFDS and traditional approaches the EFDS can capture the dynamic response pretty well but the EFDS has its limitations The change of soil resistivity and the heterogeneities of the soil resistivity affect the estimated movements greatly but the change of the soil resistivity can not be captured from the voltage data in the current implementation With continued work on solving its limitation the EFDS could become a fairly inexpensive tool for tracking movements A parametric study was performed using a finite difference program FLAC 2D In the numerical simulation the UBC Sand model Beatty and Byrne 1998 was used to model the behavior of liquefiable soils A mesh sensitivity study was performed to decide the appropriate number of nodes for the simulations and how to best model sliding at interfaces between the soil and tunnel In the parametric study effects of different geometry characteristics and soil properties on the seismic behavior of the tunnel were explored and the results are summarized in a few dimensionless plots After effects of various factors on the tunnel performance were understood suggestions for the future tunnel design were made 1 densify the liquefiable soils to reduce the cyclic mobility associated with liquefaction 2 minimize the volume of the liquefiable soils and the thickness of the liquefiable soils underneath the tunnel to reduce the volume of pore water expelled and the space through which water and soil may flow under the tunnel 3 make the elevation of the interface between high and low permeability materials shallow enough so that high pore pressures are not trapped near the base of the tunnel 4 make the liquefiable soils as permeable as possible to drain high pore pressures away from the base of the tunnel and 5 make the unit weight of the tunnel as close as to the surrounding soil *Numerical Simulation of Aerodynamics and Ventilation of Underground Road Tunnel Systems* Shyam Dayanandan,2004 **Proceedings of the 2025 7th International Conference on Civil Engineering, Environment Resources and Energy Materials (CCESEM**

2025) Muhyiddine Jradi,Jun Liu,Hüseyin Bilgin,2026-01-16 In order to exchange the latest progress in theory technology and application in the field of civil engineering environmental resources and energy materials at home and abroad in recent years and to show the latest achievements 2025 7th International Conference on Civil Engineering Environment Resources and Energy Materials CCESEM 2025 organized by the China Singapore International Joint Research Institute will be held on September 5 7 2025 in Guangzhou Guangdong China CCESEM 2025 has been successfully held for 6 times this conference will provide an international multidisciplinary cross fertilization platform for domestic and foreign outstanding experts scholars and industrial talents focusing on this research field to exchange new ideas and display research results to discuss the latest progress in theory technology and application in the fields of civil engineering environmental resources and energy materials etc and to display the latest achievements the conference sincerely invites The conference invites experts and scholars from domestic and foreign universities and research institutions as well as business people and other related personnel to participate in the conference and exchange ideas Please pay attention to the official website of CCESEM 2025 for the latest conference news registration information and submission guidelines We are looking forward to seeing you in Guangzhou for a great academic event This is an open access publication The Proceedings of 11th Asia-Oceania Symposium on Fire Science and Technology Guan-Yuan Wu,Kuang-Chung Tsai,W. K. Chow,2019-09-12 This book features selected papers from the 11th Asia Oceania Symposium on Fire Science and Technology AOSFST 2018 held in Taipei Taiwan Covering the entire spectrum of fire safety science it focuses on research on fires explosions combustion science heat transfer fluid dynamics risk analysis and structural engineering as well as other topics Presenting advanced scientific insights the book introduces and advances new ideas in all areas of fire safety science As such it is a valuable resource for academic researchers fire safety engineers and regulators of fire construction and safety authorities Further it provides new ideas for more efficient fire protection *Leading the Way Forward* Mengjun Wu,Hao Ding,Jianxun Chen,Jun Huang,Yao Rong,2026-02-27 This book is a comprehensive collection of research papers that focus on enhancing resilience intelligence and sustainability in tunnel engineering It presents cutting edge design theories innovative construction techniques intelligent operation and maintenance methods sustainable development strategies and engineering application practices of tunnel and underground engineering This book systematically organizes key contributions in critical thematic areas of tunnel disaster prevention and resilience enhancement super large diameter shield tunnel tech maintenance innovations green low carbon solutions drill blast method theories operation safety control and deep sea floating tunnels Key findings include advanced shield construction techniques optimized drill blast methods intelligent operation tools and deep sea floating tunnel research and design R D breakthroughs addressing engineering challenges and sustainable goals These contributions provide a fresh perspective on current engineering challenges and sustainable development goals This book is tailored for tunnel engineers researchers project managers and policymakers engaged in underground infrastructure development It also

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