

# Application to Graduate with Honors

Student ID: \_\_\_\_\_

I plan to defend in: FALL SPRING of 20 11

## Personal Information:

|           |   |
|-----------|---|
| Name:     | <u>Xu Zhou</u>  |
| Address:  | <u>4324 S. Halifax St.</u><br><u>Centennial, CO 80015</u> |
| CUE-mail: | <u>Xu.Zhou@colorado.edu</u>                               |
| I am an:  | <u>IN-STATE</u> OUT-OF-STATE student                      |

## Academic Information:

|   |
|---|
| <input checked="" type="checkbox"/> I plan to graduate with Departmental Honors in:<br><u>Phy Engineering Physics</u> |
| <input type="checkbox"/> I plan to graduate with General Honors   |
| Cumulative GPA: _____   |

Please attach a brief PROSPECTUS, BIBLIOGRAPHY, and TIMELINE of your thesis project to this application. When summarizing your work, consider the following:

- What is the problem you are investigating?
- What is the hypothesis you are testing?
- What is the focus of your study?
- What is your goal in this study?

Primary thesis advisor: Name: Scott Bunch Dept: Mechanical engineering

List the other members of your committee:

Name: John Cumalat Dept: Physics

Name: Kyle McElroy Dept: Physics

Name: Rishi Raj Dept: Mech. eng.

Name: \_\_\_\_\_ Dept: \_\_\_\_\_

## Departmental and General Honors Committee Checklist:

- ✓ Applicant has a total of at least three committee members.
- ✓ At least one Honors Council Representative is included on committee.
- At least one committee member from an outside department.

APPLICATION CONTINUED ON BACK OF THIS SHEET

Please initial if you are pursuing Departmental Honors:

I have consulted with my department and have completed (or am completing) the requirements they have established.

**For Honors Council Representative:**

I have met with applicant and approve him/her for departmental honors.

Printed Name: John Cumalat Signature: John P. Cumalat

Please initial if you are pursuing General Honors:

I have completed (or am completing) the requirements for graduating with General Honors.  
Please list the courses you have or are taking toward General Honors:

\_\_\_\_\_  
\_\_\_\_\_

**For ~~General Honors Council Member~~ Thesis Advisor:**

I have met with applicant and approve him/her for general honors. I agree to be on his/her defense committee.

Printed Name: Scott Bunch Signature: [Signature]

**For the Thesis Advisor:**

~~I have met with the applicant to discuss the proposed work and agree to provide the necessary help and direction for this thesis project.~~

~~Printed Name: \_\_\_\_\_ Signature: \_\_\_\_\_~~

**For the Student:**

I have read the requirements for graduating with honors at the University of Colorado. I also understand that my designation will be sent to the CU email address that I have provided and will not be given out over the phone.

Signature: Xu Yan Date: 12/06/10

*For additional graduation information including requirements, guidelines and deadlines, you can download them online at [www.colorado.edu/honors](http://www.colorado.edu/honors)*

# Graphene oxidation barrier coating on copper

(Tony) Xu Zhou

Scott Bunch, Advisor

Kyle McElroy, co-Advisor

December 6, 2010

## Prospectus

Since the discovery of graphene in 2004, it has shown some outstanding properties. I propose that graphene can be used as an oxidation barrier coating for copper. Copper is a great conductor but gets easily oxidized in the air at room temperature or higher. Using graphene as a coating material may reduce the cost because copper is commonly coated with gold. The focus is to investigate the rate of oxidation of copper that has been coated in graphene.

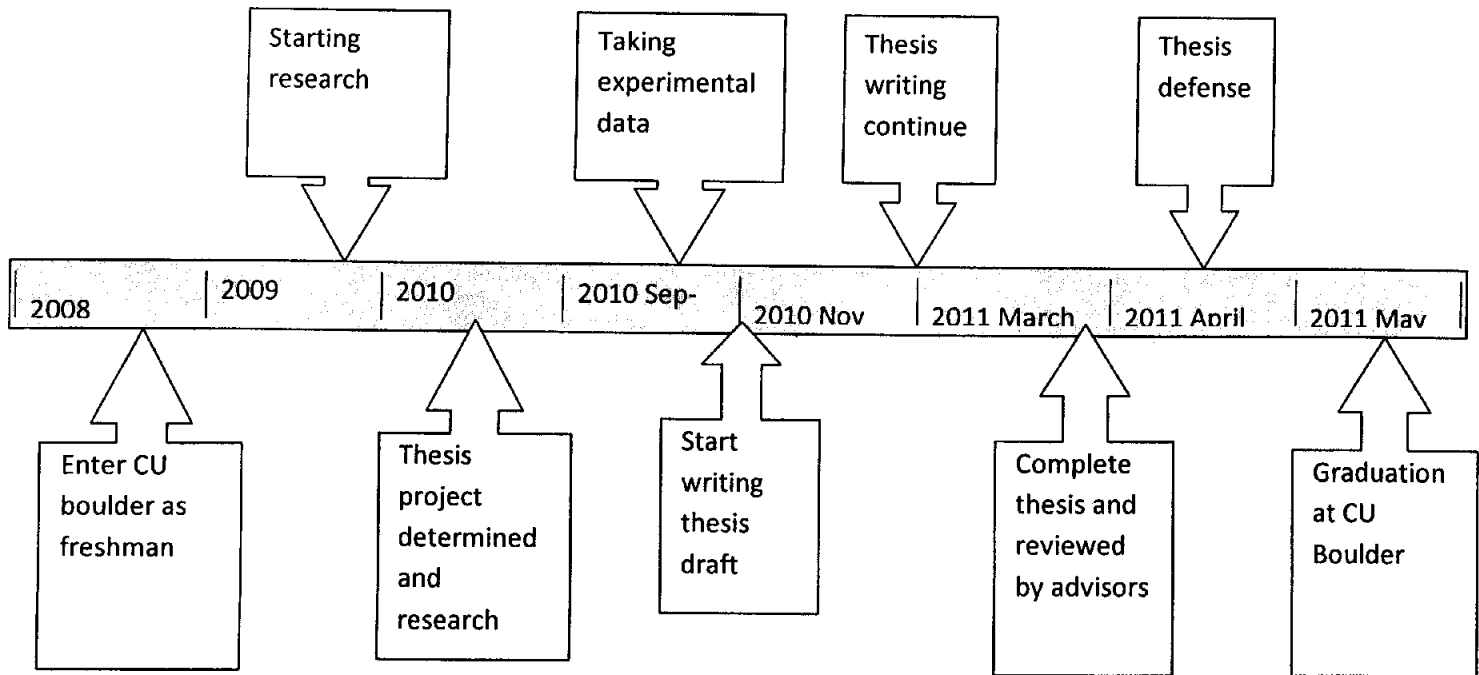
Before I can investigate the character of graphene as an oxidation barrier for copper, I must fabricate graphene on top of a copper substrate. The fabrication of graphene is still a challenge. A common fabrication method is exfoliation known as the "scotch tape method." The disadvantage of scotch tape method is the limited size of graphene film. For our purpose of getting a large area of graphene, we use a different method to coat graphene on copper. The method to grow or coat graphene on copper is called chemical vapor deposition (CVD). CVD is commonly used to produce materials other than graphene such as diamond, silicon, polycrystalline, and carbon nanotubes. The basic idea of CVD is to flow gas, which contains carbon atoms, over the top of a substrate. CVD occurs when the gas is heated to the temperature where the chemical bonds of the gas break up. Once the carbon atoms are free from their chemical bonds, they form a thin layer of graphene on the surface of the substrate.

Brief experiment description: First of all, I cut copper strips from the Copper foils with powder free Nitrile gloves. I leave a few bare copper strip in the tray. Then, I pick another set of copper strips of the same number of bare copper strips in the tray. This set of copper strips undergoes the chemical vapor deposition (CVD) process. Through CVD, graphene is coated on the copper strips. After CVD is done and furnace is in room temperature, I load the bare copper strips I left in the tray to the chamber side to side with the copper strips with graphene. Then I heat the furnace to various temperatures for different time. In this process, the chamber is ends-open so air can flow into the chamber. I leave the samples in the chamber and take them out as soon as the designated time is reached.

The oxidation of copper with graphene and bare copper is characterized using an ellipsometer. Ellipsometer shines a polarized light onto the surface of the sample and detects reflected light. It gives the information about the reflectivity of the surface and the change of polarization of the light. From these information, we are able to acquire the thickness of the copper oxide layer on the copper.

The goal of the project is to investigate how effective graphene acts as an oxidation barrier coating for copper. I hypothesises graphene coating can effectively prevent oxidation of copper up to 2 days under 120 degrees Celsius environment.

### Timeline



### References:

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