IGERT Cockrell School of Engineering– The Munich Experience 2012

Arturo Gutierrez Jr.
Goals

• Provide **exposure to the diverse approaches** in meeting energy demands.
• **Network** at conferences and meetings with research groups working on similar topics.
• **Present my work** at a conference or/and at the TUM with the purpose of further developing communication skills along with receiving critical advice on research techniques and approaches.
• **Experience the culture.**
Dresden facts:
• Located on the banks of the river Elbe
• Was a major manufacturing center, communications, art, classical music, culture and science hub before being completely destroyed on 13 February 1945

Conference review:
• Hosted by Fraunhofer
• Solar cell applications
• Solid electrolyte used for lithium ion batteries

Fraunhofer
• 60 research institutes
• Focus on applied science
• 18,000 employees
• $1.65 billion research budget
Dr. Hubert Gasteiger, TUM Chemistry Dept.

- Recipient of the 2012 Grove Medal
- Chair of Technical Electrochemistry
- Research
  - Direct Methanol Fuel Cells
  - Lithium-air battery
    - Thermal analysis
    - Oxygen consumption measurement
    - Rotating ring disc electrode voltammetry
  - Aging mechanisms in lithium titanate/lithium iron phosphate cell
Dr. Tom Nilges, TUM Chemistry Dept.

- Research
  - Ni/Co-Olivine Cathodes
  - Ion conductors
  - Thermoelectrics and Energy Materials
  - Polymorphism and phase transitions
  - Polyphosphides
  - Non-harmonic refinement of crystal structures
  - Rare Earth and transition metal Pnictide oxides
Presentation to the Department of Chemistry - TUM

- Presentation to 40-50 students, postdocs, and professors
- Everyone in seminar had similar experience with lithium ion batteries coming from either electrochemistry, solid-state physics or material science background
- Great response to research and ideas for future projects
- Probably the most enriching experience of my travels to Germany

Abstract:
Lithium manganese spinel oxide has been intensively studied as a cathode for lithium-ion batteries due to its better safety, kinetics, and low toxicity when compared to the layered oxide materials, which are the most commercialized cathode. Yet, the spinel cathode is plagued with severe capacity fade and research has been focused on techniques for reducing the amount of degradation during cycling. This seminar focuses on two of these techniques, namely: i) cationic and anionic substitutions and ii) oxide coatings. The first portion of the seminar will address how the chemical properties of the dopants affect the electrochemical performance of the cathode. A systematic study was performed and the results suggest that basic chemical properties of the dopants can be used as identifiers for predicting the relative performance of the cathode material. The second portion of the seminar will address the possibility of modifying the synthesis of coatings on spinel particles used for protecting against dissolution by the electrolyte. The aim of this research is to reduce the synthesis time for the cathode material while taking advantage of preferred segregation of certain cations to the surface.

Speaker Bio:
Arturo Gutiérrez Jr. is a Materials Science and Engineering (MSE) PhD candidate at The University of Texas at Austin. He received his B.S. (2006) in MSE with a concentration in chemistry and biology from Boise State University. As an Undergraduate Research Assistant, his projects included the fabrication of turbine components for a Brayton Cycle Heat Engine made of Low-Temperature Co-fired Ceramic (LTCC) and characterizing the thermo-mechanical behavior of LTCC. Arturo has been a Teaching Assistant (TA) for a Materials Processing Lab during his first two years at UT and currently works as a Research Assistant under the guidance of Professor Alejandro Marín. His research interests include clean energy, electrochemistry, and materials synthesis/characterization. He is the recipient of a National Science Foundation (NSF) IGERT Fellowship. His doctoral research is on synthesis and characterization of cathode materials for lithium ion batteries.
3 Sessions

• Material Advancements
• Safety and reliability of battery packs
• Large lithium-ion batteries
Understanding the Effects of Cationic and Anionic Substitutions to the Spinel Cathodes of Lithium-ion Batteries

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Introduction
Why spinel cathodes?
- Safety
- Abundance
- Fuel
- Less toxic
- Fast kinetics

Challenges
1. Manganese Disproportionation
   - Mn$^{4+}$ reduces to Mn$^{2+}$
   - Both mechanisms result in higher capacity fade
2. Jahn–Teller Dissorption
   - 

Objective
Previous research has shown that substitutions can improve the spinel cathode performance but at the expense of lower capacities due to the decreased manganese oxidation state. The objective of this work is to investigate the effects of these substitutions on the performance of spinel cathodes. The presence of Al, Mg, and Mn substitutions has been shown to improve the electrochemical performance of spinel cathodes. This study aims to further understand the impact of these substitutions on the performance of spinel cathodes.

Results
Evidence of fluorination

Cycling performance

Kinetics

Conclusions

Acknowledgments

Sponsors

Poster Session – AABC conference

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MÜNSTER

HITACHI

Fraunhofer
Dr. Spotnitz, Lithium-ion Cell Engineering Tutorial

- Owner of Battery Design Company
- Developer of mathematical models that simulate battery operation
- Tutorial
  - General aspects of lithium ion battery technology
  - Cell design
    - Energy vs. Power
    - Thermal design
    - Mechanical design
    - Performance Estimation
  - Pack design
    - Thermal
    - Electrical
    - Battery management system
    - Reliability
  - Abuse tolerance
- Cost
- Outlook
Professor Winters, High-Energy Batteries Tutorial

- Professor at the University of Münster
- Tutorial
  - How to make High Energy Batteries
  - Metallic lithium vs. anode material: Why?
  - From lithium metal to Li+ ion
  - High capacity anode materials based on Li+ ion insertion
  - High voltage cathode materials based on Li+ ion release
  - Which chemistries are worth it?
  - Lithium-sulfur
  - Metal-Air
  - Safety and the role of the SEI
Frankfurt facts:

- Financial and transportation center of Germany
- One of the world’s busiest airports
- Formerly the headquarters of U.S. Army in Germany
- Considered an “alpha world city” because of it is an international center in:
  - Finance
  - Commerce
  - Culture
  - Transport
  - Education
  - Tourism

ACHEMA Conference/Exhibition
- International Exhibition on chemical engineering, environmental protection, and biotechnology
- Close to 170,000 participants
- Technical seminars
- Business exhibitions
- Panel discussions
Sightseeing