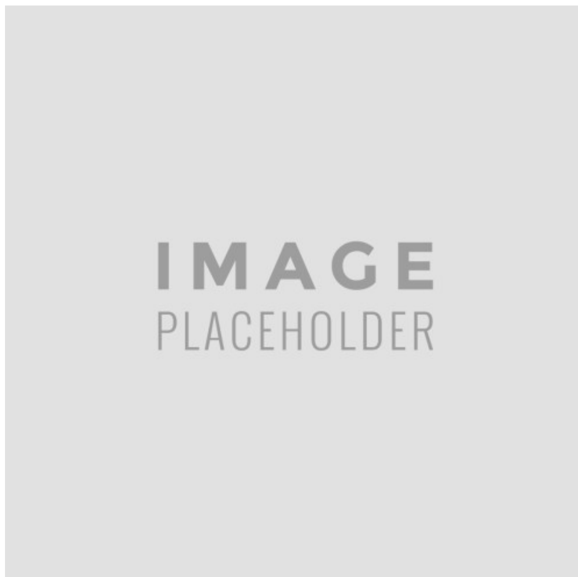
Monash University

Honours Thesis

Thin oxides in graphene devices



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Abstract:

I present a review of the use of graphene in electronic devices, both in its shortfalls and exciting properties. The electronic structure is detailed, along with various scattering sources that affect electron transport and ultimately the goal of room temperature, electronic devices. Considering heterostructures and the use of other materials to enhance graphene, I discuss the potential use of hafnium dioxide, and other oxides, as an excellent gate dielectric material for potential use in graphene field-effect devices.

Contents

0.1 Foreword

This thesis serves the purpose presenting the conclusions of my research into thin oxides on graphene. I will be arguing , and how that fits into a bigger picture of materials science and particular applications.

In chapter 1, I will outline what I hope to achieve in this project. I begin by discussing the theoretical properties of graphene and why it has attracted so much interest as an electronic material. I will also describe some challenges facing new computing technologies, including the use of dielectrics, and how my work contributes to realising solutions to new generations of this technology. I will outline a theoretical and experimental summary of the results to date seen in introducing dielectrics to graphene.

In chapter 2, I describe the various ways of producing and identifying graphene in lab use, and the characterisations I have conducted. This will include our use of atomic force microscopy (AFM), optical microscopy and Raman spectroscopy.

I will then describe the devices and measurements I have made in chapter 3. This will regard geometry and connections to devices, which allow the measurements I have perform, and the processes used to fabricate our devices. I have made graphene devices using lithography and evaporation methods, to create electrical contacts. I will also describe the oxides I have investigated in this chapter, and the methods I have used to transfer them.

In chapter 4 I will present the data and results from my measurements of the respective devices which will be placed on SiO_2. The results to here will be compared alongside data after stamping the same devices with thin oxides in chapter 5.

Chapter 1

Introduction

Chapter 2

Production & identification of graphene

2.1 Production

Since graphene's realisation in 2004[1], much research has been focused to finding effecient ways of producing large amounts of graphene[2]. Originally, the first samples ever created which have primarily been used for sensative measuremnts have been conducted using a method of exfoliation (section 2.1.1). These samples typically exhibit better electronic properties than those produced by other methods. Since 2008/2009, CVD (section 2.1.2) of carbon to create graphene films has provided another prominent method to produce large films for industrial scale applications. In particular, growth of graphene on copper sheets[3] has been a reliable way producing these large uniform sheets.

There are other methods not used in this thesis. Epitaxial growth of graphene via SiC uses heating to boil off silicon atoms to form a layer of graphene on it's surface. Chemical exfoliation

2.1.1 Exfolation

2.1.2 CVD

2.2 Indentification of Graphene

2.2.1 Optical Microscopy

2.2.2 Raman Spectroscopy

2.2.3 Atomic Force Microscopy Imaging

Chapter 3

Devices

Chapter 4

Bare graphene

4.1 CVD

4.2 Exfoliated

Chapter 5

Thin oxide graphene

5.1 CVD

5.2 Exfoliated

Chapter 6

References

[1] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva, and A. A. Firsov. Electric Field Effect in Atomically Thin Carbon Films. *Science*, 306(5696):666–669, October 2004.

[2] Yi Zhang, Luyao Zhang, and Chongwu Zhou. Review of Chemical Vapor Deposition of Graphene and Related Applications. *Accounts of Chemical Research*, 46(10):2329–2339, October 2013.

[3] Xuesong Li, Weiwei Cai, Jinho An, Seyoung Kim, Junghyo Nah, Dongxing Yang, Richard Piner, Aruna Velamakanni, Inhwa Jung, Emanuel Tutuc, Sanjay K. Banerjee, Luigi Colombo, and Rodney S. Ruoff. Large-Area Synthesis of High-Quality and Uniform Graphene Films on Copper Foils. *Science*, 324(5932):1312–1314, June 2009.