

Final Report for Period: 03/2008 - 02/2009**Submitted on:** 03/24/2009**Principal Investigator:** Thadhani, Naresh N.**Award ID:** 0453293**Organization:** GA Tech Res Corp - GIT**Submitted By:****Title:**

REU Site: Structure-Property Correlations across Nano-, Micro-, and Macro Length Scales in Advanced Materials

Project Participants**Senior Personnel****Name:** Thadhani, Naresh**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Summers, Christopher**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Gokhale, Arun**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Milam, Valeria**Worked for more than 160 Hours:** Yes**Contribution to Project:****Post-doc****Graduate Student****Undergraduate Student****Name:** Ballowe, Charles**Worked for more than 160 Hours:** Yes**Contribution to Project:**

2006 REU student who participated in research in MSE at Georgia Tech

Name: Catalan, Christian**Worked for more than 160 Hours:** Yes**Contribution to Project:**

2006 REU student who participated in research in Chemistry at Georgia Tech

Name: Greer, Vaun**Worked for more than 160 Hours:** Yes**Contribution to Project:**

2006 REU student who participated in international research at University of Campinas in Sao Paulo, Brazil

Name: Young, MacField**Worked for more than 160 Hours:** Yes**Contribution to Project:**

2006 REU student who participated in international research at University of Campinas in Sao Paulo, Brazil

Name: Holzworth, Monta

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in research in MSE at Goegria Tech

Name: Jakus, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 and 2007 REU student who participated in research in Chemistry/MSE at Goegria Tech

Name: Lin, Joyce

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in international research at Nanyang Technological University, in Singapore

Name: Strong, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in international research at Nanyang Technological University, in Singapore

Name: Lippa, Nadine

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in research in MSE at Goegria Tech

Name: Parpart, Sonya

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in research in MSE at Goegria Tech

Name: Ryan, Steven

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in research in BME at Georgia Tech

Name: Soicher, Matthew

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in research in PTFE at Goergia Tech

Name: Winters, Ian

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 REU student who participated in research in PTFE at Goegria Tech

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Name: Blinn, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Rutgers School of Engineering
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Chawla, Vardaan

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 and 2007 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with support from faculty mentor's reserach project

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2006 2005
REU Funding: REU site award

Name: Dewey, Peter

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Johns Hopkins University
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Dunham, Simon

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2006 2005
REU Funding: REU site award

Name: Feng, Ping-Ping

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer international research experience project under mentorship of faculty at Nanyang Institute of Technology in Singapore, with NSF/INT travel support

Years of schooling completed: Sophomore

Home Institution: Other than Research Site
Home Institution if Other: Johns Hopkins University
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Gladin, Jonathon

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Wooddell, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: Virginia Polytechnic Institute
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Korenblit, Yair

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer international research experience project under mentorship of faculty at National Institute of Materials Science in Tsukuba, Japan, with NSF/INT travel support

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: University of Florida
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Lorang, David

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: McAuliffe, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Meininger, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Colorado School of Mines

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Milhans, Jacqueline

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Carnegie Mellon University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Patterson, Kristin

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Virginia Polytechnic University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Sears, Steven

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Arizona State University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Silver, Kathleen

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Tindall, Nathaniel

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other: Morehouse College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Walker, Jacques

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Norfolk State University

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU site award

Name: Williams, Erin

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 REU participant working on 8-week summer research project under mentorship of faculty at Georgia Tech with NSF/REU support

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Spelman College
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Dykhne, Timur

Worked for more than 160 Hours: Yes

Contribution to Project:

2005 and 2006 REU participant working on 8-week summer international research experience project under mentorship of faculty at Beijing Institute of Aeronautics and Astronautics, China, with NSF/INT travel support

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Rutgers University
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2006 2005
REU Funding: REU site award

Name: Bayerl, Dylan

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: University of Wisconsin - Eau Claire
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU site award

Name: Chait, Daniel

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: Ohio State University
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU site award

Name: Crane, Courtney

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: Emory University
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU site award

Name: Floyd, Niklas

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Virginia Tech

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: Giddens, Taylor

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: Jackson, Yasmin

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Other

Home Institution: Other than Research Site

Home Institution if Other: Alabama A & M

Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: Huang, Yanshu

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Rice University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: Huo, Yuchen

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: University of Florida

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: Larsen, Nicole

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: McDowell, Mathew

Worked for more than 160 Hours: Yes

Contribution to Project:

2006 and 2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007 2006

REU Funding: REU site award

Name: Murff, Rebecca

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: Nichols, Patricia

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: University of Pittsburgh

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU site award

Name: Lu, David

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU site award

Name: Sanborn, Graham

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Dr. Ready in GTRI

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: Springhill College
Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree
Fiscal year(s) REU Participant supported:
REU Funding: REU site award

Name: Strutzman, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Calvin College
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU site award

Name: Thompson, Karmethia

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: Bethune Cookman College
Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU site award

Name: Wang, Jackson

Worked for more than 160 Hours: Yes

Contribution to Project:

2007 REU student who participated in research at Georgia Tech

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: CalTech
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU site award

Name: Guthrie, James

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Alamgir in MSE

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Starostina, Ekaterina

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Garmestani in MSE

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Carnegie Mellon University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Campbell, Jenna

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Gole in Physics

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Jones, Keith

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Tsukruk in MSE

Years of schooling completed: Freshman

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Weber, Joel

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Basiri-Gharab in ME

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Weller, Alex

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Snyder in MSE

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Alfred University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Chen, Lawrence

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Shofner in TPFE

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Vanderbilt University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Rowland, Janessa

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Thadhani in MSE

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Morehouse College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Moskowitz, Jeremy

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Wong in MSE

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Cornell University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Mimberg, Kirsten

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Milam in MSE. Was supported by funding through Siemens Foundation Grant

Years of schooling completed: Sophomore

Home Institution: Other than Research Site
Home Institution if Other: Brooklyn College
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2008
REU Funding: REU site award

Name: Hankins, Nathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Marder in MSE

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Vanderbilt University
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2008
REU Funding: REU site award

Name: Tapp, Maeling

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU international research project with Professor Watson Loh, at the University of Compinas and Professor Milam in MSE at GT.

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: University of Maryland
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2008
REU Funding: REU site award

Name: Martinez, Karem

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Chris Summers in MSE and Dr. Brent Wagner in GTRI

Years of schooling completed: Freshman
Home Institution: Other than Research Site
Home Institution if Other: Univ of Puerto Rico
Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree
Fiscal year(s) REU Participant supported: 2008
REU Funding: REU site award

Name: Grout, Jarrett

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Yushin in MSE

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: New Mexico Tech
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2008
REU Funding: REU site award

Name: Uriate, Viktor

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Gall in MSE

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Florida International University

Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Schaikewitz, Mathew

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Neu in ME

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Yeshiva University

Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Brown, Steven

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Ferguson in ECE

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: University of Minnesota

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Name: Basilo, Joshuo

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on REU research project with Professor Singh in MSE

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU site award

Organizational Partners

Other Collaborators or Contacts

The project involved faculty mentors from various schools at the Georgia Institute of Technology as well as mentors at international research experience sites.

The Georgia Tech faculty mentors have included:

Meilin Liu
 Chris Summers, MSE
 John Holmes; AE
 Min Zhou; ME/MSE
 Steve Johnson; MSE/ME
 Roger Narayan; MSE
 Farrokh Mistree, ME
 Janet Allen, ME
 Naresh Thadhani, MSE
 Chris Summers, MSE
 Min Zhou, ME/MSE
 CP Wong; MSE
 Arun Gokhale, MSE
 Seth Marder; Chem/MSE
 Brent Carter, MSE
 Gang Bao, BME
 Robert Snyder, MSE
 Haskell Beckham, TF&E
 Ken Sandhage, MSE
 Jean-Luc Bredas, Chemistry
 Ken Gall, MSE
 Rosario Gerhardt, MSE
 Valeria Milam, MSE
 Satish Kumar, PTFE
 Richard Neu, ME
 Preet Singh, MSE
 Meisha Shofner, PTFE
 James Gole, Physics
 Ian Ferguson, ECE
 Vladimir Tsukruk, MSE
 Jud Ready, GTRI
 Hamid Garmestani, MSE
 Brent Wagner, GTRI
 Nazanin Gharab-Bassiri

The international sites include:

National Institute of Materials Science in Tsukuba, Japan
 Meikei High School, Tsukuba, Japan
 University of Tokyo, Japan
 Nanyang Technological University, Singapore
 Beijing Institute of Aeronautics and Astronautics, China
 Behang University, Beijing, China
 University of Campinas, Sao Paulo, Brazil

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

The REU+RET site at Georgia Tech has served to provide opportunities for talented undergraduate students and enthusiastic high school teachers to experience hands-on participation in research for 8-weeks during the summer. In 2008, a diverse group of 19 science, math, and engineering students were recruited from across the country, ensuring participation of women and minority groups, and those from predominantly undergraduate institutions. The site also included participation of 5 RET teachers, recruited from various high schools in the Atlanta area. The REU student and RET teacher participants were mentored by faculty from various schools in Science and Engineering at Georgia Tech.

The REU students and RET teachers worked on research projects and at the end of their term prepared a one-page report (attached) summarizing their work. They also made oral and/or poster presentations during the middle and the end-of-the term ceremony. Research training of REU students also included developing technical communications skills, being aware of ethical issues, and learning various tools/techniques of materials characterization. Weekly (Tuesday) lunch seminars were held in which two faculty mentors presented their materials related research work. Seminars on 'ethics, lab safety, and communications,' were also be presented. Each REU student was required to pass a lab safety test. Training in oral/poster presentation and report writing was provided by our communications expert, Dr. Lisa Rosenstein.

Social activities including group dinner, barbeque, movies, and visits to parks, were coordinated across campus, during which the REU participants from our program were able to interact with those from five other REU programs at Georgia Tech.

The RET teachers worked on research projects and developed experimental- or computer-based materials modules that they can incorporate in the quality core curriculum in their respective schools, or even develop partial or complete elective courses in materials chemistry or physics, for advanced high school seniors. They worked closely with a faculty mentor and were involved in the research activities of the group. They assisted in set-up of experiments, collection of data, microstructural characterization, mechanical testing, or calculations. In this way, they were able to contribute to ongoing research and at the same time become familiar with materials science and engineering. The tasks and the themes of their research projects were such that they demonstrate that materials research is full of challenging and difficult problems, and that many critical technologies and engineering systems of the future are dependent on advances in materials. The main expectations for the teachers was that they develop an educational module (based on their research experience) that they can take back and introduce in their science/math curriculum in their respective schools.

The REU and RET participants were also involved in tours of laboratories and facilities on campus, and field-trips at companies in the Atlanta area.

Findings: (See PDF version submitted by PI at the end of the report)

The findings of the activities for the 2008 program are included as summary reports compiled by the REU student and RET teacher participants. These are included in the attached file.

The project activities from all past years are available online at:

http://www.mse.gatech.edu/Research/SURF_Program/surf_program.html

Training and Development:

REU students working on a given project were able to obtain a broad perspective of materials science and engineering related research activities, gain an experience of working in a team environment, and at the same time contribute to ongoing research. RET teachers were also involved in research, and they were able to use their experience to develop materials-based modules and take those back to their schools and incorporate it in their curriculum.

Outreach Activities:

Our interest and objective for the Research Experience for Teachers program is to develop 'partnerships' with teachers at schools in the Atlanta area. With these partnerships, we have been able to contribute to their literacy in materials science and engineering and through them generate the awareness amongst students that a career in materials science can be fun and rewarding. We hope that participation of teachers in research will enable the teachers to develop and implement inquiry-based modules that can be exciting and challenging to their students. Our 'partnership' with teachers is also geared towards providing them an enriching and confidence-building research experience. Our goal is to assist the teachers in incorporating modules in developing a 'Materials Science and Technology' course in the high school curriculum.

Journal Publications

W. Lee, J. Limb, J.-H. Ryou, D. Yoo, M.A. Ewing, Y. Korenblit, and R.D. Dupuis, "Nitride-based green light-emitting diodes with various p-type layers", IEEE J. Display Technology, p. 126, vol. 3, (2007). Published,

S.G. Lee, A.M. Gokhale, J.L. Milhans, "Reconstruction, Visualization, and characterization of Three-Dimensional Microstructure of High-Pressure Die-Cast AE44 Magnesium Alloy", Transactions of American Foundry Society, p. , vol. , (2007). Accepted,

Z.Q. Jin, C. Rockett, J.P. Liu, and K. Hokamoto, N.N. Thadhani, "Underwater Explosive Shock Consolidation of Nanocomposite Pr₂Fe₁₄B/ α -Fe Magnetic Powders", Materials Transactions, Japanese Institute of Materials, p. 1, vol. 46(2), (2005). Published,

Campbell, J; Corno, JA; Larsen, N; Gole, JL, "Development of porous-silicon-based active microfilters", JOURNAL OF THE ELECTROCHEMICAL SOCIETY, p. D128, vol. 155, (2008). Published, 10.1149/1.28118

Kepple, KL; Sanborn, GP; Lacasse, PA; Gruenberg, KM; Ready, WJ, "Improved fracture toughness of carbon fiber composite functionalized with multi walled carbon nanotubes", CARBON, p. 2026, vol. 46, (2008). Published, 10.1016/j.carbon.2008.08.01

Kang, ZT; Arnold, B; Summers, CJ; Wagner, BK, "Synthesis of silicon quantum dot buried SiO_x films with controlled luminescent properties for solid-state lighting", NANOTECHNOLOGY, p. 4477, vol. 17, (2006). Published, 10.1088/0957-4484/17/17/03

Graugnard, E; Chawla, V; Lorang, D; Summers, CJ, "High filling fraction gallium phosphide inverse opals by atomic layer deposition", APPLIED PHYSICS LETTERS, p. , vol. 89, (2006). Published, 10.1063/1.238787

Graugnard, E; Gaillot, DP; Dunham, SN; Neff, CW; Yamashita, T; Summers, CJ, "Photonic band tuning in two-dimensional photonic crystal slab waveguides by atomic layer deposition", APPLIED PHYSICS LETTERS, p. , vol. 89, (2006). Published, 10.1063/1.236023

N. Floyd, C. A. Weeks, V. R. Behrani, P.M. Singh, "Corrosion of Chromized and Aluminized Carbon Steel Samples in Alkaline Solution", Corrosion, p. , vol. , (2008). Submitted,

J. Milhans, A. Strutzman, H. Garmestani, "Elasto-plastic properties of Sealant Materials using high Temp Micro-hardness analysis", Fuel Cell Science and Technology, p. , vol. , (2008). Submitted,

M. McDowell, A. Leach, K. Gall, "Plastic deformation of pentagonal silver nanowires: Comparison between AFM nanoindentation and atomistic simulations", Physical Review B, p. , vol. , (2008). Accepted,

A. Leach, M. McDowell, K. Gall, "Bending and tensile deformation of metallic nanowires", Modelling Simul. Mater.Sci & Eng, p. , vol. , (2008). Accepted,

S.G. Lee, A.M. Gokhale, J.L. Milhans, "Reconstruction, Visualization, and characterization of Three-Dimensional Microstructure of High-Pressure Die-Cast AE44 Magnesium Alloy", Transactions of American Foundry Society, p. 719, vol. 114, (2006). Published,

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://www.mse.gatech.edu/Research/SURF_Program/surf_program.html

Description:

The web site provides a detailed description of how the program was advertised. It also includes a listing of the 2005 REU participants and provides their 1-page research project summary. Archives of previous years programs (1999-2004) are also included on this website

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Human Resource Development:

For the 2008 year, the REU program involved the participation of 19 REU students and 5 RET teachers in research experience with 18 faculty

from 8 schools/units at Georgia Tech, from May 28 to July 23, 2008.

Participants this year are involved in research experience with faculty in Chemistry, Physics, ECE, PTFE, ME, and MSE. The SURF fellows, including three minority and six female students, were selected out of a pool of more than 100 applicants. The overall group comes from 12 different institutions around the country including Alfred Univ (1), Cornell Univ (1), Carnegie Mellon (1), Georgia Tech (5), Spring Hill College (1), Vanderbilt Univ (2), Spellman College (1), Brooklyn College (1), Univ. of Minnesota (1), Univ of Puerto Rico (1), Florida International Univ (1), Yeshiva Univ (1), Univ of Maryland (1) and New Mexico Tech(1).

Of these institutions, four are PUI (Primarily Undergraduate Institute) and one are HBCU (Historically Black College or University).

The majors represented include Biomedical Engineering, Chemistry, General Engineering, Electrical Eng, Physics, ME, and MSE. The average GPA of this class is 3.7.

The 5 RET (GIFT) participants, including two minority and three female teachers, are teachers in chemistry, physics and mathematics in local area high schools.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners

Any Book

Any Product

Contributions: To Any within Discipline

Contributions: To Any Other Disciplines

Contributions: To Any Resources for Research and Education

Contributions: To Any Beyond Science and Engineering

SUMMARY OF ACCOMPLISHMENTS FROM PRIOR NSF REU AND RET PROGRAMS

P.I.s: **Naresh Thadhani (PI/PD), Arun Gokhale(co-PI), Chris Summers(co-PI), Valeria Milam(co-PI)**
 Title: [I]“Summer Undergraduate Research Fellowship” NSF/REU Site; Grant No. DMR-9820349, \$165,000; May 1, ‘99 to April 30, ‘02; Research Experiences for Teachers (RET): \$37,000-FY01, \$55,000-FY02.
 [II]“REU+RET Site: Structure Property Correlations across Micro to Nano Length Scales,” Grant No. DMR-0139081, \$435,000; Feb 01, 2002 to Jan 31, 2005
 [III] “REU+RET Site: Structure Property Correlations across Micro to Nano Length Scales in Advanced Materials,” Grant No. DMR-0453293, \$624,000; Mar 01, 2005 to Feb 28, 2009

The REU Site at Georgia Tech

The REU Site at Georgia Tech has been run as a **Summer Undergraduate Research Fellowship (REU-SURF)** program, for undergraduate students majoring in science and engineering to experience hands-on participation in research in the multi-disciplinary field of Materials Science and Engineering. The research projects have focussed under the broad umbrella of “*Structure-Property Correlation across Length Scales.*” In its **three** terms [I] 1999-2001, [II] 2002-04, and [III] 2005-08, it has involved the participation of **169 students (53 female, 40 minority, 115 non-GT)** representing **15 majors** from **61 institutions** (including **21 predominantly minority or undergraduate universities** and **40 research institutions**). The average GPA of the students entering the program has been **3.61**, and about **two-thirds** of the students have either already entered, or are planning to enter graduate school. A total of **40 faculty** from **8 different schools in the Colleges of Science and Engineering** at Georgia Tech have been involved in mentoring the students. The REU students worked on a one-to-one basis with their faculty mentors while interacting with post-doctoral fellows and graduate students. In order to ensure close interactions amongst the students (and also with RET teacher participants), they attended weekly research seminars presented by faculty mentors. Seminars on “ethics in research,” “technical communications” and “preparation for graduate school”, were also presented. Field trips at different on-campus laboratories and companies in Atlanta, including Lockheed-Martin, Southwire Industries, Universal Alloys, Panoz Automobiles, and the Fox Theater, were also organized in addition to other social activities. **Nine REU students (3 in 2005, 5 in 2006, and 1 in 2008)** also participated in *International Research Experience* at institutions in Southeast Asia and Brazil. Each year the program concluded with all REU students making an oral or poster presentation, and submitting a one-page research paper, copies of which are available online at: <http://www.mse.gatech.edu/research/surf/surf.html>. Demographics of REU program participants are listed in Table-I, followed by logistics information and outcomes (publications).

Table I – Demographic/statistical information about our past REU programs in Phase I, II, and III

REU YEAR	[I]:99-01 Average	[II]:02-04 Average	[III] 2005	[III] 2006	[III] 2007	[III] 2008	[III]:05-08 Average
# Total Applicants	56	100	85	102	78	132	104
*# Total REUs {#GT} (# Sen,Jun,Soph,Fresh)	14{5} (4,5,4,0)	18{5} (8,7,3,0)	19{6} (3,9,6,1)	17{8} (3,9,4,1)	18{6} (3,10,4,1)	19{5} (2,9,5,3)	18{6} (3,9,5,2)
# Majors	6	6	5	4	8	7	6
# Minorities	5	4	4	4	2	3	3
# Females	5	6	5	3	8	6	6
Average GPA	3.5	3.7	3.6	3.6	3.8	3.7	3.7
# already in Grad School or interested	9	14	9	11	15	10	12
Institutions Represented	9	13	12	9	13	14	12
# Faculty (Disciplines)	14 (5)	17 (5)	19 (6)	14(5)	18 (6)	18(6)	37 (6)
Stipend & Allowance	\$4,267	\$4,933	\$5,200	\$5,288	\$5,362	\$5,456	\$5,327

*No. of actual participants listed exceeds that included in our original budgets for each of three phases. Proposed numbers were 12/yr for 1999-2001, 15/yr for 2002-04, and 13/yr for 2005-08. *Additional REU participants were facilitated by Georgia Tech cost sharing and faculty grants.*

INSTITUTIONS REPRESENTED (*Universities representing Phase III participants):

Research Universities:

1. Alfred University, NY*

2. Arizona State, AZ*

3. Auburn University, AL
4. Brooklyn College, NY*
5. Cal Tech, CA*
6. Carnegie Mellon, PA*
7. Clemson University, SC
8. Colorado Sch of Mines*
9. Cornell Univ, NY*
10. Emory Univ, GA
11. Georgia Tech, GA*
12. Illinois Inst. Of Tech, IL
13. Iowa State Univ., IO*
14. Johns Hopkins Univ, MA*
15. Lehigh University, PA*
16. Mass. Inst. Of Tech, MA*
17. New Mexico Tech, NM*
18. Northwestern Univ., IL
19. Ohio State Univ., OH*
20. Rice University, TX*
21. Rutgers Univ, NJ*
22. So. Dak. Sch. M&T, SD
23. Univ. of Michigan, MI*

24. Univ. of Maryland, MD*
25. Univ. of Pittsburgh, PA*
26. Univ. of Tennessee, TN*
27. Univ. of Wisconsin, WI*
28. Univ of Rhode Island, RI*
29. Univ of Washington, WA
30. Univ. of Delaware, DE
31. Univ. of Minnesota, MN*
32. Univ. of NY, Buffalo, NY
33. Univ. of Rochester, NY
34. Univ. of Utah, UT*
35. Univ. of Missouri, Rolla
36. University of Florida, FL*
37. Virginia Tech, VA*
38. Washington State U.,
39. Yale University, CT*
40. Florida Intl. Univ., FL*

Minority/Undergrad Univ.

1. Agnes Scott College, GA
2. Alabama A&M, AL*

3. Bethune-Cookman U, FL
4. Cal State Poly Univ, CA
5. Calvin College, MI*
6. Clark Atlanta Univ, GA
7. Fort Valley State U., GA
8. Lafayette University, PA
9. Marquette University, WI*
10. Morehouse College, GA*
11. Norfolk Univ., VA*
12. Olin College of Eng., MA*
13. Univ of Puerto Rico, Mayaguez*
14. San Jose State Univ, CA
15. Southern University, LA
16. Spelman College, GA*
17. Spring Hill College, AL*
18. Univ. of Dayton, OH
19. Univ. of S. Florida, FL*
20. Xavier University, LA
21. Yeshiva Univ, NY*

STUDENTS' MAJORS REPRESENTED

1. Materials Science & Eng.	6. Civil Engineering	11. Computer Science
2. Mechanical Engineering	7. Chemical Engineering	12. Mathematics
3. Aerospace Engineering	8. Biology	13. Electrical Engineering
4. Ceramic Engineering	9. Chemistry	14. Biomedical Engineering
5. Metallurgical Eng.	10. Biochemistry	15. Applied Physics

PARTICIPATING FACULTY MENTORS (*Asterik marks faculty interested in participating in future SURF programs; Numeral marks faculty mentor participation in phase I, II, III; *Italicized* are no longer GT faculty)

1. *Alamgir, Faisal, MSE ^{III}	15. Kroger, Nils, Chem ^{III}	29. <i>Saxena, Ashok, MSE^{I,II}</i>
2. *Bao, Gang, BME ^{II}	16. Kumar, Satish, PTFE ^{II}	30. *Shofner, Meisha, PTFE ^{III}
3. *Bassiri-Gharb, Nazanin, ME ^{III}	17. Li, Mo, MSE ^{III}	31. *Singh, Preet, MSE ^{III}
4. *Beckham, Haskell, PTFE ^{I-III}	18. *Liu, Meilin, MSE ^{I-III}	32. *Snyder, Robert, MSE ^{III}
5. *Brédas, Jean-Luc, Chem ^{III}	19. <i>Lynch, Chris, ME^{I,II}</i>	33. Speyer, Robert, MSE ^{I,II}
6. <i>Cochran, Joe K, MSE^I</i>	20. *Milam, Valeria, MSE ^{III}	34. *Summers, Chris, MSE ^{I-III}
7. *Dupuis, Russell, ECE ^{III}	21. *Marder, Seth, Chem ^{III}	35. Tannenbaum, Rina, MSE ^{II,III}
8. *Ferguson, Ian, ECE ^{III}	22. <i>Marek, Miroslav, MSE^I</i>	36. *Thadhani, Naresh MSE ^{I-III}
9. *Gall, Ken, MSE ^{III}	23. <i>Narayan, Roger, MSE^{II}</i>	37. *Tsukruk, Vladimir, MSE ^{III}
10. *Garmestani, Hamid, MSE ^{II,III}	24. *Neu, Rick, ME ^{I-III}	38. *Wong, C.P., MSE ^{I-III}
11. *Gerhardt, Rosario, MSE ^{I-III}	25. *Ready, Jud, GTRI ^{III}	39. *Yushin, Gleb, MSE ^{III}
12. *Gokhale, Arun, MSE ^{I-III}	26. Sacks, Michael, MSE ^{I,II}	40. *Zhou, Min, ME ^{I-III}
13. *Gole, Jim, Physics ^{III}	27. Sandhage, Ken, MSE ^{II}	
14. <i>Hampikian, Janet, MSE^{I,II}</i>	28. Sanders, Thomas, MSE ^{I-III}	

GRADUATE RESEARCH FELLOWSHIP AND AWARDS WON BY PHASE III REU PARTICIPANTS

❖ Simon Dunham - NSF and NDSEG Graduate Research Fellowship	❖ Kristin Patterson, NSF Graduate Fellowship Honorable Mention
❖ Yair Korenblit and Jackie Milhans, Georgia Tech Graduate Boeing Fellowships	❖ Adam Jakus, Rebecca Murff, Sonya Parpart, GT Presidential Undergrad Research Awards
❖ Patricia Nichols, Dean's Fellowship through Arizona State Univ, School of Engineering	❖ Nicole Larsen (2007) and Jenna Campbell (2008), Recipients of Astronaut Scholarship, GT
❖ Karmethia Thompson, STEM Award at North Carolina State University	❖ Angela Stewart Gill "Pay It Forward" Scholarship
❖ Hanna Muchnik, NDSE&G Fellowship	❖ Adam Jakus, ASM Foundation Scholarship

PUBLICATIONS/PRESENTATIONS WITH REU CO-AUTHORS (in bold)

- Z.Q. Jin, J. Li, P. Liu, **C. Rockett**, Z.L. Wang, K. Hokamoto,* N.N. Thadhani*, "Fabrication of Bulk Nanocomposite Magnets by Explosive Shock Compaction," *J. Mater. Research*, 2005
- H. Choi, C. Seepersad, **H. Muchnik**, J. K. Allen, D.L. McDowell and F. Mistree, "Types III and IV robustness in the Design of Multifunctional Materials", *ASME DETC* 2005.
- **J. Campbell**, J. A. Corno, N. Larsen, and J. L. Gole, Development of Porous-Silicon-Based Active Microfilters, *Journal of the Electrochemical Society*, 155(2), D128-132 (2008).
- K.L. Kepple, **G.P. Sanborn**, K.M. Gruenberg, W.J. Ready, Improved Fracture Toughness of Carbon fiber Composite Functionalized with Multi Walled Carbon Nanotubes, *accepted for publ in Carbon*, '08
- **N. Floyd**, C. A. Weeks, V. R. Behrani, P.M. Singh, Corrosion of Chromized and Aluminized Carbon Steel Samples in Alkaline Solution, *Submitted to Corrosion*, 2008;
- **N. Floyd** and Preet M. Singh, Performance of Chromized and Aluminized Carbon Steel Samples in Alkaline Solution, *Poster Presented at Corrosion-2008*, New Orleans, March 2008;
- **J. Milhans**, A. Strutzman, H. Garmestani, Elasto-plastic properties of Sealant Materials using high Temp Micro-hardness analysis, *Submitted to Fuel Cell Science and Technology*;
- **J. Milhans**, A. Strutzman, H. Garmestani, Production of high yield Nano-Tube reinforced Composite Graphite composites using CVD assisten Spray pyrolysis, *to be submitted*, August 2008.
- **M. McDowell**, A. Leach, K. Gall, Plastic deformation of pentagonal silver nanowires: Comparison between AFM nanoindentation and atomistic simulations. *Physical Review B*. 2008.
- A. Leach, **M. McDowell**, K. Gall, "Bending and tensile deformation of metallic nanowires." *Modelling Simul. Mater.Sci & Eng.*,2008.
- V.T. Milam, **S. Parpart**, C.K. Tison 82nd *American Chem. Soc. Colloid & Surface Science* "The effects of mutations on assembly and disassembly of DNA-linked colloidal satellites" Raleigh, NC (June '08);
- V.T. Milam, **S. Parpart**, and C.K. Tison, 2007 *Fall Materials Research Society Meeting* "Colloidal Satellites as Optical Diagnostic Tools for Mutation Analysis," Boston, MA (December 2007);
- **S. Parpart**, C.K. Tison, and V.T. Milam, poster presentation at 2007 *Annual Biomedical Engineering Society Meeting*, "Effects of mutations on DNA as a biomaterials assembly tool," Los Angeles, CA (September 2007); **S. Parpart** - *Georgia Tech Student Travel Award for conference presentation*
- B. Baker, **R. Murff**, and V.T. Milam, poster presentation at 81st *American Chemical Society Colloid & Science Symposium* "Effects of particle additions on rheological properties of polyacrylate/polyacrylamide hydrogels," Wilmington, DE (June 2007);
- Z.T.Kang, **B.Arnold**, C.J.Summers,: B.K Wagner,,,"Synthesis of silicon quantum dot buried SiOx films with controlled luminescent properties for solid-state lighting," *Nanotechnology*, v 17, 2006, 4477-82;
- Z.T Kang, **B. Arnold**, C.J.Summers, B.K, Wagner, "Red luminescence from Si quantum dots embedded in SiOx films grown with controlled stoichiometry," *Proceedings of SPIE – The International Society for Optical Engineering*, v 5941, Fifth Int. Conference on Solid State Ligting, 2005, p 1-8
- E. Graugnard, **V. Chawla**, **D. Lorang**, and C.J. Summers, "High filling-fraction gallium phosphide inverse opals by atomic layer deposition," *Applied Physics Letters*, 89, 211102 (2006)
- S.G. Lee, A.M. Gokhale, **J.L. Milhans**, "Reconstruction, Visualization, and characterization of Three-Dimensional Microstructure of High-Pressure Die-Cast AE44 Magnesium Alloy," *Transactions of American Foundry Society*, Vol. 114, PP 719-729, 2006.
- W. Lee, J. Limb, J.-H. Ryou, M.A. Ewing, **Y. Korenblit**, and R.D. Dupuis, "Nitride-based green light-emitting diodes with various p-type layers," *IEEE J. Display Technology*, vol. 3, 2007, pp. 126-132.
- **J.L. Milhans**, S.G. Lee, and A.M. Gokhale: "Reconstruction, Visualization, and Characterization of Three-Dimensional Microstructure of High-Pressure Die-Cast AE44 Magnesium Alloy," *Symp. on Characterization of Materials*, TMS Annual Meeting, San Antonio, TX, (March 13-16, 2006).
- D. Yoo, J. Limb, Y. Zhang, A. Ewing, **Y. Korenblit**, S.-C. Shen, R.D. Dupuis, "Ultraviolet avalanche photodiodes grown on GaN substrates by metalorganic chemical vapor deposition," *WOCSEMMAD 2007 (43rd Annual Workshop on Compound Semiconductors, Savannah, GA (Feb 2007)*
- E. Graugnard, D.P. Gailliot, **S.N. Dunham**, C.W. Neff, **T. Yamashita** and C.J. Summers, "Photonic band tuning in 2D photonic crystals by atomic layer deposition" *Appl. Phys. Letts.*, 89, 181106 (2006)
- **A. Jakus**, A. Fredenburg, and N.N. Thadhani, Modeling and Simulation of Impact Response of Linear Cellular Alloys, poster presentation at *American Physical Society Annual Meeting*, March 2008.

Additionally, faculty mentors have 6 papers in preparation for submission to journals in 2008.

The RET Site at Georgia Tech

The Research Experiences for Teachers (RET) Program organized in conjunction with **Georgia Intern/Research Fellowships for Teachers (GIFT)** has involved the participation of **53 teachers (11 teachers in 2000-2001, 18 in 2002-2004, and 24 in 2005-2008)** from Atlanta Area High Schools, selected on the basis of their enthusiasm and interest in implementing inquiry, investigative, and problem solving approaches into their curriculum. About **40%** of these teachers came from inner-city schools with >97% minority population. The teacher participants worked closely with a faculty mentor and participated in the research activities of the group, e.g., assisting in set-up of experiments or data collection, microstructural characterization, or testing of mechanical or electrical properties, or running calculations with computer programs such as ABAQUS, AUTODYN, etc. In this way, they were able to contribute to on-going research, learn about the advancements in science and technology, and become familiarized with the field of materials science and engineering. They also interacted with the REU students and participated in group meeting, seminars, and field trips. A total of **11 RET teachers (5 in 2003-04 and 6 in 2005-08)** also participated in International Research Experience along with the REU student participants at institutions in Southeast Asia. The main goal and our expectation of the contributions made by the teachers, however, was geared towards their developing educational modules (based on the research experience) to take back to their schools and implement in their math, physics, or chemistry curriculum. As part of their participation in the RET program, the teachers received a \$625 weekly stipend, 10 SDU credits for the 8-week research term, and a \$700 allowance to purchase equipment and/or supplies for building their modules. Similar to the REU program, each teacher participant made an oral/poster presentation, and submitted a one-page paper describing their research and educational module. A list of participants and reports of their research and module are available online at: <http://www.mse.gatech.edu/research/GIFT/gift.html>.

REU AND RET SITE PROGRAM EVALUATION/ASSESSMENT

Evaluation of the **REU** program was performed through exit questionnaires to obtain input for continuous improvement of research projects, logistics, and meeting of goals. Responses obtained from exit questionnaires for each of the four years (05, 06, 07, and 08), illustrated by average scores shown below (1 = strongly disagree, 5 = strongly agree), revealed that our goals in terms of fulfilling student expectations, providing a learning research experience, contributions to research, fruitful interactions with faculty mentor, and increasing interest towards graduate school, are being met to various degrees.

- *REU program fulfilled my expectation as undergraduate researcher:* **05-4.2; 06-4.4; 07-4.6; 08-4.3**
- *Real learning experience to be involved in undergraduate research:* **05-4.4; 06-4.6; 07-4.7; 08-4.7**
- *Made significant contribution to ongoing research:* **05-3.8; 06-4.1; 07-3.9; 08-4.1**
- *Fruitful interactions with grad students, faculty and others:* **05-4.4; 06-4.0; 07-4.5; 08-4.2**
- *REU/SURF program increased my interest towards graduate school:* **05-4.4; 06-3.7; 07-4.3; 08-3.8**

Some of the positive comments made by REU participants have been “The REU program was “valuable,” “enriching,” “rewarding,” “enjoyable,” and worthwhile,” experience, “very well planned and executed,” and “positive force in my life.” It provided “the opportunity to use advanced equipment to perform experiments,” “a graduate student’s perspective of academia,” “ability to work synergistically with other researchers,” “opportunity to work in a diverse group of researchers with people from different parts of the world,” and “the knowledge of how research is done and how data is analyzed,” being able to do lab work without the pressure of exams.” It “furthered my knowledge of areas I had previously not explored,” “helped dispel misconceptions of research work,” “showed that research can be alternately frustrating and interesting, and tedious and exciting, and “research doesn’t always give the same outcome as one would predict.” Making oral presentations “injected more confidence for achieving career objectives and professional goals.” Most importantly they were able to “develop a resolve for continuing to be involved in research,” “build an experience that will make them more attractive candidates and better prepared for graduate school,” and “learn about new career opportunities available with a Ph.D.,” The evaluations also reveal how seriously the students view the opportunity of being involved in research, the importance they associate with their contributions to research, and the fact that research experience is valuable even if their future interests or plans can lie beyond research and academic careers. With the diversity of the participants, also comes the diversity of interests in social and extra-curricular activities, which makes it necessary to be prepared for continuous improvement of the program.

A follow-up survey of former REU students from 2005-2007 was also recently conducted, with a similar questionnaire. While the response rate was about 40%, **two-thirds of whom are currently in graduate school**, the overall evaluation and comments appear consistent with those obtained from the exit questionnaire, as illustrated below.

- *REU program fulfilled my expectation as undergraduate researcher: 4.4*
- *REU/SURF program increased my interest towards graduate school: 4.3*
- *REU program increased my interest towards a career in research: 4.4*

Their comments in terms of the overall benefit of participation in the REU/SURF program include, “I discovered the love of research and am currently working in research,” “my experience inspired me to continue to pursue undergraduate research throughout my college year,” “the experience has proven extremely valuable since I entered grad school,” “the experience helped me grow into a better engineer, researcher, and businessman,” “the program has been the primary reason for me working towards a PhD and being awarded both the NSF and NDSE&G fellowships,” “it was beneficial to observe how different research groups function so that I have a better idea of the type of group (size, atmosphere, post-docs etc) to look for in my graduate studies that will best suit my personal learning and working style.

A survey of the faculty mentors of past REU participants was also conducted, with 18 of 21 faculty responding to the questions stated below, providing an update on published work or anticipated publications with students as co-authors, and interest in continued participation.

- *Involvement of REU/SURF students has been beneficial to my research program: 4.7*
- *Past REU/SURF student(s) met my expectations as undergraduate researchers: 4.5*
- *I was able to maintain direct interaction at least once a week with my student(s): 4.25*
- *I will be interested in continuing to participate as a REU/SURF mentor: 4.8*

In addition to programmatic suggestions, a re-sounding theme that the faculty mentors expressed was “my graduate students enjoyed the opportunity to teach and mentor REU/SURF students about their research,” which extends the impact of the NSF REU/SURF program by benefiting graduate students.

The **RET program** has helped us establish a liaison and partnership with teachers from inner city, minority, suburban, and magnet schools in the Atlanta area. The teachers have expressed comments stating that the RET program provided them “a better insight into what their students will need to be successful in college.” It gave them “a hands-on experience to share with their class,” “a good sense of how to make exciting laboratory experiments,” “a new career option to present to their students,” and “a better idea of cutting-edge research.” It also showed them ways to “demonstrate the relevance of physics, chemistry, and mathematics in technology,” and “describe abstract concepts in a *quantitative* manner.” Most importantly it “raised their literacy level in science” and “earned them the respect and confidence of students and peers.” Our goal is to continue our partnership with teachers and provide a research experience that they can **share** with their students and the community, and **generate an awareness** of the “role of materials” in future technological challenges, and the “fun” associated with materials science.

Participation of REU students in the **International Research Experience** program has allowed them to gain an understanding of the research culture and philosophy of baccalaureate and higher education in East Asia and Brazil. The research projects were designed in a manner that allowed promotion of collaborations between faculty from both sides, while ensuring benefits for each participant. The REU students have gained a “sense of being involved in a research group having different cultural and social behaviors and the importance of communication in such an environment.” The RET teacher participants have become knowledgeable with the culture of baccalaureate education in East Asian countries and a realization of being “immersed” in a place with language barriers and cultural differences. Their experience has helped them be better prepared for interacting with students of diverse backgrounds in their own classrooms.

In-Situ X-ray Characterization of Nanowires

Alex Weller, Georgia Institute of Technology, SURF 2008 Fellow

Advisor: Dr. Robert Snyder, Mentor: Melanie Kirkham

Introduction:

Much research has taken place in recent years in the synthesis of ZnO nanowires (NWs) due to their unique electronic and optical properties that make them excellent candidates for the use in nano devices such as nanogenerators, LEDs, gas sensors and biosensors. Additionally, the electronic and optical properties of ZnO NWs can be finely tuned through the use of dopants.¹ Most often, however, research has centered on common synthesis techniques that require either high temperatures, dangerous gases, or the use of an extrinsic catalyst such as Au nanoparticles which makes the synthesis of ZnO NWs impractical or too expensive for many applications. An alternative method for ZnO NW synthesis is to simply heat micron sized Zn particles to around 500°C at 30°/min in air at ambient pressure. The relatively low temperature and highly pure starting materials make this a promising method for the synthesis of ZnO NWs. This paper reports the results of in-situ HTXRD of the grown ZnO NWs and suggests a possible method for the incorporation of dopants.

Procedure:

Zn powder with particle sizes in the tens of microns were placed flat on a corundum plate and heated in an Aton Paar 1200 HTK furnace open to air attached to a X'Pert Pro MPD diffractometer with a Cu source, parabolic mirror and X'Celerator line detector. After alignments, samples were characterized in-situ from 25 to 135° 2 θ with a step size of 0.02° 2 θ and time per step of 20 seconds. A baseline scan was performed at RT, and further scans were carried out at 500°C and again at RT. The existence of NWs was confirmed using SEM.

In order to confirm that the ZnO signal was due to the growth of the NWs and not due to the oxide layer on the starting Zn particles, a series of measurements were taken on a X'Pert Pro Alpha-1 diffractometer with a diffracted beam monochromator and similar settings as on the MPD. Size/Strain analysis from peak broadening was performed and instrumental broadening was accounted for using a NIST LaB6 SRM 660a standard which is known to exhibit no peak broadening due to size/strain effects.

For the S doping experiments, S powder was placed next to the ZnO NW in an enclosed MgO container and heated to 575°C in air. After processing, samples were characterized on a X'Pert Pro MRD diffractometer with a Cu source and parallel beam optics. After performing alignments, scans were taken from 30 to 33 degrees 2 θ with a step size of 0.02 and a time per step of 20 seconds.

Results/Discussion:

Figure 1 shows a typical HTXRD plot of scans taken at RT and 500C from the grown ZnO NWs. The appearance of a peak at about 31.7° 2 θ shows the formation of the ZnO phase.

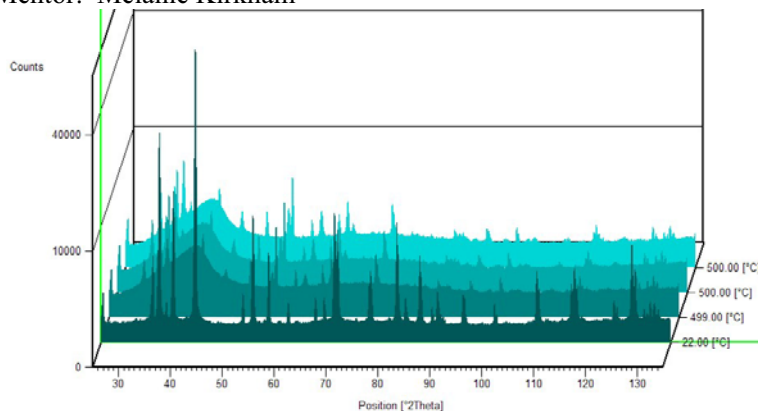


Figure 1: 3D XRD plot of in-situ ZnO NWs

Figure 2 shows an overlay of XRD patterns taken from ZnO NW and S doped ZnO NW. The use of parallel beam optics eliminates 2 θ shift due to sample height displacement. Therefore, the shift in 2 θ peak location of about 0.1° is a result of the substitution of S, which has a slightly larger ionic radius than O, into the wurtzite lattice structure. In future studies, photoluminescence could be used to confirm the successful doping of S by showing that the electronic structure of the NWs is changed.¹

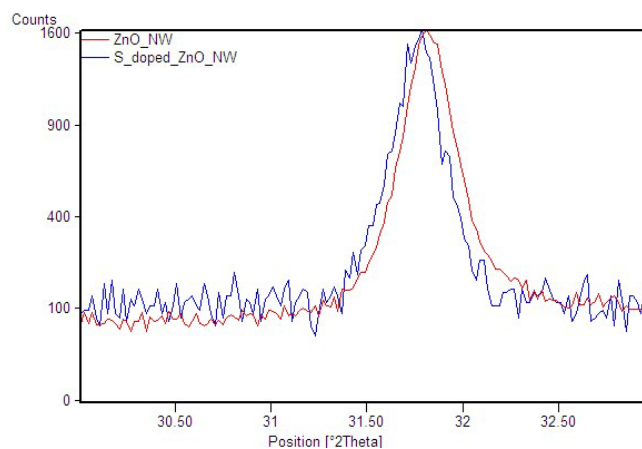


Figure 2: XRD patterns showing ZnO NW compared to S doped ZnO NW

References:

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Acknowledgements:

I would like to thank Dr. Robert Snyder and Dr. Z. L. Wang for allowing me to work with their research groups. Additionally, the following people helped me out tremendously with my research: Melanie Kirkham, Phil Graham and Dr. Jung-Il Hong.

Deposition of Multiwalled Carbon Nanotubes on Carbon Graphites

Ekaterina Starostina, Materials Science and Engineering, Carnegie Mellon University
SURF 2008 Fellow, Georgia Tech, Mentors: Dr. Garmestani and Dr. Dahmen

Introduction:

Since the discovery of multiwalled carbon nanotubes (MWCNTs) in 1991, there has been an increased interest in their properties and applications. MWCNTs consist of a central tube of nanometric diameter surrounded by graphitic layers separated by $\sim 0.34\text{nm}$. Some of their outstanding properties include great ductility, high aspect ratio, high tensile strength, and low mass density. They also have a large surface area, versatile electronic behavior, high heat conductivity, and a sufficiently low cost. In order to take advantage of these exceptional qualities, it is necessary to use them in composites.

Carbon-Carbon (C-C) composites are also known for their superior mechanical properties, which are high strength and modulus, high thermal capacity, stable frictional and wear properties, and an excellent ablation resistance at elevated temperature in inert atmosphere. There are many applications for them, such as use as re-entry parts of space vehicles, rocket nozzles and lining parts of missiles, aircraft brake discs, fission reactor, high power accelerator, sports instruments, electronic components, and medical uses.

However, there are drawbacks of the currently produced C-C composites: they oxidize readily at temperatures between 600-700°C, especially in the presence of atomic oxygen. The objective of this study is to improve the qualities of current C-C composites by creating a process that produces new C-C composites through deposition of MWCNTs on graphite structures.

Procedure:

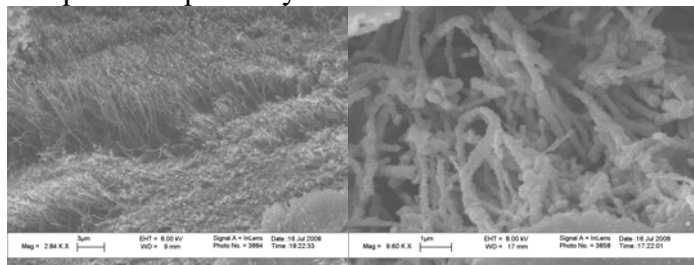
MWCNTs were synthesized by Chemical Vapor Deposition. In this process, metal catalyst Ferrocene was dissolved in liquid hydrocarbon source Xylene to form a feed solution, which was dispersed into a stream of carrier gases Hydrogen and Helium. The feed solution was introduced directly into the reactor, therefore volatilizing the solution. Aligned carbon nanotubes were then grown on the substrate.

Once MWCNTs were produced, C-C composite was made through Chemical Vapor Infiltration. It is a densification technique in which the structure to be densified is placed in a flow of

methane and the assembly is raised to 950°C. The pyrolytic carbon obtained by decomposition of methane is deposited in part in voids within the carbon-nanotubes porous structure, thereby filling said voids. To evaluate the samples, pictures from SEM and TEM were taken and carefully analyzed.

Results and Discussion:

SEM pictures of MWCNTs and C-C composite respectfully are shown below.



The figure on the left shows that the produced MWCNTs are aligned well together and have a great directional structure. The figure on the right shows the build-up on the nanotubes. It is clear that the desired densification consisting of carbon graphites onto MWCNTs has occurred. Since we were able to repeat the experiment and duplicate the results, we have a reliable process of making C-C composites.

Conclusion:

While we were able to achieve the desired structure of C-C composite, it is necessary to make thick sheets of the same structure and examine mechanical behavior and properties of the new composition. Much work needs to be accomplished to explore what this material can endure and what limitations it has. When the material has been tested, its applications can be explored.

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Piezoelectric Nanogenerator Fabric using Carbon Nanotubes

Graham Sanborn, Spring Hill College, Mobile, AL, Georgia Tech SURF 2008 Fellow

Faculty Advisors: Dr. Jud Ready and Dr. David Stollberg, Georgia Tech Research Institute

Introduction

The current world energy crisis has caused great interest in new and improved technologies to produce and store energy. Energy harvesting is one way to store energy by capturing thermal, kinetic, or electric energy that is already present in our environment. This method includes harvesting wind, solar, thermal, and even excess mechanical energy. Mechanical movement can be stored by using piezoelectric materials such as ZnO. Due to their crystalline structure, piezoelectric materials can produce a small electric current when they are mechanically deformed, or inversely, they can deform when a current is passed through them.

An effective piezoelectric generator must have a bristled or textured surface that will deform from small movements. To implement this design, a flexible piezoelectric fabric can be made using two pieces of carbon fiber (CF) that have been coated with carbon nanotubes (CNT) and sandwiched together (Figure 1). The CNT can then be coated with ZnO, creating a bristled piezoelectric surface. In this design, the bottom ZnO coated layer is the piezoelectric and the top gold coated layer deforms the ZnO when moved. The mechanical deformation of the ZnO creates a small voltage on each CNT and the conductive gold coating on the top layer forms a Schottky barrier, thus limiting current to flow to only one direction. CNT are optimal for this design because they have good adhesion to CF and a high aspect ratio which allows for maximum deformation of the ZnO.

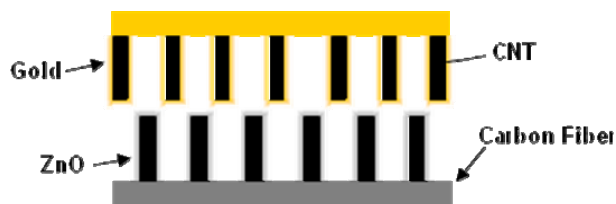


Figure 1: Design of the piezoelectric nanogenerator fabric.

Procedure

Woven CF sheets were cut into 4" square pieces and deposited with an iron catalyst about 4 nm thick using a thermal evaporator. Then the CF was placed in a chemical vapor deposition (CVD) furnace where it was heated to 820°C while various hydrocarbon gases flowed over the sample, thus growing the CNTs. The coating of ZnO or gold was applied using RF sputtering and electron beam evaporation. The coatings and CNT growth was characterized using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Electronic testing on the fabric was performed to determine the material's resistivity.

Results and Discussion

Based on the SEM images in Figure 2, CNT growth and ZnO deposition are homogeneous and complete. The good CNT growth can be attributed to good penetration of the hydrocarbon gases in the CVD through small holes in the fabric. In Figure 3, the TEM image of a single CNT coated with ZnO shows an even 1-2nm coating of ZnO. Analysis of a TEM electron diffraction pattern of the deposition layer in Figure 3 confirms that the coating is made of ZnO and that there are preferred orientations in its crystalline structure. Preferred orientations are necessary in the ZnO for there to be a net flow of electrons. Testing resistance in the gold coated layer revealed a very low resistance ($<1 \Omega$) which is necessary for the Schottky barrier. The ZnO coated layer has a significant resistance of 20-80 Ω . This result is expected and confirms complete deposition of the piezoelectric.

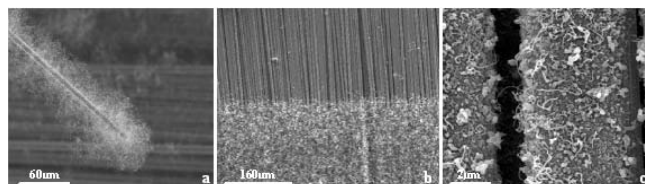


Figure 2: SEM images of (a) a single strand of CF functionalized with CNT, (b) a woven CF surface where growth is inhibited on the top, and (c) ZnO deposition on CNT/CF surface.

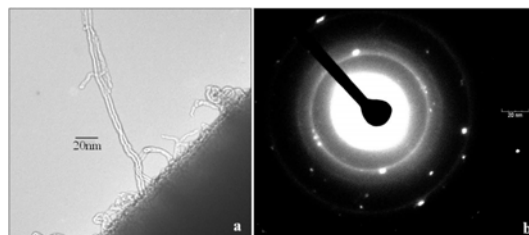


Figure 3: (a) TEM image of a coated CNT attached to a carbon fiber, (b) TEM electron diffraction pattern of the coating on the CNT in (a).

Future Work

Since complete deposition and preferred orientation of ZnO has been confirmed, the research will progress to more characterization and testing of the fabric design. Adhesion of the ZnO and gold coatings from different deposition techniques needs to be analyzed to determine which has the best adhesion. Also, the crystal orientation of the ZnO will be determined for each deposition technique so that the method that produces the fewest preferred orientations can be found. Finally, highly sensitive electrical equipment will need to be purchased in order to test the voltage output of the piezoelectric material and optimize its design.

Monolayer Deposition of Ag and Te on Polycrystalline Gold via Cyclic Voltammetry and Galvanic Replacement

James Guthrie, Georgia Institute of Technology, SURF 2008
Advisor: Faisal Alamgir

Introduction

The ultimate goal of this research is for the analysis of core-shell catalyst systems for the purpose of understanding the causes of their increased catalytic effects and resistance to CO poisoning, a phenomenon found in the literature [1] but not, as yet, fully understood or explored. However, before the final analysis can be conducted, it is necessary to first develop sound methods of creating these core-shell bi-metallic catalyst structures, leading to the current step of the overall research: creating swift and efficient methods for monolayer deposition of one catalytically-relevant metal onto another. A very precise method of monolayer deposition is found in cyclic voltammetry (CV) via underpotential deposition [2], a voltage limited method of deposition for which, through coulomb counting back-calculation, the precise amount of a deposited material can be calculated [3, 4]. The largest issue with CV, however, is that it only applies to certain systems of substrate and depositing material and thus hasn't the desired versatility for research into the plethora of catalytic bi-metallic systems. The end solution found in this research was a combination of CV and galvanic replacement, a method in which a more noble metal will replace a less noble, by introducing the electrodeposited, low-nobility monolayer into a solution of more noble metal ions. This allows for the precision of CV with the added versatility of galvanic replacement by use of a sacrificial layer of atoms.

Procedure

CV was conducted using a Solartron SI 1287 potentiostat, a custom-designed three-lead cell, a home made Ag/Ag₂SO₄ reference electrode, a polycrystalline Au substrate polished down to 0.05 micron roughness, and solutions of 1 mM Ag₂SO₄ in 50 mM H₂SO₄ and 0.4 mM TeO₂ in 50 mM H₂SO₄. After the deposition of Te onto Au, the resulting bi-metallic system was immersed in a 10 mM Ag₂SO₄ solution to allow for the galvanic replacement of Te by Ag. Verification of thicknesses and composition of deposited layers will be conducted via ARXPS and AFM, and galvanic replacement verified through EDS and XPS.

Results and Discussion

Preliminary scans were taken simply to characterize polycrystalline Au in 50 mM H₂SO₄ and bulk deposition of Ag onto polycrystalline Au

(Fig 1), primarily to familiarize oneself with CV and get a reference of where the UPD peaks might be and where to scan in order to avoid the oxidation and reduction of Au or the bulk deposition of Ag, both of which could interfere with the UPD deposition or stripping.

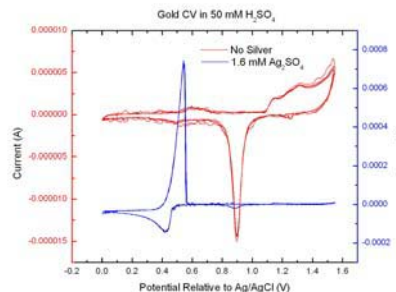


Figure 1: Au reference data (red) and bulk deposition and stripping of Ag on Au (blue) at 5 mV/s vs a Ag/Ag₂SO₄ reference electrode.

After scanning at the bulk deposition level, we attempted to find the location of the UPD peaks for Ag on Au. Two peaks were found, one at ~0.47 V and the other closer to ~0.51 V (fig 2). The coulomb charge density associated with the scan was 509 $\mu\text{C}/\text{cm}^2$. Using the back calculations, it appears that ~2.3 monolayers had been deposited in this scan. Simply by tweaking the ending voltage up, it was possible to get depositions as low as 1.03 monolayers, well within our range of need of 0.75-1.5 monolayers.

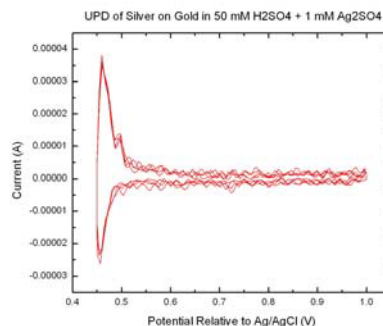


Figure 2: The UPD deposition and stripping peaks of Ag on Au at 5 mV/s vs a Ag/Ag₂SO₄ reference electrode.

Following the success with Ag deposition, characterization was begun on Te deposition on polycrystalline Au. Bulk deposition was not greatly looked into, as Te has a rate of deposition of about

0.5 monolayers/min, even in bulk deposition, and the bulk deposition peaks greatly coincide with hydrogen evolution. The UPD peaks were found and analysis begun to find the optimal voltage for depositing ~1 monolayer (fig 3). After this deposition, the sample was placed in a Ag_2SO_4 solution, to allow for galvanic replacement of Te by Ag. The ensuing sample has not yet been characterized, but will be in the following weeks. Crude verification was performed with a 36 hour bulk deposition scan and subsequent immersion, which resulted in a slight color change of the bulk deposit, letting one know that some method of replacement is occurring.

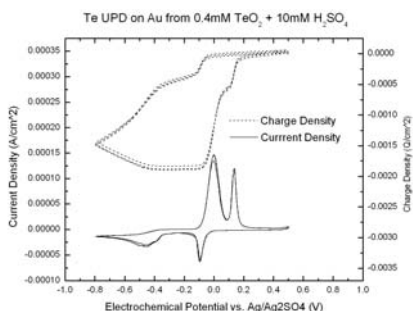


Figure 3: Te UPD on polycrystalline Au at 5 mV/s vs a $\text{Ag}/\text{Ag}_2\text{SO}_4$ reference electrode, the charge and current densities shown on the upper graph and the current shown on the lower graph, all vs. voltage.

Conclusion

Conclusions can not, as yet, be entirely determined due to the repair status of the SEM and XPS systems we have access to. The CV data, however, points to the deposition of ~1 monolayer of Ag and Te in each case, which leads one to believe this method to be a viable solution to the need for a method of bi-metallic system construction, assuming the theory of galvanic replacement holds up, an assumption which will be verified or negated in the upcoming weeks.

Acknowledgements

I would like to give many thanks to Dr. Faisal Alamgir for the plethora of advice given and the free use of his lab. Great thanks also goes to Robert Rettew, for putting up with me for the duration of the program and for always offering a guiding hand in life, research, or necessary cinema.

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Isothermal Titration Calorimetry Study of Ligand/Metal Oxide Nanoparticle Interactions

Nathan Hankins Mentor: Peter Hotchkiss Advisor: Seth Marder

Introduction

Isothermal titration calorimetry (ITC) has already proven a powerful tool for use in the investigation of the thermodynamics of molecular interactions. Its direct measurement of the global heat of reaction allows users to determine the enthalpy of reaction (ΔH_r), binding constant (K_b), and stoichiometry (N) within a single experiment – and it is the only machine capable of doing so. Because of this versatility, ITC was used to study the binding energies between barium titanate (BT) nanoparticles and ligands of varying binding groups such as phosphonic acids, carboxylic acids, and silanes in order to gain insight into the binding energy hierarchy of these molecular complexes.

Experimental

The ligands under study were octylphosphonic acid (OPA), octadecylphosphonic acid (ODPA), benzenephosphonic acid (phenylPA), trimethoxy(octyl)silane (OTMS), and nonanoic acid. Each ligand was injected at 30mM, except ODPA (at 5mM), into 8.0mg/ml BT (1.4mg/ml for ODPA), with all sets of solutions having 95:5 EtOH/H₂O as a buffer. The ITC run was set for 29 injections of 10 μ l ligand aliquots at 298K using the VP-ITC machinery and package from MicroCal. BET measurements of BT were performed with Krypton in order to obtain the surface area of the used nanoparticles. Finally, thermogravimetric analysis (TGA) was done to arrive at actual grafting densities between the ligands and BT nanoparticles.

Results and Discussion

Table 1 shows the results of the ITC and TGA runs for each ligand-BT combination.

Ligand on BT	ΔH (kcal/mole)	TGA (% Δ wt.)
OPA	-10.54	8.20
ODPA	-18.28	16.92
PhenylPA	-5.74	4.71
Nonanoic	-	-
Silane	-	-

Table 1. Enthalpy of reaction and TGA %weight loss measurements. OTMS and nonanoic acid showed no binding.

As can be seen, ODPA had the highest heat release during the binding reaction followed by OPA and then phenylPA. However, to compute the binding energy (D), one uses equation (1) that was derived by Ferreira *et al.*

$$\Delta H_r = -D - (\Delta H_{sol} + \Delta H_{cat}) - (E_s - E_{SAM}) \quad (1)$$

With some simplifications (see Ferreira *et al.*) equation (1) becomes

$$\Delta H_r = -D - \Delta H_{sol} - 11.56 \quad (2)$$

which is measured in kJ/mole. Here, ΔH_r is the total heat measured from the ITC and ΔH_{sol} is the heat of solvation for the ligand. Again, ΔH_{sol} values from Ferreira *et al.* were used for OPA and ODPA to estimate D in this study while phenylPA's ΔH_{sol} was estimated via extrapolation of the trend between carbon number and enthalpy as found in Ferreira *et al.* The resulting D values are found in Table 2.

Ligand in THF	ΔH_{sol} (kJ/mole)	D (kJ/mole)
OPA	-48.17	80.71
ODPA	-73.25	138.17
PhenylPA	-43.11	55.57

Table 2. ΔH_{sol} and resulting D values as computed from equation (2).

From these D values it is apparent that ODPA had the highest binding energy, then OPA, and finally phenylPA. This is expected as all phosphonic acids bind readily to metal oxide surfaces, but an increasing alkyl chain length helps make binding more favorable as a result of the stabilizing van der Waals forces. Finally, the BET surface area that was obtained was 19.02 m²/g.

Conclusion

ITC results and computations from equation (2) showed that ODPA had the strongest binding interaction with the BT nanoparticles, followed by OPA and then phenylPA. As discussed above, this trend is not surprising as more stabilizing forces can interact with longer alkyl chains. Carboxylic acids and silanes did not bind at all under the conditions used in this work, which further supports FTIR evidence found by Kim *et al.*

Acknowledgements

I would like to thank Seth Marder and Peter Hotchkiss for taking time out of their busy schedules to teach me so much with this research. Also, Phil Kim provided invaluable advice and support throughout my stay. Finally, I am indebted to Nick Hud and his lab for the use of their VP-ITC and knowledge thereof.

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Shock Compaction of Textured Permanent Magnets

Janessa Rowland, Georgia Tech, SURF 2008 Fellow

Faculty Advisor: Dr. Naresh Thadani Graduate Mentor: Chris Wernhberg

Introduction

Naval ships today are run on fuel and chemicals, which take up space to store and can be potentially dangerous. Electromagnetic powered ships will cut down the cost, maintenance and storage space needed compared to the use of chemicals and fuel. While magnets are used everyday to generate electricity, the energy these magnets supply is not strong enough for massive power generation. Textured Nanostructured Permanent Magnets have the potential for providing high energy product that is needed for naval applications. The objective of this present study is to investigate texture generation during shock compaction of $\text{Pr}_2\text{Fe}_{14}\text{B}$ nanostructured powder.

Procedure

Approximately five grams of $\text{Pr}_2\text{Fe}_{14}\text{B}$ nanostructured powder was placed into a three layer sieve, the smallest particles being less than 20 μm and the largest greater than 40 μm . The sieve was then placed in an ultra sonic cleaner that separated the powder into three different sizes, small (<20 μm), medium (20- 44 μm) and large (>44 μm) particles. From the smallest and largest particle powders, pellets were formed using a hydraulic pressing machine. The pellets were then mounted onto copper rods and impacted onto a rigid steel anvil at speeds of 50 – 500 m/s using 7.62 mm diameter helium gas gun. The impacted samples were then characterized for degree of compaction and texture.

Results and Discussion

Two pellets composed of particles 40 μm and larger were shot in the helium gas gun, one at 135 m/s and the other at 180 m/s. Two pellets composed of particles 20 μm and smaller were shot at 90 m/s and 135 m/s. The pellet shot at 90

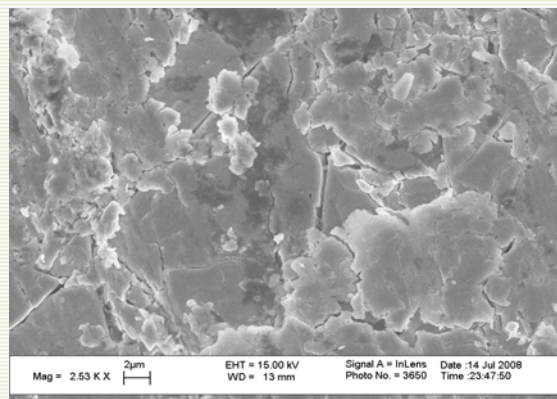


Figure 1. 2.53KX magnification of sample (40 μm > particles) shot at 180 m/s

m/s did not compact at all. The pellets shot at 135 m/s compacted and in some areas began to plastically deform. There was more bond breakage the deformation. Figure one shows the pellet shot at 180 m/s compacted. The sample was plastically deformed in more areas than the previous shots. While it was believed that when the samples plastically deformed the particles would align themselves in the magnetic plane of 0, 0, C, in all the samples we tested none of them showed strong indication of alignment in the magnetic plane. Future test would have to be performed.

Conclusion

Through shock compaction, the minimum speed range to successfully compact the nanostructured powder was discovered to be between 90m/s and 135m/s. The samples also showed through SEM bond breakage and plastic deformation. There was however not a strong indication of particles realigning in the magnetic plane of 0,0,C. More tests would need to be performed.

Shock Compaction of Textured Nanostructured Permanent Magnets

Janessa Rowland, Georgia Tech, SURF 2008 Fellow

Faculty Advisor: Dr. Naresh Thadhani Graduate Mentor; Chris Wernhberg

Introduction

Naval ships today are run on fuel and chemicals, which take up space to store and can be potentially dangerous. Electromagnetic powered ships will cut down the cost, maintenance and storage space needed compared to the use of chemicals and fuel. While magnets are used everyday to generate electricity, the energy these magnets supply is not strong enough for massive power generation. Textured Nanostructured Permanent Magnets have the potential for providing high energy product that is needed for naval applications. The objective of this present study is to investigate texture generation during shock compaction of $\text{Pr}_2\text{Fe}_{14}\text{B}$ nanostructured powder.

Procedure

Approximately five grams of $\text{Pr}_2\text{Fe}_{14}\text{B}$ nanostructured powder was placed into a three layer sieve, the smallest particles being less than $20\text{ }\mu\text{m}$ and the largest greater than $44\text{ }\mu\text{m}$. The sieve was then placed in an ultra sonic shaker that separated the powder into three different sizes, small ($<20\text{ }\mu\text{m}$), medium ($20\text{--}44\text{ }\mu\text{m}$) and large ($>44\text{ }\mu\text{m}$) particles. From the smallest and largest particle powders, pellets were formed using a hydraulic pressing machine. The pellets were then mounted onto copper rods and impacted onto a rigid steel anvil at speeds of $50\text{--}500\text{ m/s}$ using 7.62 mm diameter helium gas gun. The impacted samples were then characterized for degree of compaction and texture via x-ray diffraction

Results and Discussion

Sample 1	Fine Powder	90 m/s
Sample 2	Fine Powder	135 m/s
Sample 3	Corse Powder	135 m/s
Sample 4	Corse Powder	180 m/s

Table 1.

The samples that were shot are listed in Table 1. according to the powder size and impact speed. The pellet shot at 90 m/s did not compact at all.

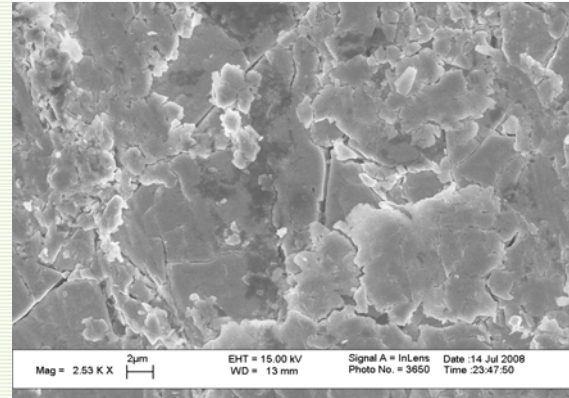


Figure 1. 2.53KX magnification of sample ($40\text{ }\mu\text{m}$ particles) shot at 180 m/s

The pellets shot at 135 m/s compacted and in some areas began to plastically deform. There was more fracture and limited deformation. Figure 1. shows the pellet shot at 180 m/s compacted. The sample was plastically deformed in more areas than in the previous shots. While it was expected that when the sample plastically deformed the particles would align themselves in the $0,0,C$ magnetic plane direction, the results from x-ray diffraction were inconclusive. Further evidence will require texture measurements. Additional tests would have to be performed under high impact conditions.

Conclusion

The minimum impact speed range to successfully compact the nanostructured powder was found to be between 90 m/s and 135 m/s . The samples also showed evidence of inter-particle bonding, plastic deformation, and intra-particle fracture increasing with impact velocity. There was only limited particle alignment observed in the shock compacted magnet. Further characterization of $0,0,C$ texture needs to be performed.

Acknowledgements

I would like to thank Dr. Thadhani for allowing me to work in his lab and all the graduate students in the lab who helped me this summer especially Chris Wernhberg.

Introduction

A unique property of porous silicon is its ability to photoluminesce. When placed under ultraviolet light, porous silicon that has been electrochemically etched in a varying number of electrolytic solutions will photoluminesce giving off a red-orange glow when excited by UV light as the photoluminescence is strong. The photoluminescent qualities of porous silicon can be utilized to create electroluminescence. Plating the wafer and a portion of the porous silicon with a conductive metal, such as gold, platinum or copper, and then running a current through the wafer will encourage the silicon to electroluminesce. Previous research resulted in a 10^{-5} percent quantum yield.¹ If the resistivity of the porous silicon surface itself is too high the electroless coating techniques being introduced can provide a considerable improvement to the system.

By successfully converting the photoluminescence to electroluminescence an innovative photocatalyst can be developed which can greatly influence the field of chemistry.

Procedure

Silicon wafers are cleaned using 49% HF to remove the oxides from the surface and trichloroethylene to strip the organics off of the substrate. Boron doped, p-type polished silicon wafers with a resistivity range from 1-20 Ω -cm are the substrates used to create the porous structures. Hybrid and aqueous electrolytic solutions generate photoluminescent porous silicon. Silicon etches for 30-60 minutes with a low current density (2.75 mA/cm^2), is rinsed with methanol after the etch and is left to dry.

Electroless gold or copper metallizing baths are deposited on the substrate as shown below in Figure 1.² With low resistance contacts attached to the Si, the coated wafer is then attached to a power supply through which a current is sent, and electroluminescence is ideal.

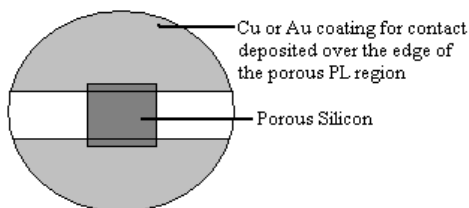


Figure 1: Si wafer schematic

Results and Discussion

For the most successful electroluminescence time was spent configuring ideal etching conditions to get a highly photoluminescent etch. Judging by the naked eye, silicon etched in an aqueous electrolytic solution consisting of 49% HF and methanol at a volumetric ratio of 1:3 respectively luminances red-orange visible light when exposed to UV rays. After etching, the Si is cleaned with MeOH to remove

HF residue. The MeOH does not affect the luminescence of the silicon once it dries.

The next step was to find a metallizing bath to coat the edges of the porous silicon to lower the resistance of the system. The first coating was an HF-based copper metallizing bath that produces thin Cu deposits in minutes. After directly removing the porous structure from the Cu solution and attaching it to the power supply, the Cu oxidizes, and the sample becomes unusable.³ To avoid rapid oxidation, a bright electroless gold metallizing bath from Transene Company, Inc. was used to plate the silicon substrates. The Transene Au solution takes hours to plate, and it was difficult to coat the proper areas of the silicon wafer (as seen in Figure 1) without interfering with the porous structure. The most successful plating techniques came from an unpublished method created by Dr. M. Schlesinger. By sending the Si substrate through a series of baths and rinses, a Cu coating was successfully deposited. This series of baths, now proven successful, is the basis for an electroless gold coating that should be ideal for the system.

Conclusion

Ultimately, the system will consist of an aqueous etch with gold plating since the thin copper coatings are not very effective due to their rapid oxidation rates. If the resistivity of the system remains too high after the coatings are worked into the system, then work will need to be done in developing low resistance contacts for the system. Laying gold nanowires across the silicon to lower the resistivity of the porous silicon surface and facilitate photoluminescent site excitation is another way the resistance of the system can be lowered if the gold plating is not effective enough.

Acknowledgements

I would like to thank Dr. James Gole for giving me the opportunity to work in his lab and for his guidance throughout this project, Serdar Ozdemir for the advice he provided, and Dr. Mordechai Schlesinger for sharing his plating techniques and being ever ready to help us when we ran into problems. I would also like to thank the coordinators of the SURF 2008 program for making the program such a fun experience and allowing me to participate and NSF.

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1. N. Koshida and H. Koyama, Appl. Phys. Lett. 1991, 60 (3), 347-349.
2. M. Schlesinger and M. Paunovic, Modern Electroplating. Fourth Ed. 2000.
3. S. G. dos Santos Filho, A. Pasa and C. Hasenack, Microelectronic Eng. 1997, 33, 149-155.

Introduction: In recent years, the use of tin/lead (Sn/Pb) solder in semiconductor materials has become a major concern. Due to the toxicity of lead and government regulations in other countries, research has been focused on formulating a substitute with comparable properties. Lead is not only harmful, but difficult to recycle in semiconductors and has a short life span of 2-3 years. Remarkable advancements have been made towards removing lead from the electronics industry.

Electrically conductive adhesives (ECAs) are one promising alternative to tin/lead solder. They are advantageous because they are environmentally friendly, have mild processing conditions, require few processing steps which reduces cost, and they can also achieve very fine pitch. However, in contrast to tin/lead solder, ECAs have lesser electrical conductivity as well as conductivity fatigue. Before going into industry, their adhesion strength and current-carrying-capability also need to be improved. The objective of this research is to study the mechanisms of using both sintering and surfactants in order to investigate their uses in ECAs.

Experimental: Samples of nano-ECAs were prepared using an epoxy resin consisting of bisphenol-A, hardener, and a catalyst. Silver flakes and silver nano-particles were used as conductive fillers. The total percentage of silver in the mixture was 80% weight.

The samples were cured at 150°C for one hour and then annealed to 180°C for 10-min, 30-min, 60-min respectively, or even further annealed at 200°C for 60-min. Bulk resistivity and contact resistance were measured according to previous methods.^{1,2}

Results and Discussion: The bulk resistivity of nano-ECAs is shown in Fig. 1. The bulk resistivity decreases dramatically after annealing at 180°C for 10 minutes. The cross-sections of nano-ECAs were shown in Fig. 2. Annealing at 180°C for longer time (30 minutes and 60 minutes) can further reduce the resistivity.

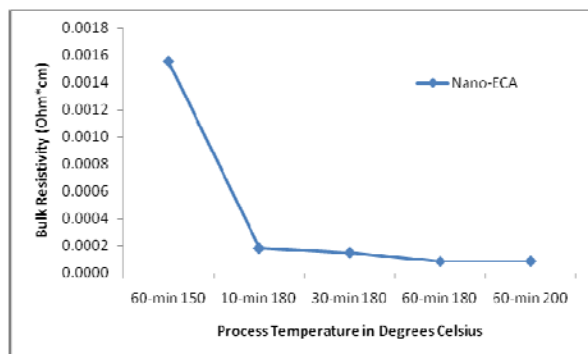


Figure 1. Bulk resistivity for different curing processes

This proves that sintering can occur in short periods of time, thus annealing silver nano-particles and reducing surface contact points. Further annealing at 200°C does not increase the conductivity much.

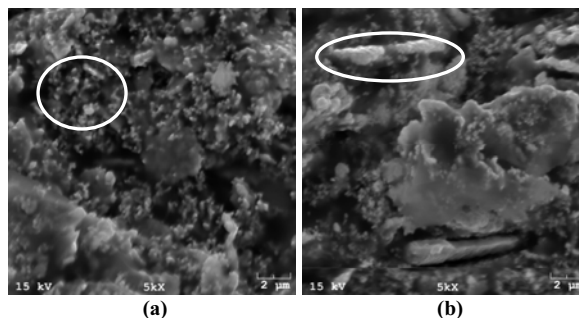


Figure 2. SEM images of cross-section of nano-ECAs (a) cured at 150°C for 60-min (b) annealed at 180°C for 10-min.

The contact resistance of nano-ECA with acid is lower than that without acid and both show stable contact resistance on gold during 85°C and 85% relative humidity (RH) aging for about 600 hours (Fig. 3).

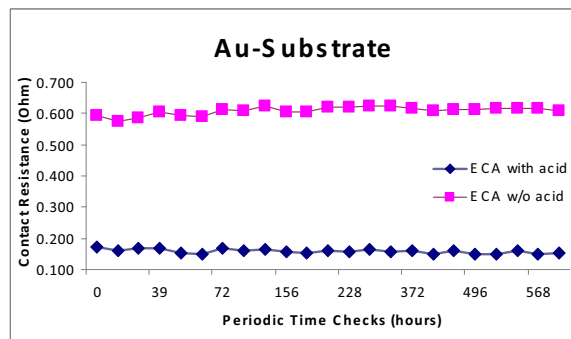


Figure 3. Contact resistance on Au-substrate under 85°C/85% RH aging

Conclusions: With introduction of sintering of silver nano-particles, the electrical properties of ECA can be significantly improved. Moreover, the formulated nano-ECA showed stable contact resistance on Au. The superior electrical conductivity of nano-ECAs will enable the application of nano-ECAs in fine pitch and high performance interconnects in microelectronics.

Acknowledgements: I would like to thank Dr. C. P. Wong for allowing me to use space in his lab and for providing me this experience; Rongwei Zhang for spending time teaching me and being a superb mentor; my program coordinators Drs. Thadini, Gokhale, Summers, and Milam; Ms. White for her assistance; and my program sponsors: the National Science Foundation and Georgia Institute of Technology.

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Nanomaterials for Carbon Monofluoride (Li/CFx) Primary Batteries

Jarret Grout, Georgia Tech, SURF 2008 Fellow

Faculty Advisor: Gleb Yushin

Mentor: Alexandre Magasinski

Introduction:

Primary batteries cannot be recharged after use. Their high energy to mass ratio makes them favorable for applications in aerospace, military, and aviation. Batteries are constructed of two main parts: an anode and a cathode. During discharge, electrons flow from the anode, through the device being powered, and to the cathode. Lithium, having a high energy to mass ratio, has been the anode material of choice, but problems have been encountered finding a cathode material that has a high energy to mass ratio.

Carbon monofluoride, CF_x, has the highest theoretical specific capacity of any cathode material, 864 mAh/g. The difficulty with using CF_x is that the material is an electronic insulator, and thus is unable to discharge fully at high discharge rates. Recent advances in production technique allow for CF_x powders to be produced on the nano-scale with increased surface activity. This study aims to use chemical vapor deposition (CVD) techniques to coat CF_x particles with a conductive, carbon layer (Figure 1) that will increase electronic properties on the surface of the particles. The effects of the carbon coatings and reduction in particle size will be compared to increases in performance.

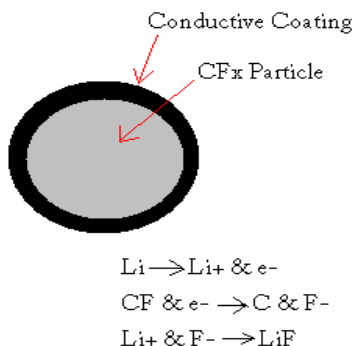


Figure 1: CF_x with carbon coating

Experimental Procedure:

Carbon was deposited on CF_x powder through a decomposition of acetonitrile. Argon gas was bubbled through a tube containing acetonitrile, carrying the vapors to a decomposition chamber. The decomposition product continued to a deposition chamber, where it was deposited on CF_x powders. Temperatures of the decomposition and deposition chambers were varied, as well as the length of time that acetonitrile was deposited. Cathodes were tape cast on 17 micrometer, conductively coated copper foil, and used 5 wt% KF Polymer binder. Standard 2016 button-cell batteries were pressed, and the samples were tested at a variety of discharge rates. Micron-scale 1000 grade and nano-scale 2065 grade CF_x powders were used.

Results and Discussion:

When batteries made with standard micron grade CF_x were discharged at rates varying between, a direct correlation between discharge rate and specific capacity was observed. The use of CVD carbon on the samples was found to increase the capacity at higher discharge rates. It is believed that deposited carbon adhered to the surfaces of the CF_x particles and effectively increased the conductivity of the particles. Because the rate of reaction, and ultimately the capacity of the battery, is dependant on the ability of the particles to react with the surroundings, the carbon acted to enhance the kinetics around the particle. Similarly, when 2065 CF_x with a carbon coating was tested, the specific capacity was higher than that of CF_x.

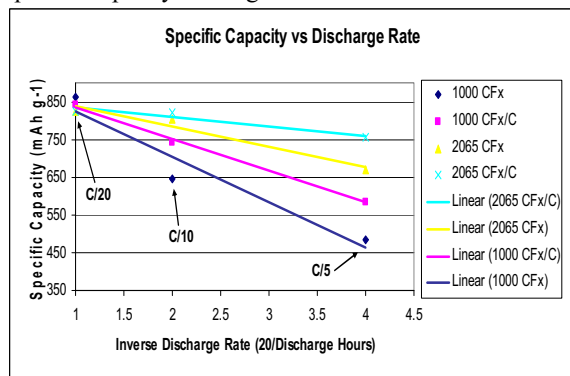


Figure 2: Effects of coatings on specific capacity

The size of the powder also played a role in the overall specific capacity of the batteries, especially at elevated discharge rates. When discharged at an elevated rate, batteries made from 2065 grade CF_x performed 39% longer than the 1000 grade equivalent. When coated with carbon, both of the samples increased in specific capacity, but the 2065 grade discharged with a 29% higher specific capacity than the 1000 grade equivalent (Figure 2). It is understood that the higher surface area of the 2065 grade powder may have allowed for better interactions with the surrounding electrolyte. Because the electronically insulating CF_x may have hindered interactions of atoms at some parts of the particles, slower discharge rates would be required to obtain similar results for 1000 and 2065 grade powders, as was the result.

Conclusions:

The decomposition of acetonitrile was used to deposit carbon coatings on the surface of CF_x particles. Increased specific capacity was measured for carbon coated samples of both 1000 and 2065 grade powders, especially at higher discharge rates. Particle size was also measured to have an inverse affect on the specific capacity.

Development and Analysis of Lead Zirconium Titanate (PZT) based Ferroelectrics

Joel Weber, Georgia Institute of Technology, SURF 2008 Fellow

Faculty Advisor : Dr. Nazanin Bassiri-Gharb Mentor : Ashley Bernal

Introduction

Ferroelectric crystals are able to exhibit a spontaneous dielectric polarization switchable among multiple directions through the application of an electric field. This, in turn, results in the formation of a hysteresis loop comparing dielectric polarization versus electric field. This hysteretic effect can be utilized for memory functions, such as ferroelectric RAM, by switching between different polarized states. In addition, all ferroelectrics exhibit piezoelectric and pyroelectric properties. The former of these is the ability of the crystal to generate an electric potential in response to a mechanical stress, or change shape due to the presence of an electric field. Pyroelectricity is the ability of the crystal to modify its spontaneous dielectric dipole in response to a changing temperature. Both of these properties make ferroelectrics essential for ultrasounds, infrared cameras, and a multitude of other microelectronic applications.

Many of these applications require accurate, reliable ferroelectric properties. This can be difficult to achieve during production as the ferroelectric effect depends on the orientation of the unit cells within the crystalline lattice (anisotropy). Defects can also affect movement of the domain walls within the crystal. These, in turn, affect the polarization magnitude under an applied electric field. Lead Zirconium Titanate (PZT) exhibits a very large dielectric constant near its morphotropic phase boundary giving it excellent ferroelectric properties. For this reason, it is the ferroelectric ceramic of choice for many applications, hence its selection for this work. The objective of the research is to develop and analyze ceramic thin films of varying thickness with consistent ferroelectric properties using PZT.

Procedure

To create the ferroelectric crystals, platinized silicon wafers were deposited with $\text{Pb}(\text{Zr}_{0.52}\text{Ti}_{0.48})\text{O}_3$ (PZT 52/48). A spin coater was used to spin the PZT sol-gel precursor on the substrate. After each deposition, the sample was heat treated on a hot plate at 350°C for one minute. Upon completion of each set of two layers, the sample was inserted into a Rapid Thermal Processing Unit (RTPU) which used halogen lights to crystallize the deposited PZT at 700°C . Rapidly approaching this temperature sought to minimize the presence of the undesired non-ferroelectric pyrochlore phase while enhancing the presence of the ferroelectrically-active perovskite phase. Crystals with 2, 4, 6, 8 and 10 layers were created and then analyzed using an X'Pert Pro Alpha-1 x-ray diffraction machine. This unit tilted the crystals while bombarding them with alpha particles in a Θ - 2Θ scan mode, measuring the diffraction pattern for range of 2θ between 20° and 60° , allowing identification

of the crystallographic phase and prevalent crystallographic orientation.

Results and Discussion

Based on data from the x-ray diffraction, it can be seen that crystals deposited with 2, 4, 6, 8 and 10 layers of PZT exhibited intensity peaks at the same 2θ angles despite having differences in thickness. From this, it can be deduced that the average response of the films will not be affected by the anisotropy of the PZT crystal itself, as the average orientation of the films is invariant for the range of thicknesses studied.

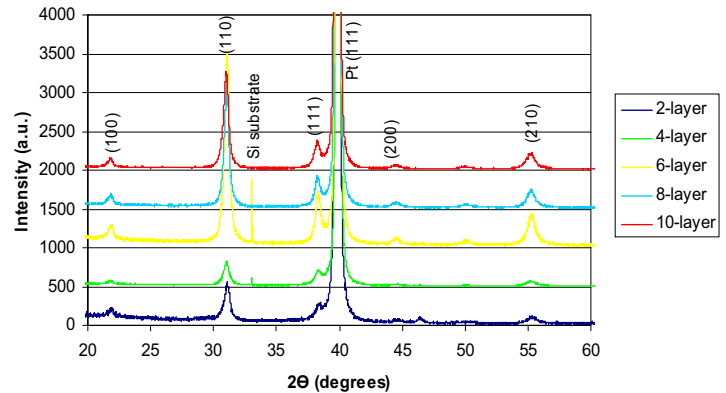


Figure 1. X-ray analysis of the PZT films. The data is normalized to the 6 layer platinum intensity at $2\theta = 40^\circ$.

Unfortunately, during the course of the research the equipment necessary for analyzing the electrical characteristics of the ferroelectrics became damaged and unusable. Because of this, the P-E hysteresis loop is available only for the 10-layer thick films.

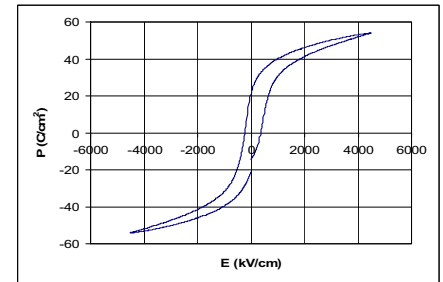


Figure 2. P-E hysteresis loop for 10-layer film.

Conclusion

The data from the x-ray diffraction is promising but remains inconclusive. It appears that the crystalline structures were consistent samples of increasing thickness. This research will be continued over the course of the next year. Future research plans include measurement of dielectric polarization versus electric field hysteresis loops, capacitance-electric field, and capacitance versus AC field frequency in order to determine how thickness can affect these properties. Another thrust will be made for deposition of these ferroelectric films on magnetically active substrate (modified GaN and GaAs) in order to create artificial/composite multiferroic materials.

Nano-Sized Light Emitters for Gamma Ray Detectors

Karem Martinez and Eugenio De Hbyos, *Georgia Tech, SURF 2008*

Advisors: Dr. Chris Summers, Dr. Brent Wagner, and Dr. Zhi tao Kang

Introduction

Scintillators, materials that absorb and reemit photons, are used in radiation detectors to transform high energy radiation into low energy rays.

Current materials for this application are expensive and inefficient. Germanium has good properties at extremely low temperatures. Sodium iodide works at ambient temperatures, but large defect-free crystals must be made, and it is susceptible to water.

Composites, particularly quantum dots (QD) in transparent matrices, offer a potential alternative. Particles smaller than 10 to 20 nanometers undergo a quantum effect that permits scintillation. Their emission and absorption frequencies can be tuned by controlling their size, making them versatile.

Several criteria must be met by the components of such a composite. The QDs should not absorb the light that they produce, and they should contain heavy atoms to stop gamma rays. A high concentration is also desired. The matrix is ideally transparent to the incoming radiation and the scintillation light.

The objective of the present study is to synthesize and purify CdTe QDs, and then introduce them into a methyl methacrylate (MMA) matrix. The effects of synthesis parameters will be studied, and the preparation method will be improved to make it practical to use in future studies. The synthesis will be verified using optical studies. The reliability of computer simulations of a sodium iodide detector will be tested.

Experimental Procedure

CdTe QDs are synthesized by combining two precursors [1]. The tellurium precursor is made by reacting sodium

borohydride, tellurium powder, and water in a nitrogen atmosphere. The cadmium precursor is made by mixing cadmium perchlorate with mercaptopropionic acid and then raising its pH. The precursors are mixed in an inert atmosphere and then heated. The amount of heating controls the growth of the nanoparticles.

To purify QDs, propanol is added to the solution, and then it is centrifuged, decanted, and dried with nitrogen.

To polymerize QDs, a surfactant is diluted in MMA or styrene. This is mixed with a water solution of QDs. Upon separation, the monomer retains the QDs. An initiator is used to cure using heat.

Optical testing consists of absorption and photoluminescence measurements performed on different spectrometers.

Simulation Procedure

The simulation is done in Monte Carlo N-Particle Transport Code (MCNP). A cylindrical model of a sodium iodide detector is specified. To analyze the accuracy of the simulation, the counts under the simulated deposition peaks are compared to experimental data. The experimental counts are measured using a mixed source of americium 241, cesium 137, and cobalt 60. Each of these sources is simulated independently.

Results

Lead and mercury were substituted for tellurium in this procedure without alteration, but synthesis failed. The amount of surfactant needed was tested. This amount varied with the ratio of quantum dot solution to polymer amount, but did not vary with the concentration of QDs. It was also found

References

- [1] H Zhang, Z Zhou, B Yang, J. Phys. Chem B 107 (2003).
- [2] W Yu, L Qu, W Guo, X Peng, Chem Mater. 15 (2003) 2854.

that the optimal temperature to polymerize MA is lower than for styrene.

The absorption and emission spectrums shifted to larger wavelngths in solutions that were heated for longer times. However, the trend is difficult to observe in small time differences. Figure 1 shows this shift for three samples that were heated for different times.

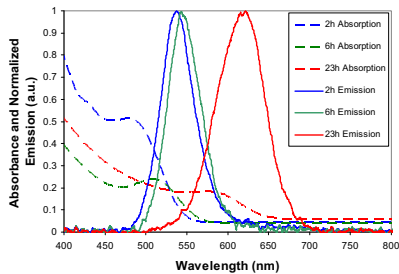


Figure 1. Absorption and emiission of 2, 6, and 23 hour samples of CdTe quant umdot water solutions before purifying.

The results of the computer simulation are summarized in table 1. Nbt e that there are two peaks for cobalt 60.

Table 1. MNP simulation results compared with experimental counts of various gamma ray sources.

	Peak Energy (keV)	Experiment a l Count (fraction)	Si mul ate d Count (fraction)	Count Ratio (si mul at ed/ exper imental)
Ameri ci um241	59.50	.244	.351	1.43
Cesi um137	661.65	.0477	.117	2.45
Cobalt 60	1173.22	.00310	.0252	8.11
	1332.49	.00299	.0235	7.84

Discussi on

As figure 1 shows, the frequency shifts are not obvious for short heating time differences because the heating temperature and rate were not well controlled. In other samples, not shown, higher times did not necessarily imply longer wavelngths. However, the trend is evident between longer time intervals, showing that QDs were effectively synt hesi zed, and that the frequencies shift with heating time.

The size of QDs can be calculated from their absorption peaks [2]. The samples shown in figure 1 correspond to 1.8, 2.6, and 3.5 nanometers, in order of increasing time.

The procedure used to prepare CdTe QDs was improved by reducing the number of steps required and by finding alternative methods to reduce the time needed to prepare a batch. This allows for a higher reproducibility of experiments as well as more productivity.

The ratios between simulation and experimental values are within one order of magnitude, which is an acceptable starting point. The code overestimates counts because it does not take into account all the mechanisms occurring during scintillation. Adjustments to the code will have to be made in the future to keep this discrepancy low

Concl usi on

QDs offer a versatile and viable alternative for radiation detectors. Their preparation is well controlled and understood. Work is needed in order to implement computer simulations.

The prepared samples need to be tested under gamma radiation instead of low energy light. Other quantum dot materials, matrices, and glass ceramics remain to be studied.

References

[1] H Zhang, Z Zhou, B Yang, J. Phys. Chem B 107 (2003).
[2] WYu, L. Qu, WGuo, X Peng, Chem Mat er. 15 (2003) 2854.

Optical Properties of Thiophene Membranes in Differing pH Values

Keith Jones, Georgia Institute of Technology, SURF 2008 Fellow

Faculty Advisor: Dr. Vladimir Tsukruk

Mentor: Veronika Kozlovskaya

Introduction

The sodium poly[2-(3-thienyl)ethoxy-4-butylsulfonate] polymer (PTH) is a unique polymer with pH-dependent optical properties. When in an aqueous solution, in basic conditions such as at pH > 7, it is reddish and has a pronounced absorption peak at ~ 430 nm. While in acidic conditions of pH 2, it becomes dark green with the additional absorption maximum at 780 nm. Layer-by-layer (LbL) deposition of polymers at surfaces is a versatile way to create ultrathin polymer membranes with controlled properties. Layers of a polyanion and a polycation can be stepwise deposited onto a surface through a spin-assisted (SA) self-assembly producing robust LbL films. SA-LbL deposition enables the experimenter to easily vary thickness and thus some properties of the membrane by varying the number of the deposited layers.

The optical properties of PTH (color, photoluminescence) are clearly pH-dependent when in aqueous solution, but it has not been shown that PTH-containing membranes react similarly. This experiment aims to create robust PTH membranes with tunable optical properties by self-assembly of PTH with 20%-quaternized poly(4-vinylpyridine) (Q20), poly(dimethyldiallylamino hydrochloride) (PDDA), branched poly(ethyleneimine) (PEI), or poly(allylamine hydrochloride)(PAH) polycations.

Procedure

PTH and the four polycations were dissolved in 0.01 M TRIS buffer and then adjusted to necessary pH with HCl and NaOH. Clean silica wafers or clean quartz slides were then put into a spin-coater and alternating layers of thiophene and polycation were deposited by spinning at 4,000 RPM up to a total of 20 bilayers. Two washes of 0.01 M TRIS buffer at the same pH were done in between each layer to remove excess of polymers. If systems would not adhere well at a certain pH, 3 bilayers of 0.2% PAH and 0.2% PSS were deposited first. During later experiments, spacer layers of PAH/PSS were deposited in between thiophene and polycation layers to ensure the polymer was not self-quenching.

The optical thickness of the films on silica wafers was determined with a spectroscopic ellipsometer. Optical properties were studied using a UV-Vis spectrophotometer or a spectrofluorophotometer.

Results and Discussion

Due to its sulfonate groups, PTH can electrostatically self-assemble with the polycations. This allows for creating thin PTH membranes. First,

growth of PTH films at different pHs was examined to determine the effect of the deposition pH on the thickness and robustness of the films. Q20 and PDDA membranes grew at pH 7.5, 4, and 2.5, while PEI only adhered at 7.5 and 4. PAH was the least robust by only adhering at 7.5.

Q20 membranes were typically the thickest, followed by PEI and PDDA membranes (Figure 1). Lower pH at the time of deposition generally caused slightly lower membrane thickness (approximately 10%). Using pre-layers of PAH/PSS encouraged greater membrane thickness.

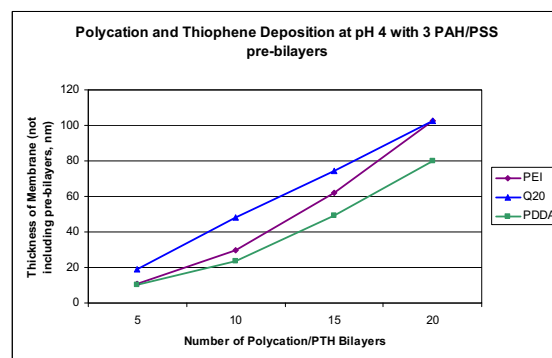


Fig. 1. LbL growth of (PAH/PSS)₃(PTH/polycation)₂₀ systems at pH 4.

Optical properties of the produced films were studied at various pHs. The membranes were immersed in solutions with a certain pH for 15, 30 min., or an hour, and their absorbance/fluorescence was measured. We found that the pH-dependent decrease in fluorescence for PTH/PEI and PTH/Q20, when they were transferred from pH 7.5 to 2.5, were due to decrease in the membrane thicknesses. After an initial drop, the thickness leveled out and did not change with pH. Samples deposited at lower pH had a constant thickness at both pH 7.5 and pH 2.5.

Absorbance/photoluminescence of the systems deposited at pH 4 and 2.5 with pre-layers, or at pH 7.5 with spacer layers, did not show any consistent changes in response to pH variations. Studies on whether relative hydration of the membranes (if they were recently in solution or dry) affects any optical properties are currently underway.

Conclusion

We have shown that robust PTH/polycation LbL membranes can be grown. Absorbance maxima of the produced films depend mostly on the polycation nature. The right combination of polycation, deposition pH, and pre-bilayers or spacer layers needs to be found to ensure strong and steady optical changes with full reversibility.

Stabilizing DNA Duplexes for Biomaterial Applications

Kirsten Mimberg, Georgia Tech SURF 2008 Fellow

Faculty Advisor: Dr. Valeria Milam

Graduate Mentor: Chris Tison

INTRODUCTION

Cancer is a complicated and prevalent disease. New drug delivery systems have been researched to target and treat cancer effectively. Current research aims at creating a multifunctional therapeutic unit with an intrinsic release mechanism for drug delivery. This study focuses on a model drug delivery vehicle using DNA as a biomaterials assembly tool. Therapeutic colloidosome assembly and disassembly is DNA-mediated. The challenge with using DNA as a biomaterials assembly tool is protecting DNA assemblies from biological nucleases aimed at clipping foreign DNA. DNA may be protected by steric hindrance if immobilized to a surface. The objective of this study is to investigate protecting surface-bound single-stranded DNA (ssDNA) from enzymatic degradation. Changing the DNA density allows us to observe the effects of DNA density on the ability of enzyme DNase I to cleave surface immobilized strands. Greater DNA surface density causes an increase in steric hindrance, which creates little free volume for enzyme activity.

PROCEDURE

Fluorescently labeled ssDNA were attached to 1 μ m polystyrene microspheres using EDAC coupling. Polystyrene beads were incubated at room temperature with FITC labeled A20-NH₂ DNA and coupling agent, EDAC for two hours. Coupled beads were washed after two hours 3 times in 0.02% PBS/Tween. DNase I was used to digest coupled beads. Coupled beads were washed in 60 μ L NE DNase I Buffer and incubated with 0.2 μ L DNase I at 37°C for up to 24 hours. Flow cytometry was used to detect fluorescently labeled DNA strands on particle surfaces before and after enzymatic processing. Fluorescence intensity was calibrated using a MESF standard curve.

RESULTS AND DISCUSSION

Enzymatic processing using DNase I on ssDNA (Fig. 1) revealed 71.17%, 66.24%, and 63.26% immobilized ssDNA remains after enzymatic exposure of 10 minutes,

1 hour, and 24 hours.

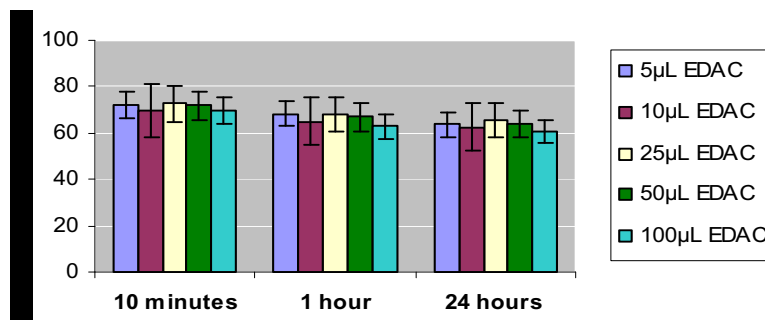


Figure 1. DNase I Digest on FITC Probes at varied EDAC. Fluorescently labeled ssDNA at varied surface densities were exposed to enzyme DNase I for 10 minutes, 1 hour, and 24 hours. Values were averaged from four trials.

Optimal DNA density was also researched. Polystyrene microspheres were coupled with 5 μ L, 10 μ L, 25 μ L 50 μ L 100 μ L EDAC to vary DNA density. Surface densities were measured in oligonucleotides/ μ m². Results show maximum surface densities at 25 μ L EDAC, after which surface densities plateaued between 25-50 μ L EDAC. Compared to results at 25 μ L and 50 μ L EDAC, surface densities were slightly lower at 100 μ L EDAC. This observation may be attributed to fluorescence quenching and requires ongoing investigation.

CONCLUSION

DNase digests on ssDNA show 63.26% immobilized strands remain after 24 hour exposure, with majority of cleavage occurring in the first 10 minutes of exposure. Further cleavage is not significant over prolonged periods of time. Surface-immobilized ssDNA may be protected from enzymatic degradation. This shows great promise for using DNA as a biomaterials assembly tool. Future research may investigate using ssDNA tails to protect primary probe sequences from being cleaved by enzymes.

Processing and Characterization of Poly (*para*-phenylene) Nanocomposites

Lawrence Chen, Polymer, Textile, and Fiber Engineering, Georgia Tech SURF 2008 Fellow

Faculty Advisor: Dr. Meisha Shofner Graduate Student Mentor: Bradley Johnson

Introduction: The focus of the research was to determine the potential benefits in material properties that a poly (*para*-phenylene) polymer nanocomposite could offer. Single-walled (SWCNT) and multi-walled (MWCNT) carbon nanotubes as well as carbon nanofibers (CNF) have been widely employed as reinforcing agents in polymer matrices with the goal of improving mechanical and thermal properties.¹ It was hypothesized that such modifications to poly (*para*-phenylene) could yield a nanocomposite with similar enhancements.

SWCNT, MWCNT (Swan Chemicals), and CNF (Pyrograf Products) were used to create the fiber network within the polymer matrix. For the polymer matrix, a thermoplastic resin known commercially as PrimoSpire-250 was chosen based on its strength due to the poly (*para*-phenylene) molecular structure.

Experimental: Polymer batches consisting of 0 (neat), 0.5, 1, and 3 wt% of each nanofiller were melt mixed in a Brabender Intelli-Torque Plasti-Corder batch mixer equipped with roller blades. It was estimated that the shear force obtained from using a melt mixer would be sufficient to disperse the fillers.² Processing parameters for a 45 gram batch sample was 260°C, 40 rpm, and a run time of 8 minutes. Each batch was mixed in a nitrogen environment to prevent degradation.

A loading technique was developed to reduce torque loads experienced by the machine. 25 grams of PrimoSpire were loaded initially followed by 10 grams of resin and an appropriate amount of nanotubes at the 70 second mark. The rest of the resin was added to the mixer at the 120 second mark. Samples were then dried at 180°C for two hours before compression molded into sheets at 290°C and 7 tons.

Tensile test samples were die cut at 182°C and tested according to ASTM D368 standards on an Instron (model 5566). Tensile modulus was calculated based on the initial slope of a stress-strain diagram, and the strength was calculated at the fracture load. Scanning electron microscopy (SEM) was used to view fracture surfaces. Thermal gravimetric analysis (TGA) was performed on a TA Instruments TGA Q 5000 at 10°C/min from 40°C to 700°C in nitrogen (25mL/min) to determine thermal stability.

Results: Table 1 shows that at 1 wt% concentration, PrimoSpire/CNF demonstrates an increase in toughness and yield strain while the nanotube composites experienced either a slight decrease or statistically insignificant change in mechanical properties. MWCNT nanocomposite properties at other concentrations (data not shown) also displayed negligible changes.

Table 1. Mechanical Properties of 1 wt% of Selected Nanofillers at 95% C.I.

	PrimoSpire	1%SWCNT	1%MWCNT	1%CNF
Elastic Modulus (GPa)	4.8±0.3	5.0±0.1	5.0±0.2	4.6±0.3
Toughness(MPa)	4.0±1.8	2.1±0.8	4.4±0.3	6.6±2.4
Yield Stress (Mpa)	135±6	122±20	137±3	139±5
Yield Strain (%)	4.6±1.3	3.1±0.6	4.8±0.2	6.8±1.9

SEM images of CNF 1wt% composite (Fig. 2) show that although good dispersion was achieved, pullout of fibers was present. This accounted for the relatively large increase in

strain to failure. SEM images of 1wt% SWCNT and MWCNT (Fig. 1) samples displayed poor dispersion.

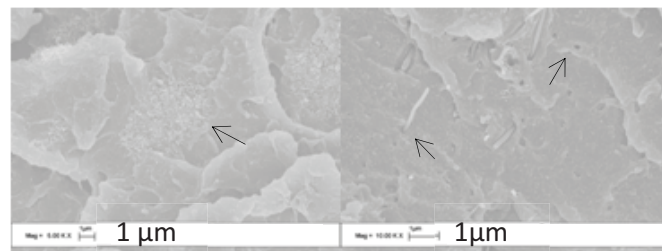


Fig 1. Poor dispersion of MWCNT shown by agglomerates.

Fig 2. Pullout of fibers shown by gaps and unclevaged nanofibers result in high strain%.

Table 2 shows minimal increases in initial degradation temperature but a slight decrease in the rate of degradation with increasing percent concentrations of CNF. No significant improvement was observed in either of the nanotube composites.

Table 2 . Mass loss rates of CNF samples at heating rate of 10°C/min in N₂.

	Temp (°C)	Weight (%)	Deriv. Wt (wt%/°C)
Neat	547	95	0.13
0.5 wt% CNF	550	95	0.13
1 wt% CNF	548	95	0.11
3 wt% CNF	548	95	0.10

Conclusions: The brief mechanical behavior characterization, accompanied by thermal analysis and SEM imaging, provided insight to some of PrimoSpire nanocomposite's tendencies. The method of melt mixing poly (*para*-phenylene) to create nanocomposites proved to be ineffective at the given parameters. Batch mixing proved unsuccessful as a means to disperse the SWCNT and MWCNT throughout the matrix at all levels of concentration as evident from the SEM images. Agglomerates of fillers could potentially act as defects in the material and thus weaken the matrix integrity by the decreasing material properties as shown in Table 1.

Although melt mixing was suitable for dispersing CNFs, a CNF pullout was present. Pullout could be minimized with better adhesion of the CNF to the polymer matrix. Since both CNF and poly (*para*-phenylene) possess a high degree of nonpolarity and a molecularly rigid structure, interfacial interactions is potentially minimal. Adding functional groups to both the polymer matrix and the CNF to increase the intermolecular forces could possibly increase matrix adhesion.³

Increasing concentration of well-dispersed CNF yielded slight improvements in derivative thermogravimetric mass loss. This phenomenon could be explained by the presence of the CNF network acting as a barrier to lower mass flux of polymer out of the sample.

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Synthesis of Alumina from Micellar Templates of Surfactants

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IREP 2008: Georgia Institute of Technology and University of Campinas, Brazil

INTRODUCTION

Surfactants, also known as surface-active agents, adsorb at surfaces and interfaces in order to lower the free energy of a phase boundary. Because of their properties, surfactants are commonly used in soaps and detergents. This property of surfactants can be explained by its amphiphilic nature. Surfactant molecules consist of a lyophilic (soluble) and lyophobic (insoluble) end. When the concentration of surfactants in a medium reaches a critical concentration, aggregates known as micelles are formed. A variety of micellar structures can be formed depending on the type of surfactant, solvent, and relative concentrations of the components in the system.

The goal of this project was to use micellar structures as a template for the synthesis of alumina. Two types of surfactant systems with different micellar structures were synthesized and tested for its compatibility as a template for alumina growth.

METHODS

The first micellar template was created using a complex salt (cetyltrimethylammonium polyacrylate) that consisted of a cationic surfactant and a polymeric counterion. The complex salt ($C_{16}TAPA_{6000}$) was synthesized by first converting $C_{16}TABr$ into $C_{16}TAOH$ by using an ion exchange resin. The $C_{16}TAOH$ was then titrated with a high molecular weight polyacrylic acid (M.W. 450,000 g/mol) until the equivalence point was reached. Once the equivalence point was determined, an additional titration was performed and stopped at the pH that corresponded to the equivalence point. Once the system was prepared it was placed in a refrigerator to equilibrate overnight. Upon reaching equilibrium, the solution was freeze-dried.

The complex salt was then mixed in a solution with a specified concentration of butanol and water, which was known to produce a reverse worm-like micellar structure. It was proposed that an aluminum nitrate/urea solution could be introduced to the system, and due to its polar nature, it would gather inside of the worm-like channels and react to form alumina instead of mixing with the butanol. From this reaction, it was desired to retrieve long cylindrical structures of alumina after dissolving the polymer surfactant complex. Six samples were prepared with varying concentrations of an aluminum nitrate solution in order to evaluate its interactions with the system.

The second micellar template was created using a non-ionic surfactant, Renex-100. A liquid crystalline

micellar template had been formed previously by mixing a solution of Renex-100, cyclohexane, and a calcium phosphate solution. In this case, the calcium phosphate solution was replaced with an aluminum nitrate solution. By mass percentage, the composition was 45.5% Renex-100®, 45.5% aluminum nitrate solution and 9% cyclohexane.

RESULTS & DISCUSSION

In order to determine how the aluminum nitrate reacted with the different surfactant systems, the systems were evaluated using birefringence evaluations, small angle x-ray scattering (SAXS), x-ray diffraction (XRD) and scanning electron microscopy (SEM). Due to time constraints, the second system has only been evaluated for birefringence at this time.

Results from all techniques mentioned above confirmed that the addition of the aluminum nitrate solution destroyed the existing micellar template and produced a disorganized, amorphous structure. The samples evaluated did not exhibit birefringence (characteristic of organized structures), and presented broad, single peaks when evaluated with x-rays. SEM images also showed structures with no apparent order. These results can be explained by the strength of the interaction between the aluminum ion and the counterion of the complex salt.

An optical microscope was used to observe the second system (with Renex-100) between two crossed polarizers to determine if it maintained its liquid crystalline structure after the addition of the aluminum nitrate solution. Birefringence was observed, indicating that the order was maintained. Further analysis will be conducted using SEM and XRD to characterize the structure present.

Figure. Image of 2nd system exhibiting birefringence between crossed polarizers



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Thermomechanical Fatigue of a Directionally Solidified Ni-Base Superalloy

Matthew Schaikewitz, Georgia Institute of Technology, SURF 2008 Fellow

Faculty Advisor: Dr. Richard Neu Graduate Mentor: Robert Kupkovits

Introduction

In an effort to increase efficiency and energy output of gas turbines, there has been a push over the past several years to increase the firing temperatures. The problem is, however, that increasing the temperature also reduces the fatigue life for the turbine materials, especially for materials in the blade section where conditions are the harshest. Developing and optimizing materials which can withstand the extreme conditions has been a continuous challenge to many material engineers.

Because of its high yield strength and resistance to creep and oxidation, turbine manufacturers have been using directionally solidified nickel-base superalloys in the blade section. The objective of this research is to characterize the thermomechanical fatigue behavior of one such material, CM247LC-DS, in the presence of varying stress concentrations. This involves performing tests which mimic the thermal and mechanical stresses endured by the turbine blades. Upon conclusion of the research, fatigue life models for the material will be predicted, and manufacturers will use the data for current and future design work.

Procedure

The orientation of the specimens was either longitudinal or transverse, and the gauge section was either smooth ($kt=1$) or notched ($kt=2$). Specimens were loaded into a servo-hydraulic test frame and continuously cycled between compression and tension and between 500°C and 950°C. For in-phase (IP) tests, maximum tension corresponded to maximum temperature, and for out-of-phase (OP) tests, maximum compression corresponded to maximum temperature. The heat was provided by an induction heater whose coils were centered around the gauge section. Force was measured by the test frame and displacement by an extensometer. Specimens were cycled until failure.

Results and Discussion

Crack initiation was defined as a 5% load drop for axial displacement-controlled (DC) tests and a 10% stiffness drop for force-controlled (FC) tests, which corresponded to a crack length between 0.5 mm and 1.0 mm. The results of the tests are shown in Figure 1.

All of the smooth specimen tests were DC and OP, with failure resulting primarily from fatigue and cracking of the surface oxide layers which form at high temperatures. Stress-strain hysteresis for one of these specimens can be seen in Figure 2.

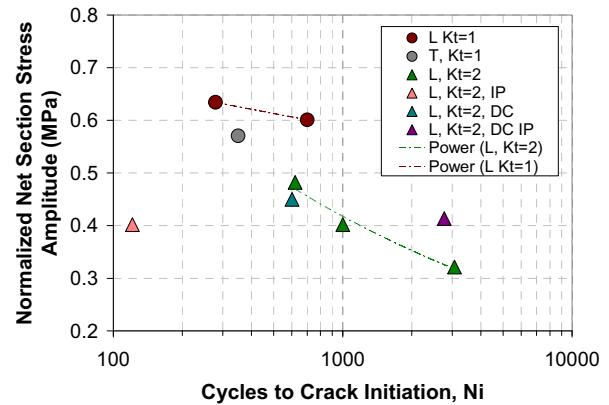


Figure 1. S-N data points of all tests performed. Stress values have been normalized.

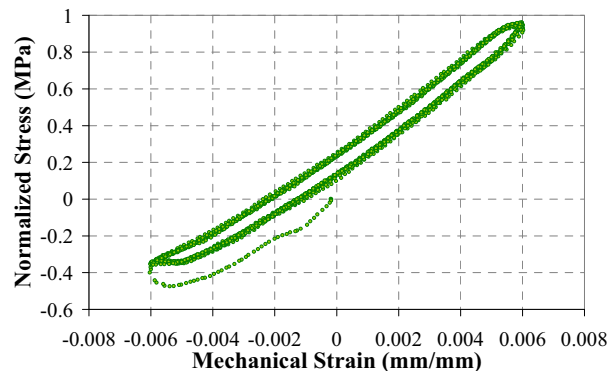


Figure 2. Stress-strain curve for a longitudinal smooth specimen. Stress values have been normalized.

Notched specimens, however, were conducted in both FC and DC. For the IP FC test, creep ratcheting lead to failure by creep rupture rather than cyclic fatigue. For the notched DC IP test, notch strengthening and stress relaxation at the peak temperature caused a shift in the stress-strain curve toward the compressive direction, which also reduced the maximum tensile load and extended fatigue life. The notched OP DC data point lies very close to the OP FC curve, indicating that control mode in this case did not significantly affect the damage mechanism.

Conclusion

We have begun constructing stress-life curves for our material while varying load, phase, orientation, stress concentration, and control method. Further testing is needed to generate a comprehensive fatigue life prediction model.

Characterization of GaN based Semiconductors

Steve Brown, University of Minnesota, Georgia Tech SURF 2008 Fellow

Faculty Advisor: Dr. Ian Ferguson Graduate Advisor: Nola Li

Introduction

The growth and characterization of GaN based semiconductors is important to many different fields and applications. GaN is the leading semiconductor in the LED industry and plays a vital role in solid-state lighting. GaN is also widely used in solar cells which can reach upwards of 45% in efficiency. We are also looking at GaN for its possible viability as a multiferroic material suitable for use in spintronics.

New recipes and growths of GaN are being made around the clock in our lab and it is vital that these new semiconductors are characterized for all the possible properties they might have. The objective of this study was to characterize GaN based semiconductors for properties that would make them suitable for solid-state lighting, solar cells, and spintronics applications.

Procedure

Materials were analyzed using two different tests: VSM and photo luminescence. A 7400 LakeShore vibrating sample magnetometer was used to find the hysteresis of induced magnetic fields. Photo luminescent (PL) measurements were conducted using a 248nm laser, a monochromator, and a photo multiplier tube (PMT). Results for both procedures were then graphed with Origin. Tests measuring Magnetic Circular Dichroism (MCD), the Anomalous Hall Effect (AHE), and various ferroelectric properties were also planned, but unfortunately did not come together in time.

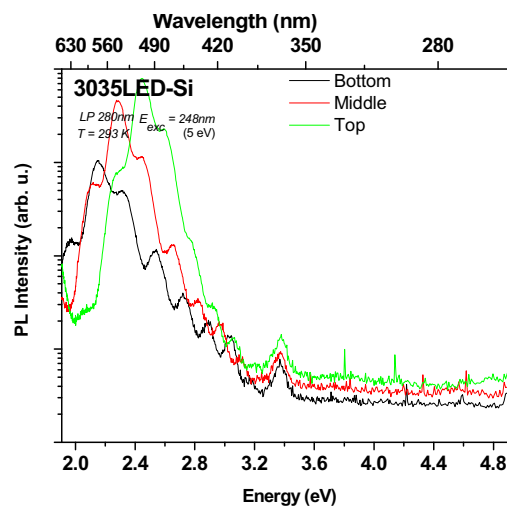


Fig. 1: Typical PL results

Results and Discussion

About ten samples were measured using VSM and about thirty samples were characterized using photoluminescence. Fig. 1 shows what the results of a typical photo luminescence measurement looks like. The materials characterized by the VSM didn't show any unique properties, but there were some suitable LEDs characterized by PL. A ferroelectric tester was setup, but no tests were run with it. Parts of the MCD system were repaired, but it's still not running. Studies were done on how to set up an AHE system, but it didn't get put together.

Conclusion

A lot of good data on various GaN semiconductors was gained this summer in addition to setting up the PL, VSM, and ferroelectric systems that are ready to take measurements. The MCD system only needs a few more repairs. The AHE system needs to be built but there is a rough outline as to how it should be built. When all these tests are in place interesting materials can be characterized easily and efficiently.

Selected Corrosion Susceptibility of Duplex Stainless Steel at the Micro-Scale

Joshua Basilio, Georgia Institute of Technology, SURF 2008 Fellow
Advisor: Dr. Preet Singh; Graduate Mentors: Kevin Chasse, Matthew Taylor

Introduction

Duplex Stainless Steel is formed from two phases of iron, austenite (FCC) and ferrite (BCC), which have been treated with elements such as chromium to reduce corrosion susceptibility. Austenitic stainless steels are characteristically tough while Ferritic stainless steels are characteristically corrosion resistant. [1] In mixing the two phases, the resultant duplex stainless steel exhibits generally greater strength and corrosion resistance than single phase stainless steels.

In typical samples of the most common duplex grade, 2205, austenite and ferrite phases are distributed homogeneously at roughly equal volume fraction in the microstructure. Since the two phases will tend not to fail at equal rates, it is important to understand the corrosion susceptibility of the individual phases within the microstructure. With this knowledge, the material can then be subjected to heat treatment to influence homogeneity and volume fraction of the two phases to provide for the best possible mix of strength and corrosion resistance.

Materials Selection and Procedure

Samples of DSS 2205 were prepared from 1cm² squares with a thickness of approximately 2 mm. Several samples were heat-treated at 1100°C for one hour in an Argon Purged environment. All samples were polished to 0.05 micron and etched using a 40% NaOH solution. Optical microscopy at 200x showed the as-received samples to have a ferrite-austenite volume fraction of 50-50 while the heat-treated samples displayed a ferrite-austenite volume fraction of 60-40.

Samples were then subjected to a battery of potentiodynamic and cyclic polarization corrosion tests. Electrochemistry was performed using a custom made glass microcell with a 300 micron capillary tip and a Gamry potentiostat. A Ag/AgCl reference electrode with a KCl salt bridge, a Pt counter electrode, and a 3.5 wt.% NaCl aqueous test solution were used for electrochemical tests. This setup is depicted in Figure 1. Samples were mounted in bakelite with a contact wire spot welded on the surface. Random spots were chosen for comparison testing between the heat-treated and as-received samples. Three areas of high concentration of each of the two phases within the heat-treated sample were identified at 50x and marked macroscopically. These six spots were used for comparison testing between the two phases.



Figure 1. Electrochemical testing setup.

Results and Discussion

Polarization curves show heat-treated samples having generally lower corrosion potentials than as-received samples. Similarly, ferrite spots in the heat treated sample have generally lower corrosion potentials than austenite spots in the same sample. Ferrite spot locations achieved passivation at earlier voltages than austenite spot locations. The ferrite spots held to this state of passivation for longer periods of time and thus had a controlled rate of corrosion. Austenite spots tended to have a fluctuating corrosion rate, and did not show long periods of

passivation. Finally, ferrite spots broke the passivation state into the transpassive state at higher voltages than the austenite spots. Figure 2 details aggregate polarization curves of the ferrite and austenite phase while Figure 3 details a micrograph of two selected spots after corrosion at 50x.

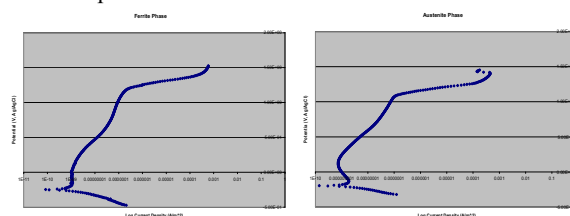


Figure 2. Polarization curves of Ferrite (left) and Austenite (right) phase test spots.

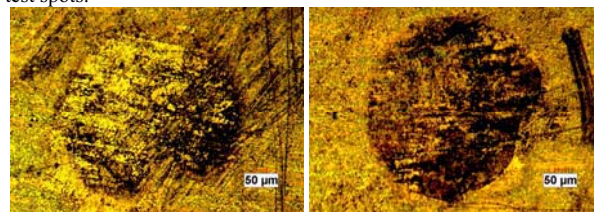


Figure 3. Optical Micrographs of Ferrite (left) and Austenite (right) phase test spots at 50x.

Conclusions

We can reasonably conclude that the ferrite phase is generally more resistant to corrosion than the austenite phase. The ferrite phase reaches equilibrium between anodic and cathodic corrosion more rapidly and maintains a controlled passivation state for a longer period of time before reaching accelerated transpassive corrosion. Similar results from comparison between the as-received sample and the heat-treated sample are obtained since the heat-treated sample displays a greater volume fraction of ferrite. Future work can be done to make comparisons of other properties, such as toughness, with respect to ferrite percentage. In addition it may be possible to anneal samples in such a way so as to isolate austenite phases so that failure of the austenite phase due to corrosion does not result in failure of the whole microstructure. [2]

Acknowledgements

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The Fundamental Nature of Adhesion of the Carbon NanoTube

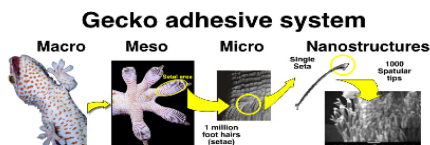
2008 Gift fellow: Ursula Gordon; Georgia Institute of Technology – Material Science & Engineering

Faculty Mentor: Dr. Seung Jang & Research Mentor: Dr. Jiil Choi

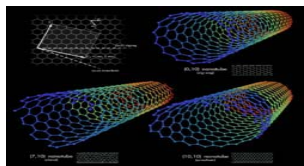


I. Motivation

For almost 20 years scientist have been amazed at how the gecko can walk up vertical walls and even hang from ceiling by one toe. The major force holding the gecko on a surface was from the van der Waals forces induced by many aligned microscopic elastic hairs (setae – 3 to 130 μm in length) which split into smaller spatulae (0.2 – 0.5 μm in diameter) on the gecko feet.



This discovery about the gecko foot has motivated many to manufacture microarrays of carbon nanotubes, research, and simulate the forces acting on them – our choice the armchair Carbon Nanotube - to mimic the gecko foot.



My **Research Objective** is to find out “Why is it sticky?” or better put to find out “**What is the fundamental nature of the adhesion of the Carbon Nanotube?**” Is the only driving force van der Waals Force (no load). Now, we want to add a load and ask how do we sustain this object and Why.

II. Procedure

Simulations were performed with the Energy Minimization Method by using the Density Functional Theory (DFT). Many different nanowires with varying axial orientation, lengths, and geometry were tested. The Valence Terms and the Nonbounded Terms were calculated. The incremental process was repeated until a desired minimum Energy was reached.

III. Results

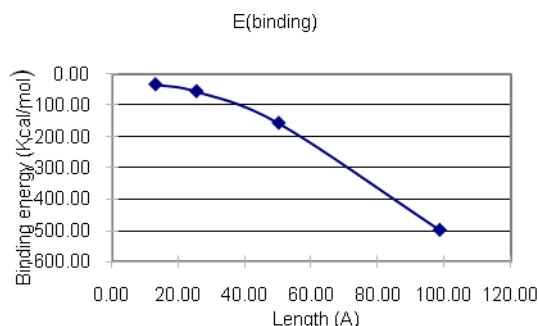
$$\text{Total Energy} = E(\text{Total}) - [E(\text{SWNT}) - E(\text{Si-surface})]$$

1) Contact Area Dependency

- Length: 12.9 Å, 25.3Å, 50.1Å, 98.7Å



SWNTs : 10 x 10 Armchair SWNT, Hydrogen terminated, - Si Surface: [111] Direction



Fi

g-1. As the length of the SWNT increases, the binding energy decreases.

First we looked at area dependency to confirm van der Waals force is dependent on contact area. We found that as the contact area (or the length of the SWNT) increases the binding energy decreases (which mean that it is adhesion).

2) Dragging (I): Moving to Left & Right

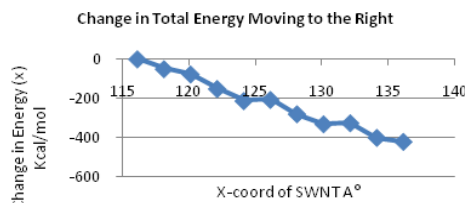
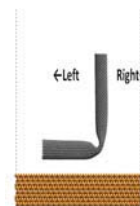
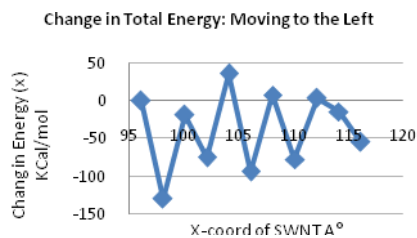


Fig-2. Moving the top two layers to the left or right. Binding energy was calculated using the relation.

Secondly, we wanted to know why the Carbon Nanotube is adhesive. Thus we created a simulation moving only the top two layers of the Carbon Nanotube to the left and then to the right. We found that when we moved to the left, there is not much change in the contact area and a slight fluctuation in the Energy. However, when we moved to the right contact area decreased and the Energy decreased. Thus the total energy was more stable and hence the Carbon Nanotube reproduced the same result from the first case.

3) Dragging (II): Bending Half to the Left & Right

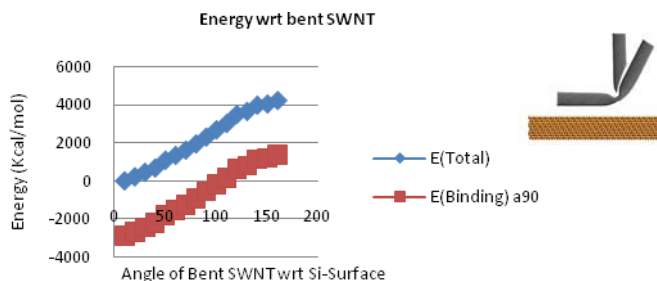


Fig-3. Bending the half of the SWNT from the 90 degree to the left or right by 10 degree.

Lastly, we wanted to take a look at the bending of the Carbon Nanotube and see if there were any other forces that had an effect on the Total Energy. We took a closer look at the van der Waals Energy function. At first glance, the function seems to just increase as you bend the Carbon Nanotube (where the bend angle was between the SWNT and the Si-surface). However, if you look at the graph of the van der Waal Energy, you can see that there are local maximum values obtained around 40° and again at 120°.

IV. Conclusion

In Conclusion, our simulation has looked at 3 aspects of the Carbon Nanotube. We may have found another characteristic acting on the adhesion force. Before 40° the Carbon Nanotube hates being bent. Once it has moved beyond 40°, there is a buckle in the

Carbon Nanotube and there is no big change in the van der Waals Energy and the contact area is about the same. This is why it has obtained a heavy load. Then around 120° there is an abnormal bond length. We know from the first investigation that it was due to van der Waals force; however the Carbon Nanotube itself is not adhesive. The adhesion only occurs when the Carbon Nanotube interacts with another surface. We found that when we increase the contact area the binding energy increases.

V. Future Works

Applying force to atoms in a time dependent system

VI. Acknowledgements

I would like to acknowledge Dr. Jang, Dr. Choi, GaTach MSE, CEISMIC, and NSF for all of your help, guidance, and opportunity to share and investigate the study of Mathematics in the Real World setting.

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**A Study of Improving Electrical Capacitance By
Depositing V₂O₅ on Carbon Nano-structures**

**Brian Herdt
2008 GIFT Fellow
Dr Gleb Yushin, Mentor**

An improvement in electrical capacitance through the deposition of metal-oxides on carbon nanostructures has been demonstrated. Manganese Dioxide has been used for some time but does not deliver the necessary performance in capacitors for many aerospace and energy storage applications such as for use in hybrid electric cars. Capacitors high charging and discharging rates coupled with a theoretically infinite cycling life may make capacitors a replacement for some secondary batteries. Ruthenium oxides deliver super-capacitor performance but the use of ruthenium on a large scale is prohibitive due to its very high cost. Recent studies have shown that use of vanadium oxides on carbon nanoforms can produce relatively affordable super-capacitor performance.

Electrical capacitance varies directly with the surface area of the material holding the charge. An increase in the surface area per gram of substance in a capacitor will increase the performance. In this project two carbon nanoforms were studied. Multiwalled Nanotubes (MWNT) have a surface area of 200 m²/g and oxidized carbon black (CB) has a surface area of 700 m²/g. It is believed that the particle size and uniformity of V₂O₅ layer deposited on the carbon nanoforms are critical for the performance of super capacitors. In this study solid V₂O₅ will be reacted with 35% H₂O₂ then deposited in a sol-gel process. The factors that determine particle size and uniformity depend on the degree of the oxidation of the carbon structures, method of the V₂O₅ sol deposition, post deposition annealing time and temperature and the quality the V₂O₅ sol. Capacitors were constructed using the materials produced and tested for capacitance and frequency response.

The CB was delivered oxidized and it was determined that the best capacitor performance using MWNT was observed after this substance was oxidized 30 to 60 minutes in a mixture of sulfuric and nitric acid at 90 deg C. V₂O₅ sol production proved to be problematic as the reaction runs using the same proportions reactants but in different amounts produced very different products. Small amounts of reactants produced some good initial capacitance results but larger amounts of reactants produced a V₂O₅ sol that had properties that best matched the desirable outcome described in the literature. Initial results using this sol on CB have been disappointing. So far MWNT have outperformed the CB despite the smaller surface area of the MWNT. Further studies need to be carried out to determine the degree of deposition and uniformity. Also the method of depositing the V₂O₅ sol may need to be further developed. Initial results have shown good performance using annealing temperatures of 180, 300 and 500 deg C with the higher temperatures usually giving somewhat better results.

Materials Modules: Thin Films and Chocolate

Marie Johnson, GIFT Fellow 2008

Faculty Mentor: Dr. Valeria Milam

Working with Materials Science and Engineering (MSE) at Georgia Tech has opened opportunities for my students and for me as a physics teacher. MSE offers an opportunity to link chemistry and physics so that my students understand the sciences they study are interrelated. There are many students at Chamblee High School that opt out of taking higher level science courses. Offering MSE modules in our courses allows students to begin to think about MSE as an option. In the future our plan is to offer a year long course in Materials Science aimed at those students who opt out of higher level science courses.

MSE modules developed each summer will be used in the MSE course offered at Chamblee High School. These modules will be used in my AP Physics classes as well. Two modules were developed this summer: thin film interference and chocolate. Thin film interference is observed in oil on water in parking lots and in soap bubbles. Students will produce a soap bubble mixture to use for an activity in thin films. Using this bubble mixture developed in collaboration with Pamela Gilbert-Smith, chemistry teacher at Chamblee High School, and her class, students will make their own thin films. Observing thin films and the resulting constructive and destructive interference patterns will allow the students to begin thinking about thin films. Students will then observe the flow pattern in the film as they hold it vertically. Changing the film by inserting a wet straw at the top will cause vortex shedding in a very observable pattern that students will measure and record. Students will determine flow velocity from the vortex shedding. A lecture about thin film calculations will follow this activity. Students will be able to calculate the thickness of a film necessary to emit a particular wavelength of light. This objective has been covered in each AP Physics course I have taught; now students will be able to observe it as well.

The second module involves processing chocolate. Processing chocolate so that the crystals have the right size and formation takes skill. Students will process chocolate of their own to cast into molds. The cast chocolate will then be tested for its strength, hardness and product quality (shine and taste). Students will also test chocolate bars already on the market for these same properties. There are five parts to the chocolate module: Casting Chocolate, “Can Your Chocolate Bar Support the Load?”, “Build a Better Chocolate Bar”, Tensile/Charpy” Test and the Indent Test.

Casting chocolate allows the students to process a material that requires some specific steps and precise temperatures. Rates of cooling chocolate can be changed to observe the differences in the material after processing. A bend test will be performed after processing to determine the strength of their cast chocolate. After the bend test, students will make a composite chocolate bar and test the strength after reinforcing it with a material of their choice. A tensile test will be performed with a household hammer and a device that allows it to swing like a pendulum to hit the chocolate breaking it. Observation of the failure edge will be performed under a digital microscope. The indent test

will be performed on three different mass produced chocolate bars, Hershey’s Milk Chocolate Bar, Nestle Crunch Bar and Hershey’s Almond Bar. The crisped rice represents voids in a material, the almonds represent reinforcement and the milk chocolate is a uniform control. The indent test will be performed at room temperature, a few degrees above room temperature and a few degrees below room temperature. See Figure 1 for results. The increase in temperature produced a larger indent in the chocolate bars. Students should see similar results. Figure 2 shows the materials used to perform the indent test. Students will continue the study by making and casting their own chocolate bar and repeating the indent test.

These modules are designed to allow the students to explore materials and learn more about MSE. Students will also share the chocolate module with students at the middle school that feeds into Chamblee High School. Opening doors for our students to new careers and new uses of science is a priority. The collaboration with MSE, Pamela Gilbert-Smith and I has increased awareness of MSE for our students. We hope to continue this collaboration in the future.

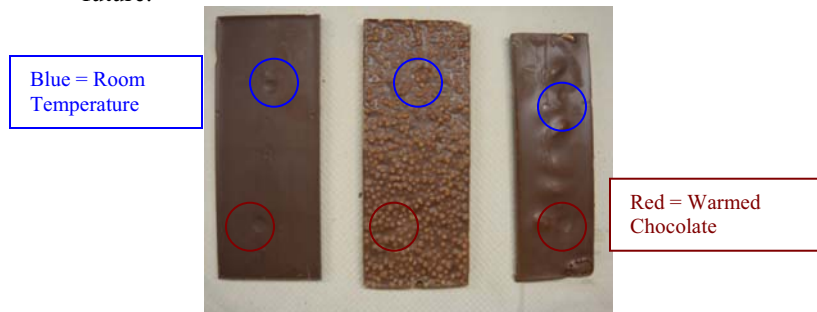


Figure 1. Indent Test on Processed Chocolate Bars



Figure 2. Indent Test Materials

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THE ELECTROCHEMICAL CELL

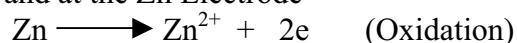
Steven C. Thedford, Redan High School GIFT 2008 Fellow
Faculty Advisor: Faisal M. Alamgir Graduate Mentor: Robert Rettew

INTRODUCTION

During the operation of an electrochemical cell two simultaneous chemical reactions occur - anodic and cathodic. Furthermore, the reactions at the anode and cathode are independent of each other. In a Zn-Cu battery, the reaction at the Cu electrode can be expressed as



and at the Zn Electrode



Over time the electrodes become corroded, and this reduces the EMF of the cell. Yet, a salt bridge can be used to inhibit corrosion in an electrochemical cell as demonstrated in this study.

PROCEDURE

A pipe cutter was used to cut a 5 cm long piece of copper wire. Afterwards, 50 ml of 50 mM sulfuric acid was poured into two 400 ml beakers. A syringe was used to inject a solution of sodium chloride into a piece of plastic tubing. The tubing was upheld upright so the two ends of the tubes were at the same height so that solution inside of the tubing would be at the same pressure. The two ends of the tubing were rotated simultaneously one hundred and eight degrees into the beakers to maintain the equal pressure in the tubing. The copper rod was placed upright in one beaker and a galvanized nail was inserted into the other beaker. Alligator clips were connected to the nail and copper and the other end of the alligator clips were connected to a multimeter, which measured the voltage across the electrochemical cell.

RESULTS

A multimeter recorded a voltage of about 1 volt across the electrodes; the voltage reading corresponds to the difference in the electrochemical potential of copper and zinc as indicated in The Electrochemical Series Table.

The Electrochemical Series

$\text{Cu}^{2+} + \text{e}^- \longrightarrow \text{Cu}$	0.34 eV
$\text{Fe}^{3+} + \text{e}^- \longrightarrow \text{Fe}$	-0.036 eV
$\text{Cr}^{3+} + \text{e}^- \longrightarrow \text{Cr}^{2+}$	-0.73 eV
$\text{Zn}^{2+} + 2\text{e}^- \longrightarrow \text{Zn}$	-0.76 eV
$\text{Al}^{3+} + 3\text{e}^- \longrightarrow \text{Al}$	-1.66 eV
$\text{Na}^+ + \text{e}^- \longrightarrow \text{Na}$	-2.71 eV
$\text{Ca}^{2+} + 2\text{e}^- \longrightarrow \text{Ca}$	-2.76 eV
$\text{K}^+ + \text{e}^- \longrightarrow \text{K}$	-2.92 eV
$\text{Li}^+ + \text{e}^- \longrightarrow \text{Li}$	-3.05 eV

In addition, the purpose of the bridge was to prevent the electrodes from corroding. After sitting for over an hour, the voltage of cell had only decreased slightly. Yet, when three electrochemical cells were connected in series, it was unable to light up a 1.7 V LED because the current was only about 50 mA. A salt bridge can be used reduce the corroding of electrodes in Cu-Zn electrochemical battery. Yet, the battery does not have enough current to light a LED.

REFERENCES

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- Dietterle, M., Will, T, Kolb D. M. *The initial stages of Cu electrodeposited of Ag (100) an in situ STM study* Department of Electrochemistry, University of ULM D-89069 Ulm, Germany.

Materials Science Engineering in the High School Classroom

Pamela Y. Gilbert-Smith, GIFT Fellow 2008

Faculty Advisor: Dr. Valeria Milam

Dr. Valeria Milam's research group is developing a cancer treatment delivery system called the Multifunctional Drug Delivery Vehicle. The core of the system is spherical with DNA controllers inside. There are strands of DNA attached to the drugs being delivered and tumor cell receptors that are attached to its surface. The assembly of DNA, controllers, drugs, and cancer cell receptors/recognition devices are delivered to the site of the tumor. The Multifunctional Drug Delivery Vehicle then releases/implants treatment then degrades.

Consequently the modules focus on intermolecular interactions. The first module, Bubbles/Thin Films is being developed with Marie Johnson to be used with chemistry and physics classes.



Figure 1. Represents material that may be used to adjust the bubble solution.

In chemistry, students will use the Bubbles/Thin Films module, as they adjust the bubble solution (see Figure 1.) to increase the life of their bubble, to explore intermolecular bonding/hydrogen bonding; mixtures; colligative properties (surface tension, adhesion, cohesion; evaporation) and pH. The bubble spherical shape will be used to illustrate Gibb's Free Energy. Free play with bubbles will have students test the concepts of hydrophobic and hydrophilic. In physics, the focus will be light reflection and refraction. Due to time and breadth of content, it is most probable that students work on this module throughout the year in chemistry continuing the following year in physics.

Starting with the idea of ink, the second module has developed into using tattoo ink to teach colligative properties with a forensics format. The techniques of Colorimetry and Paper chromatography of known and unknown samples will be used to identify the ink and therefore the tattoo artist responsible for the crime.

Continuing to work to bring Materials Science and Engineering to the K-12 classroom, we are investigating different methods of making the modules available. Possible ideas CD's, print copies and publishing/hosting on Dr. Milam's/MSE or Chamblee's website. We are exploring the idea of including modules written by other MSE/GIFT fellows into our "Using Materials Science and Engineering Lessons in Your Classroom."

Chamblee's Science National Honor Society students will adapt the modules to teach the Materials Science and Engineering lessons/activities to middle /elementary school students.

Teaching a course in Materials Science and Engineering or using the modules infused into existing courses addresses The School Improvement Plan for Chamblee Charter High School. The science component focuses on Science Fair for tenth grade students; using technology; and addressing the needs of our ELL (English Language Learner) students.

Our Materials Science and Engineering modules support engaging students with well planned, interactive, hands on lessons with real world applications taught with a student centered inquiry based approach.

SURF/GIFT 2008 Schedule of Seminars, Field Trips, and Presentations

- All SURF and GIFT Fellows are required to attend the seminars and field trips
- The seminars will be in Room 299 of Erskine Love Manufacturing Building
- The seminars will generally be held on **Tuesdays** from 11:00 am to 12:00 noon, and will be followed by lunch (**Exception: on July 15 the seminars will be from 11:30 am to 12:30 pm**)

Date	Speakers
Thu, June 29	Safety Seminar: Deborah Wolfe-Lopez
Tue, June 3	Professor Robert Snyder Professor Valeria Milam
Tue, June 10	Professor Naresh Thadhani Technical Communications Seminar: Dr. Lisa Rosenstein (to be confirmed) Field-Trip: Tour of high-strain-rate Lab
Tue, June 17	Professor Hamid Garmestani Professor Faisal Alamgir
Tue, June 24	Professor Meisha Shofner Professor Ian Ferguson <i>Field-Trip: "Behind the Scenes at the FOX Theatre"</i>
Thu, June 26	MID-TERM SURF PRESENTATIONS
Tue, July 1	Professor Nazanin Bassiri –Gharb Professor Rick Neu
Tue, July 8	Professor Vladimir Tsukruk Professor Preet Singh
Tue, July 15	Professor Chris Summers Professor Gleb Yushin
Tue, July 22	Professor Thomas Sanders, Graduate School
Wed, July, 23	FINAL SURF & GIFT PRESENTATIONS