HEMI

HOPKINS EXTREME
MATERIALS INSTITUTE

Student Research Internships and Apprenticeships

Summer 2018

JOHNS HOPKINS
UNIVERSITY

From the HEMI Director

Welcome to the Hopkins Extreme Materials Institute (HEMI) at Johns Hopkins University. Each summer, we offer a number of opportunities for high school, undergraduate, and graduate students to conduct research within HEMI and at partner institutions. Our programs are very competitive, and we always have excellent applicants. These exciting opportunities allow students to experience state-of-the-art research techniques, laboratory facilities and individual mentorship firsthand. Students gain valuable insights into university-led research, which will hopefully inspire them to pursue a future career in a STEM-related field.

I am proud of the students and the research activities they conducted during this summer. I am also grateful to the faculty hosts, mentors, and administrative personnel who ensured the students had the resources and guidance for a rich and rewarding experience. HEMI would like to acknowledge the funding organizations: Army Educational Outreach Program, Army Research Office, Army Research Laboratory, Maryland Institute College of Art, The Leadership Alliance, and The Whiting School of Engineering at Johns Hopkins University for providing the financial resources which make these opportunities possible. The summaries included (written entirely by the students) provide a glimpse of the hard work of these dedicated students. I hope this encourages students to apply in 2019!

Sincerely,

KT Ramesh
Director
Alonzo G. Decker Chair Jr. Professor of Science and Engineering

Contents

HEMI Administration Supporting these Programs

Lori Graham-Brady
Associate Director

Victor Nakano
Executive Prog. Dir.

Bess Bieluczyk
Sr. Admin. Coord.

Jess Ader
Comm. Specialist

Research and Engineering Apprenticeship Program (REAP)

REAP is a summer STEM program that places talented high school students, from groups historically under-represented and underserved in STEM, in research apprenticeships at JHU. REAP apprentices work under the direct supervision of a mentor on a hands-on research project. REAP apprentices are exposed to the real world of research, gain valuable mentorship, and learn about education and career opportunities in STEM. REAP apprenticeships are 5-8 weeks in length (minimum of 200 hours) and apprentices receive a stipend.

Program Goals

- To provide high-school students from groups historically under-represented and underserved in STEM, including alumni of the AEOP's UNITE program, with an authentic science and engineering research experience;
- To introduce students to the Army's interest in science and engineering research and the associated opportunities offered through the AEOP;
- To provide participants with mentorship from a scientist or engineer for professional and academic development purposes; and
- To develop participants' skills to prepare them for competitive entry into science and engineering undergraduate programs.

Funding Sponsor

Army Educational Outreach Program

Website Information

https://www.usaeop.com/program/reap/

2018 REAP Students with U.S. Army Guests

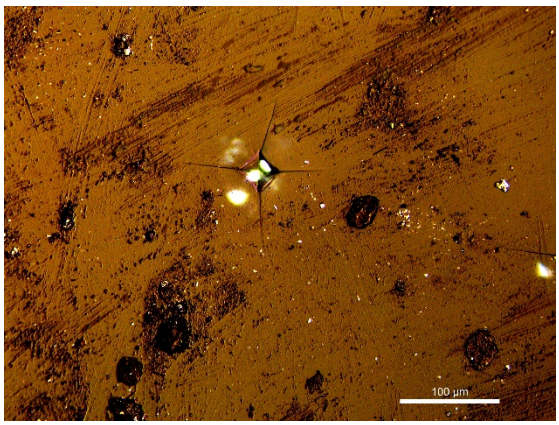
Taylor Beverly

Eleanor Roosevelt High School, Greenbelt, Maryland
Mentor: Kimberly Andes
Faculty Host: Professor KT Ramesh
Department of Mechanical Engineering
Johns Hopkins University

Project Title: Using Indentation to Analyze Amorphization within Single Crystal Quartz

This summer I focused on the concept of pressure and shear induced amorphization which is the breaking of bonds within a material which then results in the randomized restructuring of those newly broken molecules. This newly formed structure is then called an amorphous band and causes the material to weaken and fail earlier than expected. Within my experiment I used single crystal quartz as the material being tested, and a Vickers Indenter to create the high levels of stresses need to create amorphous bands. In order to make the indents I first had to prepare each sample of quartz. The first

process of preparing the quartz was to cut each twenty millimeters in diameter samples of quartz into 5x5 millimeter pieces using a diamond wire saw. This approach varied from my mentor's initial attempt at performing indents of the quartz, and it helps to increase accuracy with the spacing of the indents and allows one to make many more indents that will be easier to locate. I then had to mount each individual newly cut piece using a mounting press. I originally started with two uncut samples of quartz and ended up mounting a total of twenty-four 5x5 millimeter quartz samples because the outer rim pieces were too small to indent. Once finished mounting each sample I was then able to use the Vickers Indenter. One of my main goals while using the Vickers Indenter was to find the most ideal load to apply to the quartz in order for amorphous bands to form. In order to determine the most ideal load I performed various idents on one sample of quartz and analyzed each one to see which load made a big enough indent, and also created the least amount of damage. By the end of the experiment I concluded that the 1000N load was the most ideal to create amorphization. In addition to finding the ideal load, I was also able to use the Vickers Hardness equation to calculate the hardness of the quartz.



A 1000N Vickers Indent to a sample of single crystal quartz at the 20x objective

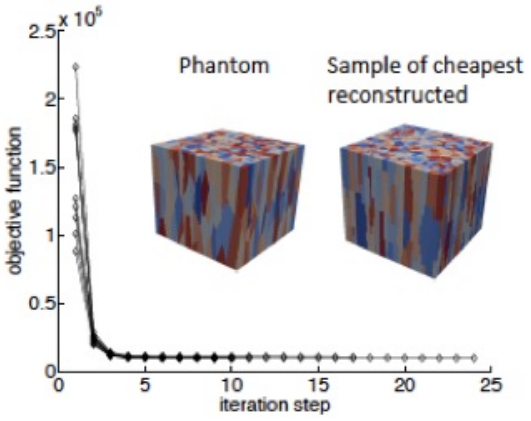
Chimmuanya Iheanyi-Igwe

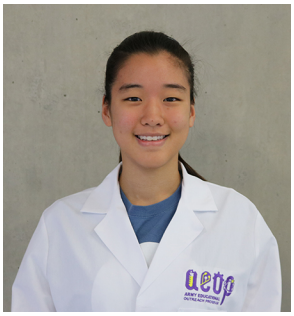
Howard High School, Ellicott City, Maryland
Mentor: Noah Wade
Faculty Host: Professor Lori Graham-Brady
Department of Civil Engineering
Johns Hopkins University

Project Title: Error Quantification of Microstructure Characterization

For creating computational models, material samples undergo a data collection process resulting in the creation of a digital three-dimensional microstructure of the original material. During this process, different parameters are set that affect the accuracy of the microstructural data set. However, current methods do not provide adequate ways to quantify the accuracy of the microstructure. Therefore it is not possible to understand exactly how these parameters will affect the accuracy of the final model. In order to solve this problem, we created a computational method that is able to simulate the data collection process of microstructure characterization. A digital synthetic material is sliced and analyzed through the program, varying each parameter to simulate the reconstruction process microstructures undergo. This material serves as the baseline for other simulations as it can be altered without loss

of data. A 160x160x160 voxel phantom representing a nickel alloy was used for the simulations. During the reconstruction, the effects of the parameters are tracked relative to the amount of error produced. My role was to run test simulations of the framework, using code from MATLAB to conduct data processing through DREAM-3D. Using this software, I was able to set different filters for specific datasets, and see how each final microstructure was affected by my choices. Using this method, one can learn how their parameters affect their data, and determine which are best suited for their specific data set. Overall, this method helps to optimize parameter selection, and provide further insight into the data collection process.





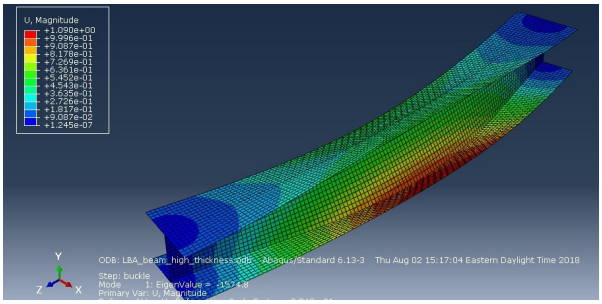
Grace Kim

Poolesville High School, Poolesville, Maryland
Mentor: Aakash Bangaore Satish
Faculty Host: Professor Michael Shields
Department of Civil Engineering
Johns Hopkins University

Project Title: Implementation of Uncertainty Quantification with Python (UQpy) within ABAQUS

Uncertainty Quantification with Python (UQpy) is a general purpose python toolbox that helps users to model uncertainty in physical and mathematical systems. This incorporation of uncertainty is essential to take into account the uncertainties that are present within the physical world. UQpy allows for much more efficiency in the process of propagation of uncertainty through models. Throughout my internship, I worked specifically on the interfacing of UQpy with commonly used third party software applications such as ABAQUS (a finite element analysis software). To begin this process, the user needs to provide a template input script for the third party model that UQpy can use to create sample input files. UQpy generates random inputs according to the specified probability distributions through advanced sampling methods enabling the user to conduct Monte Carlo simulations with variance reduction, and replaces the variables the user identifies within the template input script. UQpy then will utilize several other scripts (UQpy_Input, UQpy_Model, UQpy_Output) in order to run the 3rd party models. I utilized UQpy to run an ABAQUS beam analysis model to observe the effects of changing the Young's modulus and the thickness of an I-beam on the eigenvalue. The eigenvalue corresponds to the critical buckling load applied onto an object and hence, represents the moment capacity for beams. When the load reaches this moment capacity, the beam buckles, which is considered a stability failure. The larger the moment capacity, the stronger the beam becomes as larger force must be applied to

create a failure within the beam. For each parameter, I ran 100 samples with inputs generated through UQpy to see the direct correlations of each variable separately. Then I ran 100 samples with changes in both parameters to see if there were any changes in the response of the beam. Through the large data analysis conducted by UQpy, I was able to find that separately, both the Young's modulus and the thickness of the beam had direct relationships with the moment capacity, but when combined, the thickness of the beam was the dominant parameter.



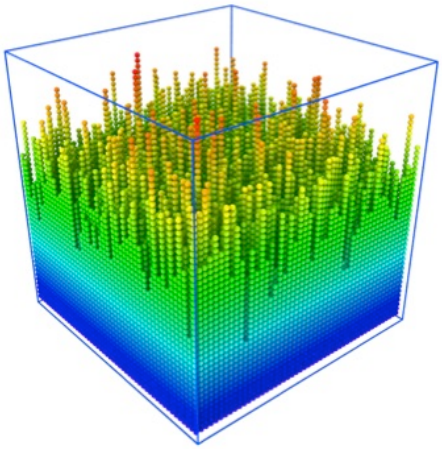
Brook Mesfin

Walter Johnson High School, Bethesda, Maryland
Mentor: Joel Clemmer
Faculty Host: Professor Mark Robbins
Department of Physics and Astronomy
Johns Hopkins University

Project Title: Simulating Disorderly Surface Growth Models in 3D

During my six weeks at the Bloomberg Center for Physics and Astronomy, I worked on creating three-dimensional models of various types of surface growth such as the Random Deposition Model, the Surface Relaxation Model, and the Eden Model. Understanding surface growth is vital due to its ubiquity in nature. Wildfire, tumors, and molecular beam epitaxy (a process used to create computer chips and CD's) are just a few examples that model surface growth. After learning Python, I could then work on the first and most basic model, the random deposition model. In this model, particles are released from above until sticking perpendicularly to a flat surface, which forms a surface over time. Because there is no correlation between the given heights at one position versus another, this model creates a very rough surface. However, in the surface relaxation model there is correlation between points on the surface, so when particles fall along each column, they essentially "stop and think" where the lowest height is in respect to the particle's current location. With this model, particles tend to smoothen out – or "relax" – over time mimicking nature's innate property to be at equilibrium and in balance. The final and most complicated model of the three is the Eden model where each new particle can be added at any perimeter point of a previously deposited particle. This enables the interphase to form overhangs and other interesting features, which actually models the growth of a tumor. After writing the code for all the models, I then transferred it into OVITO, a visualizing tool, to study the interphases in 3-D. I analyzed how each statistic such as the average height, standard deviation, and the Hurst exponent differ with

model and sample size. In order to study these finite size effects, it was necessary to move on to the Homewood High-Performance Cluster (HHPC), a supercomputer capable of running these larger system sizes.



3D Random Deposition Model

Undergraduate Research and Apprenticeship Program (URAP)

URAP provides undergraduate students with an authentic science and engineering research experience alongside university researchers sponsored by the Army Research Office. Through this commuter program, students will develop skills in Army critical science and engineering research areas in a university lab setting to prepare them for the next steps of their educational and professional career.

The US Army established the Center for Materials in Extreme Dynamic Environments (CMEDE) to design, develop and test improved soldier protection materials. JHU leads the CMEDE collaborative research alliance, which includes university and research institutions across the United States, the United Kingdom, and Germany. Together these partners, in close collaboration with the Army Research Laboratory, serve a vital role as a materials-by-design capability for the US Army. URAP opportunities within CMEDE are available at universities performing research on this program.

Students receive an educational stipend and contribute to the Army's research in the laboratory while learning research methods, using advanced research equipment and becoming a part of an active research group. This authentic experience provides exposure to science and engineering research careers.

Program Goals

- Provide authentic science and engineering research experience to undergraduate students pursuing science and engineering majors;
- Introduce students to the Army's interest and investment in science and engineering research and the associated educational opportunities available through the AEOP and DoD;
- Provide participants with experience in developing and presenting scientific research;
- Provide participants with experience to develop an independent research program in preparation for research fellowships, graduate school, and careers in science and engineering research;
- Benefit from the expertise of a scientist or engineer as a mentor for professional and academic development purposes; and
- Develop students' skills and background to prepare them for professional and academic development purposes.

Funding Sponsor

Army Educational Outreach Program and the Center for Materials in Extreme Dynamic Environments

Website Information

URAP - https://www.usaeop.com/program/undergraduate-research-apprenticeship-program-urap/

CMEDE - https://hemi.jhu.edu/cmede/

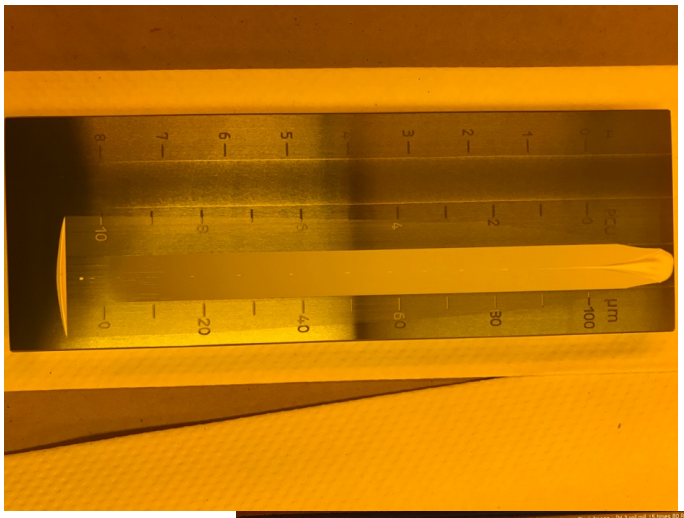
2018 Undergraduate Research and Apprenticeship Program (URAP) Awardees

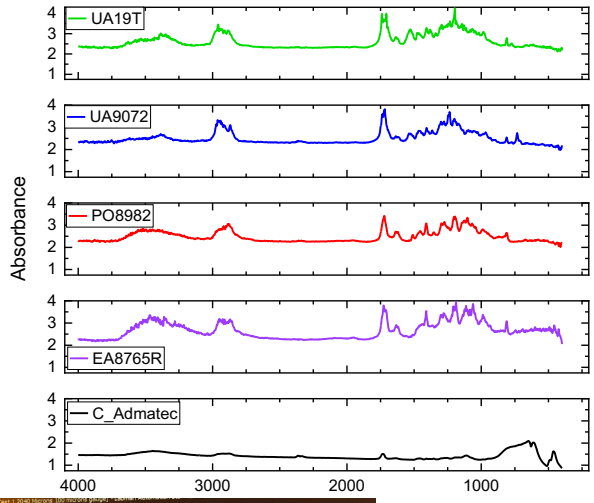
Krishna Bhutada

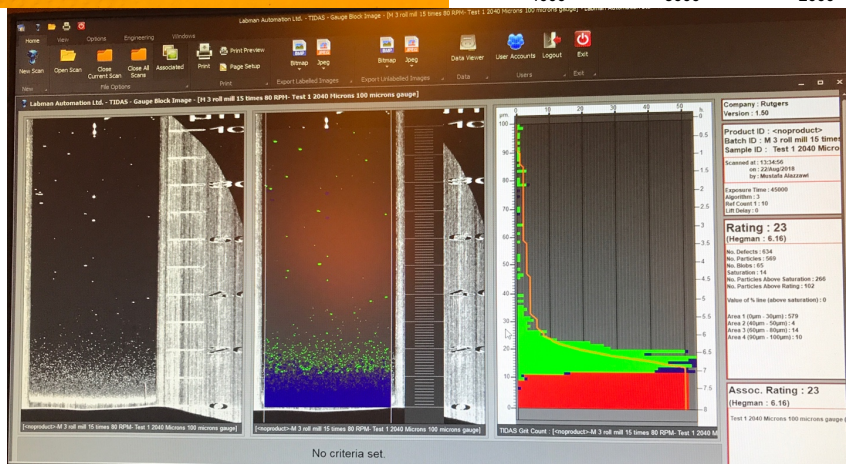
Rutgers University, Piscataway, New Jersey
Mentor: Berra Beyoglu
Faculty Host: Professor Richard Haber
Department of Materials Science and Engineering
Rutgers University

Project Title: Evaluation of Commercial Additive Manufacturing Slurries

Characterization tools and methods were used to evaluate the components of commercial additive manufacturing slurries. First, to identify the specific alumina as well as potential polymers used in the commercial additive manufacturing slurries being evaluated I used Fourier-transform infrared spectroscopy, particle size analyzer, and BET analysis. Utilizing the three roll mill, the slurries were rolled to find the ideal combination of speed in revolutions per minute and the number of times milled to reduce the amount of agglomerations and improve the consistency. Methods such as the Malvern Kinexus helped to determine the optimal rheology to increase dispersion, colloidal and emulsion stability for the slurries by examining the cohesive energy. The automated Hegman gauge, TIDAS, helped to examine exactly how finely ground the solid alumina particles were dispersed within the slurry.





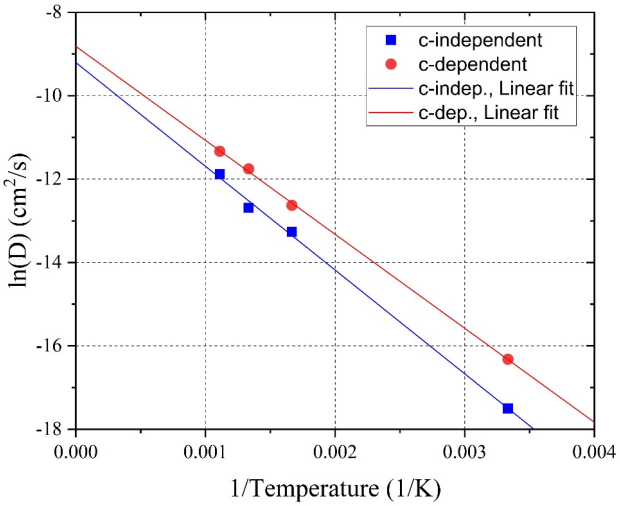


Chaitayna "Chad" Daksha

University of Delaware, Newark, Delaware
Mentor: Sanjib Chowdhury
Faculty Host: Professor Jack Gillespie
Department of Mechanical Engineering and
Center for Composite Materials
University of Delaware

Project Title: Molecular Modeling of Epoxy-Amine Inter-Diffusion

Inter-diffusion between a matrix and fiber sizing is an important mechanism governing interphase formation during composite processing. Diffusion governs the concentration gradients, interphase thickness and the resulting atomic structure and properties of the interphase. Film former Epoxy and curing agent Jeffamine are two main constituents of the matrix and sizing phases, respectively. In this study, the inter-diffusion between an Epoxy film former (Epon) and Jeffamine curing agent is investigated by performing a series of molecular dynamic simulations using the general AMBER force field (GAFF) classical interatomic potential. In the simulations, Epon and Jeffamine phases are initially combined to form a discrete boundary followed by relaxation, tracking of molecules and the creation of concentration profiles. All simulations are performed over a wide range of temperatures. Simulation results indicate that inter-diffusion is Fickian type and temperature dependent inter-diffusion follows Arrhenius law. Inter-diffusion coefficients at room temperature are on the order of 10^{-8} cm^2/s. The use of short-term data to predict long time scale diffusion and interphase morphology is assessed.



Comparison of diffusivities calculated using concentration dependent vs. concentration independent methods. Results show good agreement.

Stephanie Hernandez

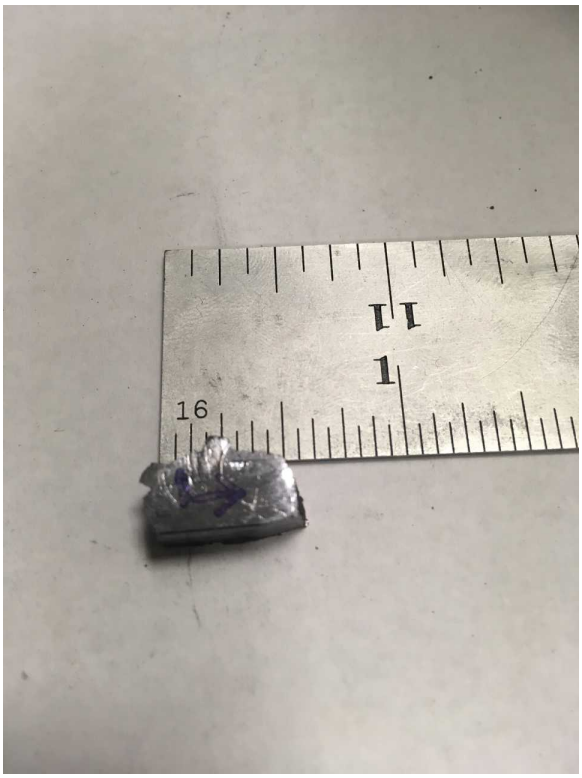
Johns Hopkins University, Baltimore, Maryland
Mentor: Suhas Eswarappa Prameela
Faculty Host: Professor Timothy Weihs
Department of Materials Science and Engineering
Johns Hopkins University

Project Title: Study of Extrusion Parameters on the Microstructure Evolution of Mg Alloys

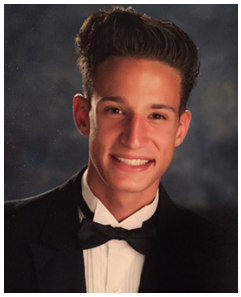
As part of the Material in Extreme Dynamic Environments (MEDE), our project is focused on creating a lightweight yet strong material to be used in body armour for soldiers. Magnesium and its alloys are the focus of our research due to their potential in having a high ballistic performance comparable to that of steel as well as being far less dense than other metals. Magnesium alloys such as Mg-9Al (wt.%) (A9) and Mg-6Al (wt.%) (A6) are experimented on to analyse their dynamic and spall strength.

In this project, A9 and A6 have undergone Equal Channel Angular Extrusion (ECAE) under differing parameters to achieve ultrafine grain sizes of 200 to 500 nanometres. Crystals within the sample are broken up to create more grain boundaries and induce dynamic precipitation inside the grains. These alloys are processed through extreme plastic strain through simple shear, specifically through Route B_c (a method in which the extruded sample is rotated 90° clockwise at each successive pass). Comparative study for both materials have been carried out in similar parameters that include temperature, extrusion rate, backpressure, and number of passes.

Before the sample is extruded, pre-existing precipitates must be removed, so the sample is solution treated in which it is placed in a furnace at 450°C for 24 hours. It is then cold water quenched. To verify that the solution treatment was successful, optical microscopy and X-ray diffraction have been used to analyse the grain boundaries and surface for any precipitates. In future, we plan to employ scanning electron microscopy (SEM) on the extruded samples for texture evolution and precipitate distribution.



A sample of A9 extruded at a 2 pass through the BC route.



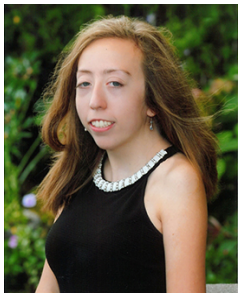
Sean Kennedy

University of Delaware, Newark, Delaware
Mentor: Raja Ganesh
Faculty Host: Professor Jack Gillespie
Department of Mechanical Engineering and
Center for Composite Materials
University of Delaware

Project Title: Single-Fiber Fragmentation Testing of S-Glass/Epoxy Composites

During the summer of 2018 at the Center for Composite Materials, I worked on Single-Fiber Fragmentation Testing of S-Glass/Epoxy Composites. During the completion of the 300 hours, I received hands-on training and experience in many different disciplines of research such as sample preparation, data collection, and data analysis. The goals of this research were to perform Fiber Fragmentation tests on 10-micron diameter S-glass fibers embedded in Epoxy dogbone specimens, determine the fiber-strength distribution at a gauge length corresponding to the ineffective length of the composite, and measure the interfacial debond growth that accompanies the fiber fracture. The main focus of this research was the study of micromechanical damage mechanisms leading to composite tensile failure, which include fiber break, matrix plasticity, interfacial debonding, and matrix micro-cracking. Sample preparation included isolating and laying a single S-glass fiber in a silicone mold, preparing and pouring an Epoxy mixture in the mold, putting the mold through a heat cycle to cure the Epoxy, and carefully polishing the samples with increasingly fine grit sandpaper. Thermal compressive residual strain is introduced into the fiber during the cure shrinkage of the specimen from the post-cure temperature to room temperature due to the mismatch in Coefficient of Thermal Expansion between the fiber and the matrix. To counteract this, a precisely calculated pre-strain is introduced into the fiber by suspending weights during specimen preparation. The objective of the single-fiber fragmentation test was to measure the number and location of fiber breaks as a function of applied strain on the Epoxy specimen using a screw-driven MTI mini-tensile tester at a nominal strain rate of 0.001/min. The microscope used to observe the breaks was a Keyence VHX Digital Microscope with transmitted cross-polarized lighting. In addition to the number of breaks as a function of strain, I was also able to measure the interfacial debond length as a function of strain using ImageJ software. The future work of this research includes extending the fragmentation testing to multiple-fiber specimens in order to understand how the interaction between multiple fibers affects these damage mechanisms.

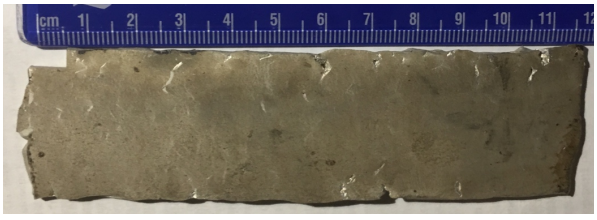
Beatriz Medeiros

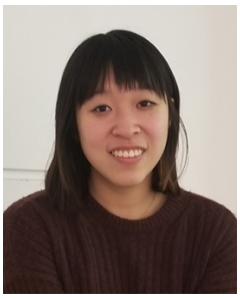


Johns Hopkins University, Baltimore, Maryland
Mentor: Suhas Eswarappa Prameela
Faculty Host: Professor Timothy Weihs
Department of Materials Science and Engineering
Johns Hopkins University

Project Title: Study of Rolling Parameters on The Microstructure Evolution of Mg Alloys

The Materials in Extreme Dynamic Environments (MEDE) project is focused on designing light body armor materials for soldiers. We focus on magnesium alloys because they are less dense than commonly used materials such aluminum and steel and show a promising potential for improved dynamic performance. The main goal is to improve dynamic and spall strength of magnesium by modulating the microstructure of the material. We employ thermomechanical processing techniques to change the microstructure of magnesium and magnesium alloys. Rolling is one such thermomechanical process, which is commonly carried out for grain refinement as well as to control texture. I have done extensive literature review on various techniques of rolling such as conventional rolling, hot rolling, multi-pass rolling, confined rolling, asymmetric rolling, etc. I have also sought to understand the effects of each of these kinds of rolling on grain size distribution and texture. I focused on determining the key parameters for rolling of magnesium and magnesium alloys. I then began by learning conventional rolling and determining the necessary conditions such as the amount of thickness reduction per pass and the temperature required to avoid cracking and undesired deformation (curving) in the material. After determining these parameters, I carried out hot rolling on pure magnesium at 200OC with 10% thickness reduction per pass for a total thickness reduction of 50% from the original thickness of 5mm. I performed X-ray diffraction (XRD) on the sample before and after rolling to analyze the effect of rolling on texture. It was found that after rolling, a significantly larger peak occurred in the XRD analysis for the (001) plane, the basal plane, which is the closed-packed slip plane in the magnesium lattice. This result indicates that slip deformation was successfully activated, as intended, during the process of hot rolling such that slip planes were aligned with the c-axis normal to the rolling direction. In addition, I performed etching and optical microscopy in order to observe the effects of rolling on grain size, which showed that rolling resulted in grain refinement and that grain size remained uniform across the normal plane of the rolled sample. I have future plans to perform Electron Backscatter Diffraction (EBSD) on the sample in order to better measure both grain size and texture in the rolled sample.





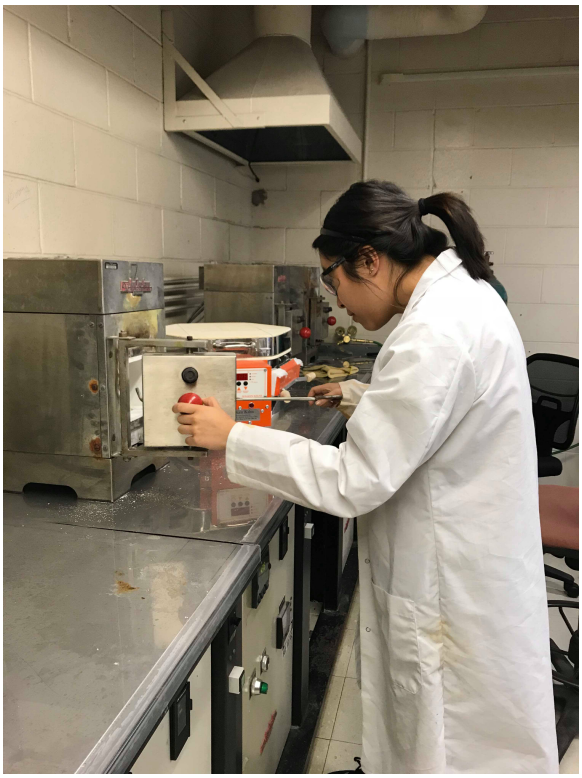
Kaitlin Wang

Rutgers University, Piscataway, New Jersey
Faculty Host & Mentor: Professor Richard Haber
Department of Materials Science and Engineering
Rutgers University

Project Title: Molten Salt Synthesis of Boron Nitride

We investigated the effect of molten salt (NaCl/KCl) on boron nitride synthesis for the purpose of lowering the synthesis temperature through improved reaction kinetics. We used standard boron nitride precursors of boric acid and ammonium chloride with sodium and potassium chloride and were successful in synthesizing developed boron nitride. Following this, we are currently attempting to use melamine and urea as well to demonstrate the effect on varying precursors. Various eutectic salt compositions were tested for the sake of attempting to further lower the synthesis temperature due to having lower melting points. However, these proved ineffective as the salt medium then reacted with the precursors.

Samples were analyzed using XRD as well as FTIR to conduct phase and composition analysis. Precursors were prepared by using standard molar ratios and crushed using mortar and pestle. These precursors were then heated in a furnace at varying target temperatures.



Ethan Wise

University of Delaware, Newark, Delaware
Mentor: Sanjib Chowdhury
Faculty Host: Professor Jack Gillespie
Department of Mechanical Engineering and
Center for Composite Materials
University of Delaware

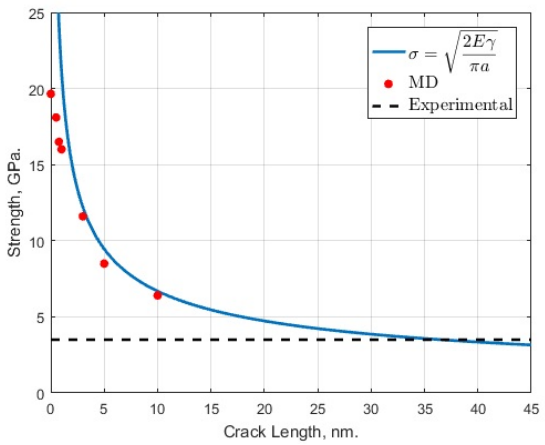
Project Title: A Molecular Dynamics Study of Glass Fiber Fracture

Project-1

Performance of glass fiber-epoxy composites is greatly influenced by sizing structure and its interaction with the fiber surface and epoxy resins. The structure of the Glycidoxypropyl-trimethoxy silane (GPS) based sizing layer and its interaction with glass fiber surface are studied using molecular dynamics (MD) simulations. A non-aqueous sizing layer is prepared by mixing 0-30% wt. concentration of GPS with film former. First, silica-sizing systems are equilibrated with non-reactive General AMBER Force Field (GAFF) to identify the equilibrium sizing structure. The condensation reaction, which forms Si-O-Si linkages between GPS molecules and between GPS and glass surface, is modeled with a cross-linking algorithm. Silica-sizing models are then subjected to tensile loading with reactive force field ReaxFF to determine mechanical properties. Simulations results show that silane molecules agglomerate and make macromolecules creating inhomogeneous sizing structure. Under mechanical loading, damage initiates and propagates in the FF rich region. An increase in the GPS concentration shows no improvement in mechanical properties.

Project-2

Glass fiber performance is also influenced by surface cracks, which develop during manufacturing and handling. Effects of surface cracks on the mechanical properties of glass fibers are studied through reactive, all-atom MD simulations. Energy dissipation mechanisms are studied via bond breakage and a discretized J-Integral calculation. Surface cracks of different lengths are created by deleting atoms. Interatomic potentials are determined by ReaxFF. Simulation results indicate that surface cracks have no effect on glass fiber modulus. However, fiber strength is significantly reduced by the presence of surface cracks. The MD derived strength versus crack-length response is in good agreement with continuum mechanics prediction. An extrapolation of MD results indicates that the average experimental fiber strength corresponds to a surface crack of 35 nanometers.



Strength vs crack length of silica glass fiber

Extreme Science Internships (ESI)

ESI provides opportunities for Morgan State University (MSU) students to participate in both internal and external internships associated with the Center for Materials in Extreme Dynamic Environments (CMEDE). ESI are STEM-focused with a particular emphasis on providing research opportunities related to MEDE, a basic research program focused on designing, developing and testing improved soldier protection materials.

ESI is open to undergraduate and graduate students in MSU's School of Computer, Mathematical, and Natural Sciences and the School of Engineering.

Internal ESI are hosted by MSU faculty on the campus of Morgan State University. External ESI are conducted at one of the CMEDE university and research institutions located across the United States, the United Kingdom and Germany. ESI are paid internships in accordance with MSU policies and regulations.

Program Benefits

- Opportunities for undergraduate/graduate students to gain a research experience, and to present the findings of their research;
- Opportunities for students to meet colleagues at majority institutions to develop research collaborations;
- Engage representatives from majority academic institutions to explore opportunities to pursue graduate degrees; and
- Expand their professional networks and further position students for future job opportunities.

Funding Sponsor

Army Research Laboratory through the Center for Materials in Extreme Dynamic Environments

Website Information

Morgan State University ESI

https://www.morgan.edu/school_of_computer_mathematical_and_natural_sciences/student_programs/internships_and_fellowships/extreme_science_internships.html

CMEDE

https://hemi.jhu.edu/cmede/

2018 External ESI Students

Tyler Amory-Moody

Morgan State University, Baltimore, Maryland
Mentor: Dr. Dereje Seifu, Morgan State University
Faculty Host: Dr. Shashi Karna
U.S. Army Research Laboratory at Aberdeen Proving Ground, MD

Project Title: Utilizing PPMS to measure the transport property of tunneling magneto-resistance for Fe/$Bi2Te3$ /Fe

Characterization of tri-layer thin films Fe/ $Bi2Te3$/Fe is accomplished through various methods including utilizing the Physical Properties Measurement System (PPMS). Various other methods are employed resulting in verification of values and additional characterization. Those methods include using the Vibrating Sample Magnetometer (VSM), Torque Magnetometry (TMM), Magneto-Optics Kerr Effect (MOKE), Scanning Electron Microscopy (SEM), and Raman spectroscopy. All measurements on the sample were conducted at room temperature and the results were compared to known values whenever possible. Further transport measurements were performed using the four-point probe technique which required the use of two different instruments (SES 4200 four-point probe machine and a Keithley Sub-Femto Amp Remote Source Meter). The PPMS will be interfaced with software in the near future to collect data such as the sample's resistivity at a greater rate and at temperatures that correspond to liquid helium. All experimental data were recorded in a laboratory notebook in an organized manner.

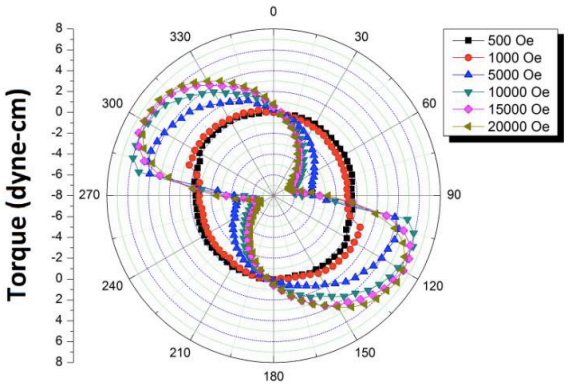
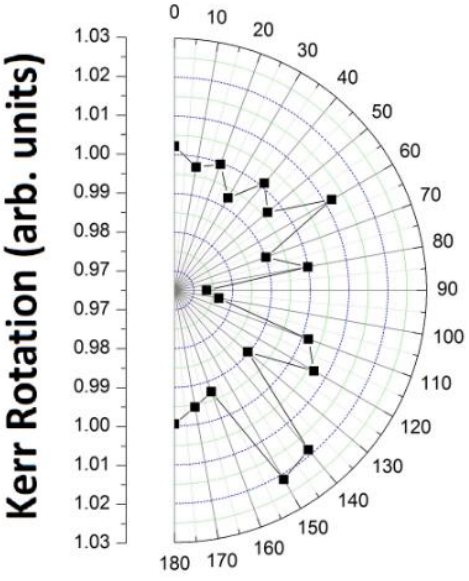


Fig 1 Torque vs Angle

Fig 2 Kerr Rotation vs Angle

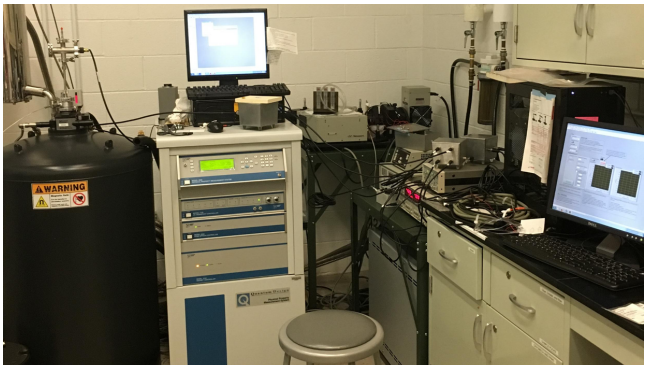


Nafetalai Fifita

Morgan State University, Baltimore, Maryland
Faculty Host: Dr. Adam Phelan
Department of Physics & Astronomy
Johns Hopkins University

Project Title: Novel magnetic susceptibility measurement with the Chicago Diamond Anvil Cell (DAC)

This project was focused on a novel method to measure magnetic susceptibility of materials integrated into the Chicago Diamond Anvil Cell. The design is a three-pair coil system (figure 1) with a 4.7K external resistor connected in series with the source to minimize temperature dependent of current in the coil. One pair is the sample coils, drive and pick-up coils and the other two are compensation pairs (One for coarse compensation and the other for fine compensation). The pickup circuit is connected to a pre-amplifier (SR560 Stanford Systems) and Lock-in amplifier (SR830 Stanford Systems). The concept is to place the sample inside the drive coil excited by AC source of 0.8V at 757.1Hz frequency which triggers the sample to induce a current I on a pick- up coil. This initial current I is cancelled out by current I_{c1} and I_{c2} from the two pairs of compensation coils. The DAC (together with the drive and pick-up coil) is then connected to an insert (which comes with the Chicago DAC) for Helium gas induced pressure and put inside PPMS where the temperature can be set to as low as 2K. The temperature is increased from 2K at a steady rate and a jump at the critical temperature of the material can be observed. All coils were wounded using a 25µm insulated copper wire with the Sample Coils, drive = 1450 turns, pick-up = 170 turns. Coarse compensation pair, drive compensation coil = 2800 turns, pick-up compensation coil = 550 turns. Fine compensation pair, drive compensation coil = 2800 turns, pick-up compensation coil = 60 turns (about $1/10^{th}$ of the coarse compensation pair). Using these set of coils the 800mV initial excitation was compensated down to about 8mV with x3000 gain at 120.46Hz. Now that the compensation has reached an acceptable level, the next step is to find a suitable frequency and set a cut-off since there is a sensitivity overload at 120.46Hz.



Michael Guy

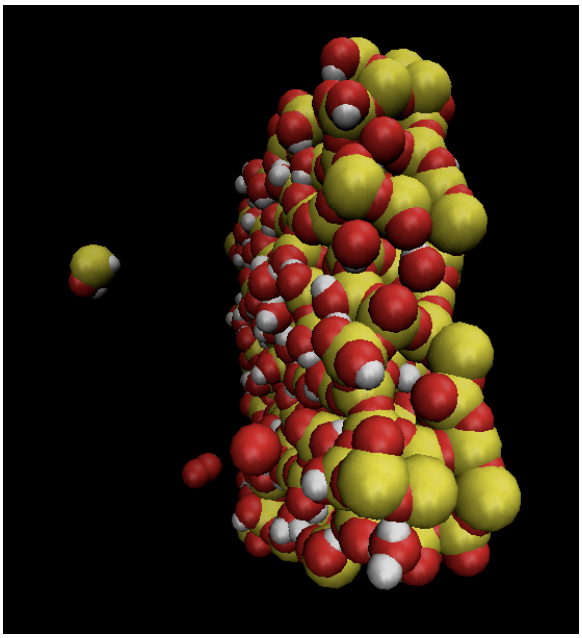
Morgan State University, Baltimore, Maryland
Faculty Host: Professor William Goddard
Department of Chemistry & Chemical Engineering
California Institute of Technology

Project Title: Doping, Force Fields, and Molecular Collisions

The first project that I was tasked with was to model computationally what had already been shown experimentally. The premise for our project is that in 2015 the European Space Agency discovered that there was a notable amount of molecular Oxygen on a comet (67P). This is particularly interesting as O2 is extremely rare on a cosmic scale. The prevalent hypothesis on this issue was that this must have been formed primordially along with the early universe by mechanisms that could only be guessed at. However, recently, Dr. Kostas Giapis found a mechanism that shows that this O2 formation may occur in real time. By accelerating H2O or CO2 ions at a surface such as Au or SiO2 at a significant enough velocity (~100 ev) O2 can be produced by the collision. We were able to run a collision that does this successfully and have produced molecular oxygen from H2O.

The second project that I worked on is applying a water force field that was developed by a professor in our group at Caltech, Dr. Naserifar to various amino acids. Dr. Naserifar's force field is a considerably more accurate representation of real water than the force field is a considerably more accurate representation of real water than the force fields that have been developed previously. We were tasked with applying this force field to various amino acids.

The third project was about doping nitrates. Nitrates are extremely important to agricultural practices across the world. Placing cobalt in the second layer of nitrates has been shown to reduce the total energy of the system. Therefore, we have been provided 6 layers of iron atoms with hydrogens and nitrogen towards the top layers in various configurations. Our task was, for each of the configurations, to replace an atom in the second layer of the surface and to analyze the total phonon energy of each configuration to determine the lowest energy frame.

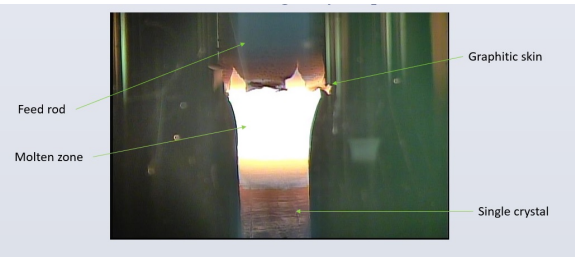


Michael Straker

Morgan State University, Baltimore, Maryland
Faculty Host & Mentor: Dr. Adam Phelan & Professor Tyrel McQueen
Department of Chemistry
Johns Hopkins University

Project Title: Crystal Growth and Characterization of Boron Carbide

Boron carbide is an inexpensive, light weight ceramic with potential for applications in body armor, high temperature thermoelectrical conduction, ionizing radiation shielding, and neutron detection. The rhombohedral crystalline structure of the material means that mechanical, electrical, and physical properties may vary along differing orientations. Thus, measuring anisotropic properties requires the use of single crystals. Single crystals of boron carbide are non-trivial to grow; thus, few studies have been conducted measuring the properties of this material across its varying planes. Single crystals of boron carbide were grown through the floating zone method through utilizing PARADIM"s laser diode floating zone furnace. Using laue diffraction, we identified several distinct rhombohedral crystal directions. The material was then cut along these planes using multiple methods which include a diamond crystal cutter saw and a diamond wire saw. In future work these slices of the crystal will be used for impact testing, transport properties measurements, etc.



HEMI/MICA Extreme Arts Summer Projects/Internships

Extreme Arts is a joint program between HEMI at Johns Hopkins University and the Maryland Institute College of Art (MICA). The program brings faculty and students from both institutions together to explore unique perspectives on extreme events. The program aims to encourage collaboration among artists and researchers to examine data, interpret outcomes, and translate results from extreme events in new ways. It is our hope that this dialog will create a stronger community through a shared sense of curiosity and exploration.

The Extreme Arts summer projects/internships provides an opportunity for MICA students to spend a summer within HEMI. Students receive a stipend during the internship, which is co-advised by MICA and HEMI faculty members.

Program Goals

- To provide an opportunity for meaningful engagement among engineers, scientists, artists and designers that sparks a creative dialog and leads to new outcomes;
- To explore systems of communication that translate ideas and provide platforms for engineers, scientists, artists and designers to discuss concepts and develop a common understanding;
- To create programming between JHU researchers and MICA faculty/students that examines new approaches to HEMI-related materials research and data visualization; and
- To design a framework that serves as a model for sustained, long-term partnership between JHU and MICA.

Funding Sponsor

The Whiting School of Engineering at JHU and MICA

Website Information

https://hemi.jhu.edu/academic-programs/hemimica-extreme-arts-program/hemi-micasummerinternship/

Shangtong Li

Focus Area: Interdisciplinary Sculpture
MICA Advisor: Ryan Hoover, Interdisciplinary Sculpture
HEMI Advisor: Professor Sung Hoon Kang
Department of Mechanical Engineering
Johns Hopkins University

Project Title: Biodegradable composite based on plasticized starch with organic waste

I am currently exploring the relationship between human and the natural world by confronting the modern mass culture and our disposable lifestyle. My project is creating an alternative to traditional art-making materials such as resin, polystyrene, plaster, and MDF which are harmful to the environment when they are produced, used, and discarded. I am exploring the possibilities of using renewable resources such as starch, and waste materials like sawdust and orange peel to create a sustainable material that can

be used under different machining method and artistic applications. This material is biodegradable, sustainable and energy saving. By utilizing wastes to make sustainable materials is a way to give them a longer lifespan. I am redirecting them from standard waste streams that terminate in landfills and contribute to global warming. I would like to ensure an accessible production approach in order to democratize the use of this material. I want these materials to be able to be made by students and people from all backgrounds, economic levels, and education levels. I will share my results online to foster an open-source community of makers who can experiment with these wastes and make their own versions according to their needs and expertise. In tandem with my art making, I would like to facilitate workshops on how to make these materials by inviting people to collect their own organic waste materials and introduce the potentials of them.

Amy Wetsch

Focus Area: Multidisciplinary Art
MICA Advisor: Jonathan Latiano, General Fine Arts
HEMI Advisor: Professor Sarah Hörst
Department of Earth and Planetary Sciences
Johns Hopkins University

Project Title: Clouded In Mystery

Titan is a captivating and puzzling moon about 1.4 billion km from Earth. It is Saturn's largest moon and in many ways one of the most Earth-like worlds in our Solar System. Titan contains rivers, lakes, seas, sand dunes, mountains, and it even has an Earth-like hydrological cycle. These physical processes may seem familiar, except they are composed of entirely different materials than what we know on Earth. For example, the liquid that flows across Titan's surface is not water; but rather is a mixture of methane and ethane.

Much of Titan is still unknown because of its dense atmosphere encapsulating the moon. Imagine what it would be like to fully uncover and visualize such a place. Picture taking off your shoes and squishing your feet in sand composed of complex organics and being able to experience a different environment that is in many ways parallel to our own home.

During my time at HEMI I have observed Sarah Hörst and her research group as they conducted various experiments. Whether they use the planetary haze research chamber (PHAZER), a spectrometer, or a microscope, they are chipping away at mysteries far out in our Solar System. This research not only contributes to a greater

understanding of celestial bodies, but to our understanding of Earth.

While interpreting this scientific data, I am creating a large-scale installation, sculpture, and drawings. Materiality is important in my work and I am experimenting with mixing glue, iridescent film, bioplastic, salt, glass, cotton, and various other materials. I have incorporated recycled materials from the lab such as copper gaskets that can only be used once in the PHAZER, sands that were used in a Titan wind tunnel experiment, and old HVAC tubes. The end products will reflect my interpretation of what the surface and thick haze of Titan may be like to experience.

I aim to capture the wonder and awe of the extreme scientific progression that allows this knowledge to be possible. The work created through this internship is ongoing and will be exhibited at the Bromo Seltzer Arts Tower in Baltimore in November of 2018.

The Leadership Alliance Summer Research – Early Identification Program

The Leadership Alliance is a national consortium of more than 30 leading research and teaching colleges, universities, and private industry. They are united by a shared vision – to train, to mentor, and to inspire a diverse group of students from a wide range of cultural and academic backgrounds into competitive graduate training programs and professional research-based careers.

Program Goals

- Provide undergraduates with training and mentoring in the principles underlying the conduct of research and prepares them to pursue competitive applications to PhD or MD-PhD programs.
- Offer closely mentored research experiences in the life and physical sciences, social and behavioral sciences, and the humanities at 20 research institutions across the country.

Funding Sponsor

The Leadership Alliance

Website Information

http://www.theleadershipalliance.org/programs/summer-research

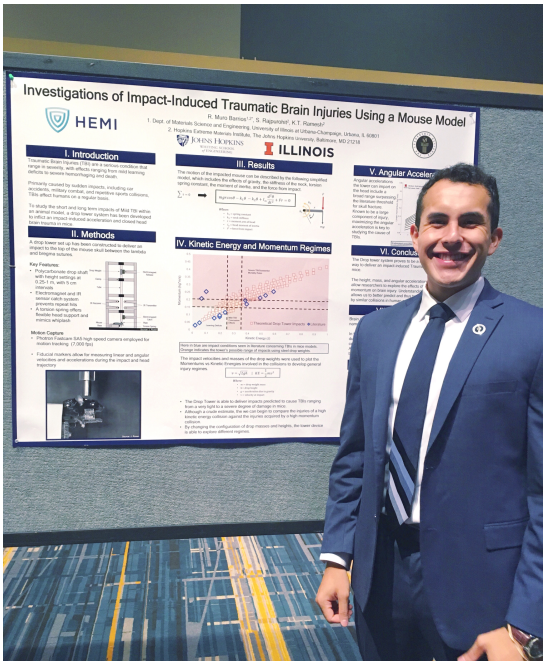
Raymundo Muro-Barrios

Focus Area: Multidisciplinary Art
Faculty Host: Professor KT Ramesh
Department of Mechanical Engineering
Johns Hopkins University

Project Title: Investigations of Impact-Induced Traumatic Brain Injury Using a Mice Model

Traumatic Brain Injuries (TBI) are a serious condition often accompanied by a loss of brain function and consciousness. TBIs are primarily caused by sudden impacts, including car accidents, military combat, and repetitive sports collisions. To study these impacts within an animal model, a versatile drop tower system has been developed to inflict an impact-induced acceleration and closed head brain trauma in mice. The drop tower system utilizes a freefalling mass to deliver a quantifiable “dose” of impact in terms of momentum and kinetic energy to the mouse subject. A magnet system is used to avoid repeat hits. Motions of the mouse head are studied using a Photron Fastcam SA-5 camera and motion tracking software. We study the relationships between the momentum, kinetic energy, and head angular acceleration, with the hope of connecting these variables to axonal injury thresholds. The drop tower proves to be a robust and simple method to study TBIs in mice and can

help shed light on the complexities of human TBIs and TBI care.



On behalf the Hopkins Extreme Materials Institute at Johns Hopkins University, we would like to thank the support from the sponsors and organizations that made these student opportunities possible: