

# 2011 中技社科技研究獎學金

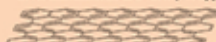
## CTCI Science and Technology Research Scholarship

### Preparation of Graphene and its Application on Nanocomposite Bipolar Plate for Proton Exchange Membrane Fuel Cell

國立清華大學 化學工程系 博士班三年級 蕭國雄  
指導教授：馮振基 講座教授

#### 研究重點

Graphene is a potential new material for developing novel nanomaterial in a variety of applications.



One atom thick, 2D sp<sup>2</sup> bonded carbon

#### Properties of graphene:

- High carrier mobilities up to 200,000 cm<sup>2</sup> V<sup>-1</sup> s<sup>-1</sup>
- High thermal conductivity: 4800-5000 W m<sup>-1</sup> K<sup>-1</sup>
- High Young's modulus: ~1,200 GPa<sup>25</sup>
- High fracture strength: 130 GPa<sup>26</sup>
- High surface area: ~2600 m<sup>2</sup> g<sup>-1</sup>

#### Properties of Bipolar Plate Required

- High electrical conductivity;
- Good mechanical properties;
- Thermal stability at operating temperature;
- Low permeability to fuel and oxidant;
- Low cost, low weight, and good processability.



- Mechanical strength<sup>25</sup>
- Liquid phase exfoliation of graphite<sup>26</sup>
- CVD and Epitaxial growth<sup>27</sup>
- Redox method<sup>28</sup>
- Electrochemical method<sup>29</sup>
- Hummer method<sup>30</sup>



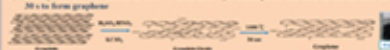
Progressive exfoliation  
High surface area of graphene  
Graphene/graphite composite

Using thermal reduction method to prepare massive amount of graphene.  
BPP and low compression process.  
Incorporating graphene in low cost matrix can reduce program cost of high performance nanocomposite bipolar plate (BP).  
Using graphene as reinforcement, the properties of BP significantly improve. Moreover, MWNT reinforced BP at the same loading. In addition, comparable enhancement of the composite BP, MWNTs loading 1.5 times higher content than graphene.

#### 研究成果

#### Graphene Preparation

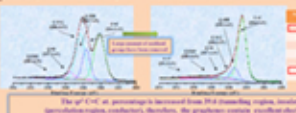
- Graphite oxide was prepared by mixing natural graphite with sulfuric acid, nitric acid, and potassium dichromate (chromic acid method).
- The GO was etched with HCl water repeatedly until the pH of the filtrate was neutral.
- Finally, the GO was heated to 1050 °C in an inert gas atmosphere and held in the furnace for 30 min to form graphene.



#### Thermogravimetric analysis



#### X-ray Photoelectron Spectroscopy (XPS)

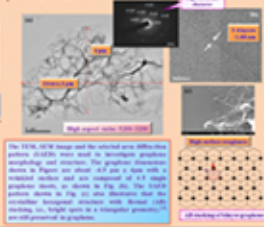


The pH of C 1s at approximately 284.6 eV is deconvoluted into 3 peaks, assigned to 5s<sup>2</sup> sp<sup>2</sup> hybridized carbon, oxidized carbon, and oxidized carbon.

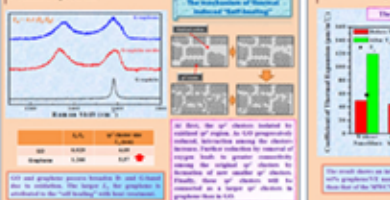
#### X-ray diffraction pattern



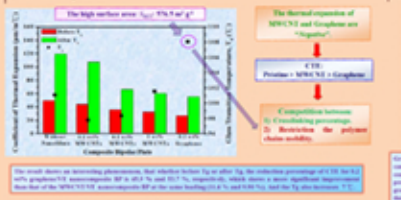
#### Morphology and Structure



#### Raman Spectrum



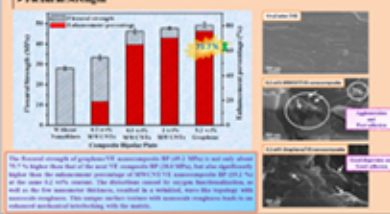
#### Thermal Expansion



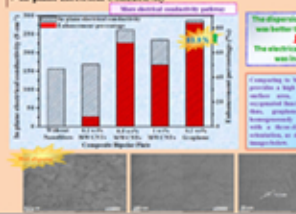
#### Thermal Conductivity



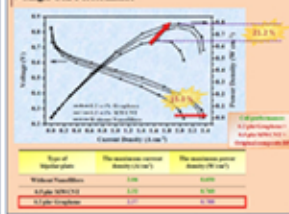
#### Flexural Strength



#### In-plane Electrical Conductivity



#### Single Cell Performance



#### 研究生活及心得

在研究生活的幾年，影響我成長最多的是我參與各項學術與教育，在老師與學長的指導之下，得以有機會參與研究與團隊計畫，從實作中發現問題到找到解決問題，在這一段學期的學術與團隊活動中，學習了研究學問，也認識了許多同學，在老師與學長們的指導與鼓勵之下，更可以多元化的嘗試不同領域，以觀自我研究與團隊的表現，也認識許多優秀的同學，更學習到團隊合作、團隊協作的研究理念，發現出許多對社會有貢獻的研發。