

Hoffman Estates High School Engineering Students Work with ChemMatCARS Through Argonne's Exemplary Student Research Program 2015 – 2016

In the fall of 2015, a group of Hoffman Estates High School engineering students accepted an invitation to join Argonne National Laboratory's Exemplary Student Research Program (ESRP). Scientists from ChemMatCARS, a national synchrotron facility dedicated to research in chemistry and materials research at the Center for Advanced Radiation Sources, University of Chicago, agreed to work with the HEHS team. The team consists of sophomores Allison Schrader and Matt Vlasaty, juniors Harpreet Auby, Jill Prigge and Miraj Shah and senior Dillon Vadgama.

On October 12, 2015 the team visited Sector 15 at Argonne's Advanced Photon Source (APS). The APS at the U.S. Department of Energy's Argonne National Laboratory provides ultra-bright, high-energy storage ring-generated x-ray beams for research in almost all scientific disciplines. During this visit they met with Dr. Binhua Lin and Dr. Yu-Sheng Chen of ChemMatCARS to learn about the Advanced Crystallography and Liquid Surface X-Ray Scattering facilities. The team also met Sean Griesemer, a University of Chicago undergraduate student researcher who has been working with Dr. Lin for the last three years.



The ESRP team at the University of Chicago – February 7, 2016

After the October meeting, the team discussed the options presented and requested to work with the Liquid Surface X-Ray Scattering setup. Dr. Lin, the ChemMatCARS Deputy Director, assigned Sean Griesemer to guide the team through the steps required to write a proposal and conduct research on nanoparticles using the Liquid Surface X-Ray Scattering equipment.

Argonne ESRP

Using the world-class facilities at Argonne's Advanced Photon Source (APS), high school students and their teachers work with Argonne scientists to prepare a research proposal, design an experiment, set up the experiment, gather and analyze data, make conclusions, and prepare a final poster. In this program, school teams are considered to be part of the larger Argonne international synchrotron light source user community.

ChemMatCARS

ChemMatCARS operates as a national research resource for the chemistry and materials research communities. ChemMatCARS welcomes students at all levels – high school, undergraduate, graduate and post graduate, into our laboratories, giving them the opportunity to learn about x-ray science and instrumentation as well as to be involved in hands-on activities.

The first step was to decide on an experiment. After brainstorming and research, it was decided that the team would continue the work started by Dr. Lin and Sean Griesemer. The team started writing an APS General User Proposal (GUP) and held a video conference with Sean on October 26, 2015 to help answer questions and finalize details. Sean reviewed several revisions of the proposal to help refine the content prior to the final submission. On October 30, 2015 the team submitted a proposal requesting three 8 hour shifts to “further investigate the assembly of binary mixtures of spontaneously self-assembled iron oxide nanoparticle films and their corresponding macromechanical properties.”



Team video conference with Sean Griesemer to discuss the research proposal.

All General User Proposals are reviewed by a panel of scientists. Researchers from around the world may submit proposals to work at one of the 35 sectors available at the APS and all proposals are judged. At the beginning of December the team was informed that they were approved for all three shifts. Their proposal earned a score of 1.7 on a scale of 1 to 5 where 1=Extraordinary, 2=Excellent, 3=Good, 4=Fair and 5=Poor.

According to Dr. Lin, three shifts are normally scheduled consecutively in a 24 hour period. The students were scheduled to begin their first shift at 8:00AM on February 14, 2016 and end their third shift at 8:00AM on February 15, 2016. In order to work at the APS, the students needed to register as APS users, receive badge numbers and complete all required training sessions. In addition, an on-site sector orientation needed to be completed when arriving for the first shift.

In preparation for their beam time, the team met with Sean Griesemer in Dr. Binhua Lin and Dr. Stuart Rice's lab at the James Franck Institute at the University of Chicago on February 7, 2016. The team learned the procedures for making nanoparticle solutions, preparing the equipment for scanning and organizing the data received from a scan.





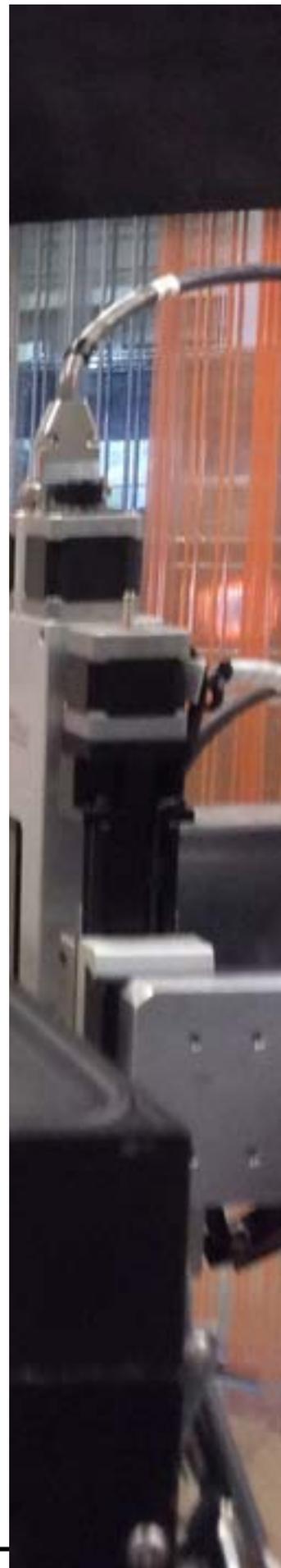
Miraj Shah prepares to make the first nanoparticle solution.

A sample solution was made by mixing 10 and 15 nanometer iron oxide nanoparticles in chloroform. The students would repeat the preparation of their test solutions on the day of their x-ray experiment in order to avoid long-term aggregation of the nanoparticles.

The Langmuir trough must be cleaned, filled with deionized water and the surface pressure of the water measured to be 72 mN/m (millinewton/meter) prior to applying a nanoparticle film. Though the equipment in Dr. Lin's lab is different from the setup that is used at ChemMatCARS, the team learned the basic procedures to follow at ChemMatCARS.



Jill Prigge and Dillon Vadgama clean and prepare the Langmuir trough.





Jill Prigge makes the mixture for application in the Langmuir trough.

The film is made by depositing the nanoparticle solution by syringe to the liquid-air interface of a Langmuir trough. The nanoparticles self-assemble into a monolayer film over the course of the deposition process. The Langmuir trough reduces the testing area and compresses the nanoparticle film. As the area is reduced, a sensor monitors changes in the surface pressure until a predetermined value is reached.



Dillon Vadgama applies the nanoparticle mixture to the liquid in the Langmuir trough.

In addition to the equipment, the team was given a brief introduction to the software used to collect and analyze data from the experiments. Sean was assisted by University of Chicago undergraduate student researchers Melanie Calabro and Pascal Pragnell.



The team after completing required sector training at the APS.

The team arrived on the morning of February 14, 2016 to begin their first shift. After finishing their sector training, Dr. Lin and Dr. Bu gave the team two short introductory lectures on synchrotron x-ray radiation and liquid surface x-ray scattering. The team broke into three groups for the first experiment. Dillon Vadgama and Jill Prigge began making samples and setting up the Langmuir trough. Harpreet Auby and Matt Vlasaty worked with Dr. Wei Bu on the procedure for performing the x-ray scattering measurements. Allison Schrader and Miraj Shah began working with Dr. Lin and Sean on the protocols for retrieving data, tabulating measurements, and keeping an electronic notebook as the data was collected.



Dillon and Jill prepare to stamp their first nanoparticle film.





Harpreet and Matt learn how to collect data from Dr. Wei Bu.

The team members took turns at each of the tasks. Overall, they found that it took between 30 and 45 minutes to clean and prepare the Langmuir trough before applying the nanoparticle film. Making the nanoparticle mixture took between 20 and 30 minutes. The application of the mixture took between 45 minutes and an hour. After the film was applied, a helium purge took about 20 minutes. The helium helps to reduce the number of molecules in the trough that may interfere with the path of the x-rays. The test itself required about 20 minutes. After the scan, a sample of the film was stamped onto a solid substrate for future study at an electron microscopy facility at the University of Chicago. This required between 15 and 30 minutes. As the team learned the process, they took about four hours to complete the first x-ray experiment from start to finish. By the end of their last shift, at about 7:00AM, they were able to complete an experiment in two and a half hours.



Allison and Miraj learn how to interpret and organize data from Sean Griesemer.



The ESRP team being guided by Dr. Binhua Lin and Sean Griesemer. Jill and Dillon can be seen in the video feed from the test hutch on the top monitor.

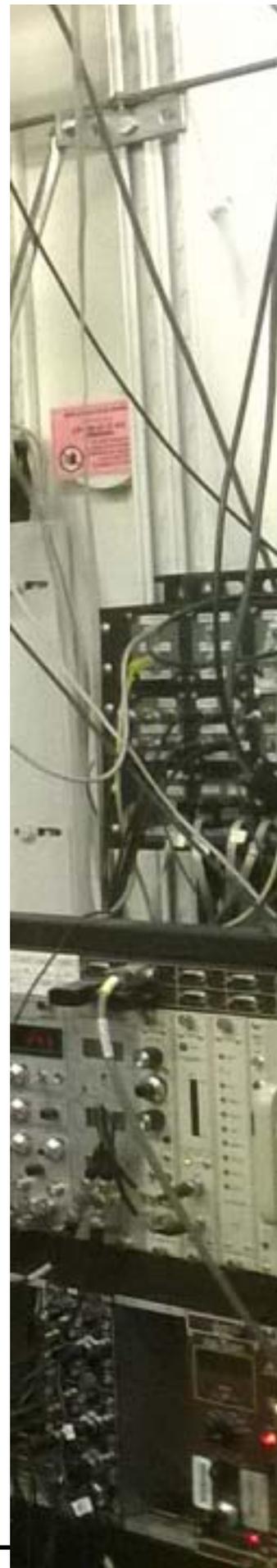
In the next few months, the team will work with Dr. Lin and Sean to analyze the data. The data collected by the team will be used as part of a larger data set. Sean Griesemer ran two days of testing in October 2015 and will run two more days of testing at the end of February 2016. After all of the data is collected and analyzed, the team will create a poster presentation and attend the 2016 Annual User's Meeting in May.

Written by Wayne Oras, Jr.

All photos courtesy of Wayne Oras, Jr. unless otherwise noted.

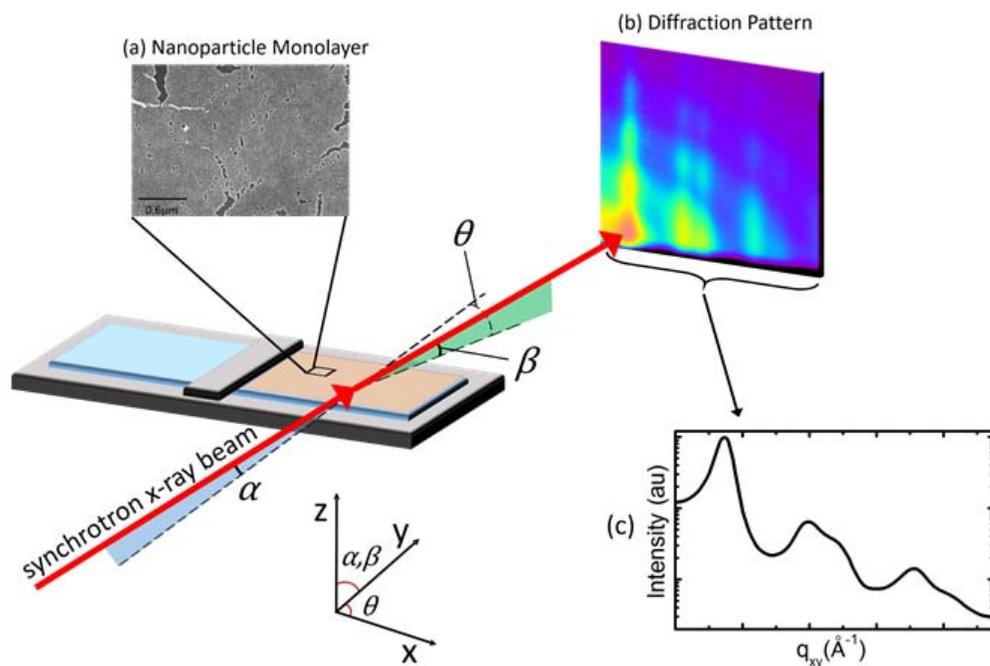


The ESRP team working with data while a test is running. Dr. Wei Bu and Sean Griesemer help guide the process.





The team working while a test is in progress.



Schematic of the geometry of Liquid Surface X-ray Scattering on the monolayer of iron oxide nanoparticle film on the surface of water:

- Scanning microscopy image of the nanoparticles
- X-ray diffraction pattern of the monolayer of nanoparticles
- Integrated intensity of the diffraction pattern.

Image courtesy of Dr. Leandra Boucheron, University of New Mexico.
Description courtesy of Dr. Binhua Lin, ChemMatCARS, University of Chicago.



HEHS ESRP team and ChemMatCARS Personnel – February 14, 2016
Image courtesy of Patti Pedernana and Kimberly Simms

The Hoffman Estates High School ESRP Team:

Allison Schrader, Sophomore	Jill Prigge, Junior
Matt Vlasaty, Sophomore	Miraj Shah, Junior
Harpreet Auby, Junior	Dillon Vadgama, Senior
Wayne Oras, Faculty Sponsor	

The Hoffman Estates High School ESRP Team would like to acknowledge:

Dr. Binhua Lin, Deputy Director, ChemMatCARS
 Dr. Wei Bu, Beamline Scientist, ChemMatCARS
 Dr. Yu-Sheng Chen, Operations Manager, ChemMatCARS
 Constance Vanni, Assistant Manager, User Programs, APS
 Sean Griesemer, Undergraduate Student Researcher, University of Chicago
 Melanie Calabro, Undergraduate Student Researcher, University of Chicago
 Pascal Pragnell, Undergraduate Student Researcher, University of Chicago
 Kimberly Simms, Sector User Coordinator, ChemMatCARS
 Louis Harnisch, Educational Program Coordinator, Argonne National Lab

Dr. Lin acknowledges the support of Sean Griesemer, Pascal Pragnell and Melanie Calabro, and the Lin/Rice laboratory at the University of Chicago under the University of Chicago MRSEC (NSF/DMR-1420709).

ChemMatCARS Sector 15 is principally supported by the Divisions of Chemistry (CHE) and Materials Research (DMR), National Science Foundation, under grant number NSF/CHE-1346572.

This research used resources of the Advanced Photon Source, a U.S. Department of Energy (DOE) Office of Science User Facility operated for the DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357.



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