SLATT UNDERGRADUATE RESEARCH FELLOWSHIP
FINAL REPORT

SCHOLAR NAME:	Marlena Muszynska
FACULTY ADVISOR:	Dr. Ian Lightcap
PROJECT PERIOD:	Winter Session 20/21
PROJECT TITLE:	Synthesis, Characterization and Electrochemical Testing of Iron/Iron Oxide Clusters as Potential Replacements for Platinum in Hydrogen Fuel Cells
CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):	(X) Energy Conversion and Efficiency ( ) Sustainable and Secure Nuclear (X) Smart Storage and Distribution ( ) Transformation Solar ( ) Sustainable Bio/Fossil Fuels ( ) Transformative Wind

MAJOR GOALS AND ACCOMPLISHMENTS

Summarize your research goals and provide a brief statement of your accomplishments (no more than 1-2 sentences). Indicate whether you were able to accomplish your goals by estimating the percentage completed for each one. Use the next page for your written report.

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Ti-Nanoxide MC/SP and T/SP coating	Fluorine doped tin oxide (FTO) glass slides were coated with MC/SP or T/SP using the doctor blade method and were cured/baked in muffle furnace.	100%
Electrophoretic deposition of graphene	Graphene oxide, suspended in ethanol, was deposited onto the cured TiO2 paste at 90 volts for 45 seconds.	100%
Iron deposition, nitrogen purge	Films were submerged in FeCl3 ethanol solution, underwent 20 minute N2 purge, deposition of metal nanoparticles.	100%
UV-Vis spectroscopy analysis	UV absorbance spectra were used to confirm the composition of each film layer.	85%
UV light exposure variation analysis	After the N2 purge, the films either were or were not placed in in front of a 200W xenon lamp for 5 minutes. XRF analysis followed.	70%

RESEARCH OUTPUT

Please provide any output that may have resulted from your research project. You may leave any and all categories blank or check with your faculty advisor if you are unsure how to respond.

CATEGORY	INFORMATION	
EXTERNAL PROPOSALS SUBMITTED	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount)	N/A
EXTERNAL AWARDS RECEIVED	(Sponsor, Project Title, PIs, Award Date, Award Amount)	N/A
JOURNAL ARTICLES IN PROCESS OR PUBLISHED	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s)	N/A
BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s)	N/A
PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH	(Event, Presentation Title, Presentation Date, Location)	N/A
AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT	(Purpose, Title, Date Received)	N/A
INTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)	N/A
EXTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)	N/A
WEBSITE(S) FEATURING RESEARCH PROJECT	(URL)	N/A
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail)	N/A

RESEARCH EXPERIENCE

Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

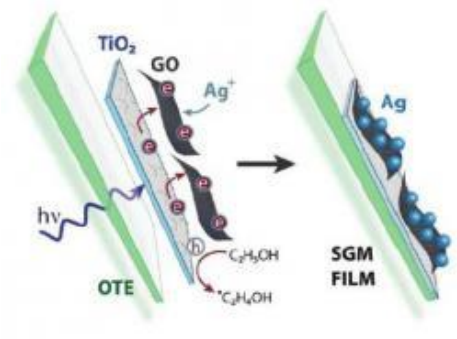
Overall, I really enjoyed my winter session research experience. Despite the fact that some of the applicable principles were beyond the scope of anything I had been taught prior, Dr. Ian Lightcap thoroughly explained the objectives and procedures. The work of past undergraduates that worked on this project was extremely useful in guiding my own work.

FINAL WRITTEN REPORT

(Please use the space below to describe your research project and objectives, any findings and results you can share, and graphs, charts, and other visuals to help us understand what you achieved as a result of this research experience.)

Scheme:

The methods developed for this project rely on the methods developed for a prior study, *Lightcap et al. 2012*. The scheme below demonstrates the composition of an ideal film after the controlled depositions. Instead of silver ions, iron ions were used for this project.



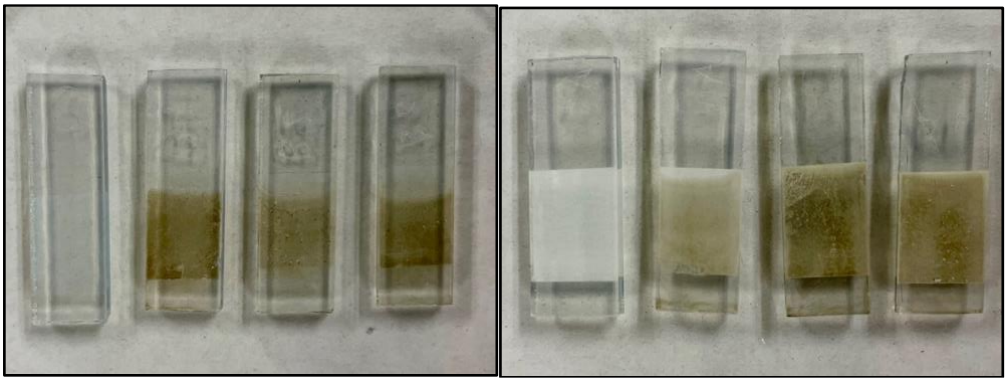
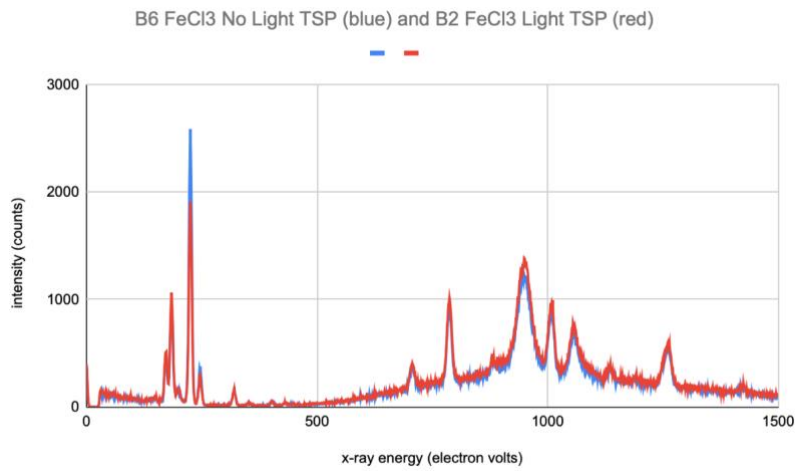
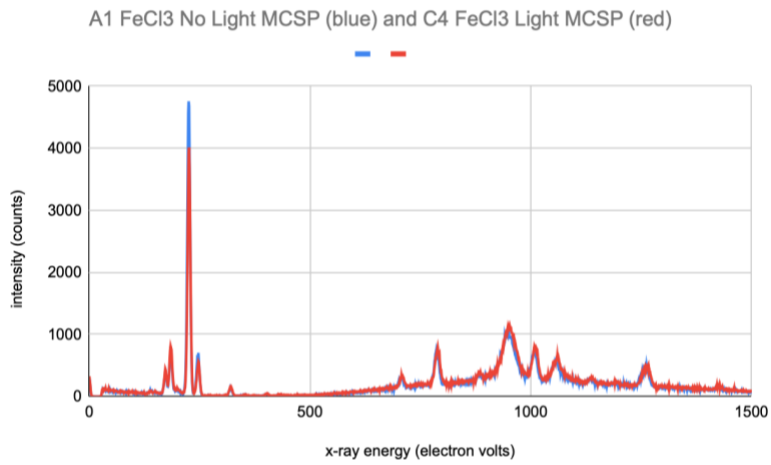


Figure 1. *Images of resulting films at each step of depositions on two types of Ti-nanoxide.* Films from left to right: C2-TiO2 T/SP, B4-EPDG T/SP, B2-EPDG/FeCl3 Light T/SP, B6-EPDG/FeCl3 No Light T/SP, A3-TiO2 MC/SP, A4-EPDG MC/SP, C4-EPDG/FeCl3 Light MC/SP, A1-EPDG/FeCl3 No Light MC/SP.

Methods of measurement:

Electrochemical characterizations of the materials were done to assess its catalytic efficiency and stability for oxygen reduction reactions. Ultraviolet–visible spectroscopy and x-ray fluorescence spectrometry were the two main analytical methods used up until this point.





Conclusions:

This project significantly relied on the efforts of previous undergraduate students whose work lay the foundation for the synthesis of sub-nanometer Fe clusters on graphene sheets. Two variables were investigated, the effects of illumination exposure for iron deposition and the type of titania paste used. The current data does not support the existing notion of illumination as necessary for Fe deposition, though statistical analyses and more precise measurements that quantify the relative amounts of iron nanoparticles should be done to verify this claim. If UV illumination is unnecessary, the implications of this study could be significant in better understanding electron photogeneration and scavenging mechanisms.

References:

Lightcap, I. V., Murphy, S., Schumer, T., & Kamat, P. V. (2012). Electron Hopping Through Single-to-Few-Layer Graphene Oxide Films. Side-Selective Photocatalytic Deposition of Metal Nanoparticles. *The Journal of Physical Chemistry Letters, 3*(11), 1453-1458. doi:10.1021/jz3004206