NIHERST/NASA I² FINAL REPORT

GABRIELLE MOTILAL

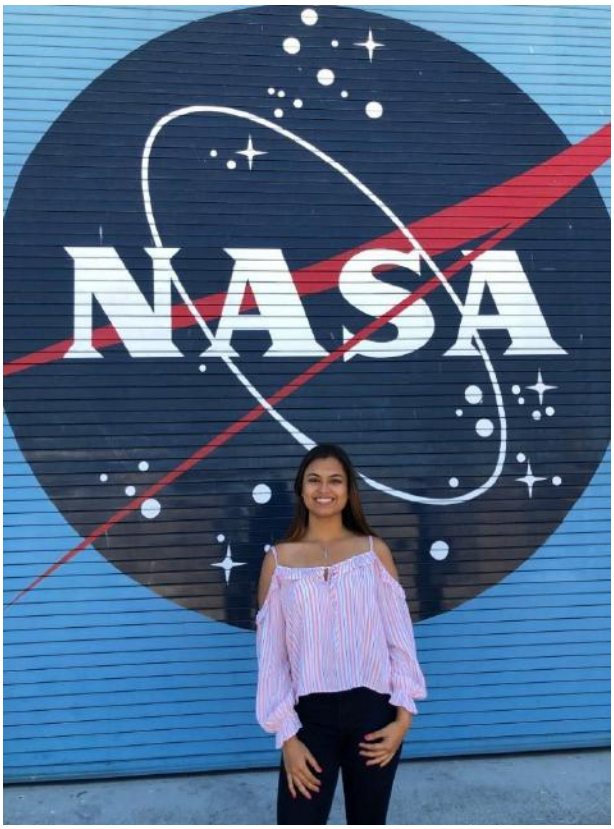

Photo Taken: NASA Ames Research Center in California, USA.

"A ship is always safe at shore but that is not what it's built for."
~Albert Einstein

ACKNOWLEDGEMENTS

Getting to NASA was by no means a small victory. It is and will always be a massive victory for me and those who supported me along the way. I could not have done it all on my own. This victory is shared among all those who contributed to my success in getting to NASA.

I give special thanks to my late mother, Beverly Babita Loutan-Motilal for instilling passion into my heart to always reach for the stars and pursue education regardless of situation and circumstance. I also give great thanks to my second mother, Aunty Denise for her unwavering support throughout my journey to get to NASA, from the beginning to the end. Another very important lady, Ms. Lydia - I give my heartfelt and most honest thank you to you and your husband because through our combined efforts, together with God on our side, we achieved the impossible in such limited time.

I give thanks to my grandmother, Brenda Motilal for believing in me and my father, Collen Motilal, my boyfriend Hiroyasu Kimpara, and all my friends for supporting me as well as my Physics teachers such as Mr. Abdul, Mr. Lakhan, and lecturers such as Dr Clarke, Dr. Haque who answered all my questions in class and supported me in the best way possible so I could qualify to get to NASA. Lastly, thanks to my Korean mentor, Dr. Dongil Lee for your advice, guidance and jokes.

To my sponsors, thank you very very much to Spice Boys Foundation as well as Atlantic, CBTT, PLNL and also United Airlines for kindly sponsoring all of our flights. Lastly, I would like to thank NIHERST, Ms. Rampersad and team, and NASA, Ms Parker and her team, for working together to afford us citizens of Trinidad and Tobago this amazing opportunity to experience, learn and grow academically in the areas of Science and Technology which allowed us to make lasting memories via the global cultural exchange aspect of the NASA I^2 Program.

It is my hope that the many others that come after me can gain sponsorship and support so that they too can continue to share similar amazing stories, experiences and gained expertise which enhance our nation and advance our scientific community even further than before through this joint effort. Thank

you all for helping me reach to the stars - achieve a dream I had ever since I saw the stars for the first time. I am truly thankful to each and every one of you.

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Overview of Intern Background and NASA Internship

Academic Journey

I am from the Piparo-Williamsville region in south Trinidad and Tobago. At three years old, I graduated from Smiling Tots kindergarten in Williamsville where I was taught to appreciate different cultures. I was very eager to explore new levels, so at the young age four I started at Riversdale Primary School. My teachers were very kind and caring, even on a personal level. They taught me about the importance of rules, morals, perseverance, determination and having a belief system, all the ingredients which I believe to be necessary for success in any and all paths of life.

At our graduation, I was the valedictorian and got to share my experience on holistic growth throughout the years. Then, the life of real studies came-studying to make the grades. Upon graduating Marabella North secondary school twice, I am proud to have cupped a total of 17 awards related to academic performance mainly in Physics, Chemistry and Biology at the CSEC and CAPE levels. I am now a student at the University of the West Indies studying Physics and Materials Science.

Last academic year, I became the President of the UWI StarGazers which is the Astronomy club of UWI. Together with my UWI StarGazers Executive Team, we successfully hosted the massive Total Lunar Eclipse Event in January 2019 at UWI which hundreds of people attended. My passion in Astronomy led me to become one of 5 undergraduate UWI students to pioneer Radio Astronomy in the Caribbean Region in conjunction with the National Radio Astronomy Observatory (NRAO) in the United States.

As a result of my work in Radio Astronomy, I was awarded the Physics Head of Department Prize for the Best Final Year Research Project. I am now a member of the newly formed Trinidad and Tobago Radio Astronomy Community (TTRAC). In January of this year 2019, I was nominated by the UWI International Office to represent Trinidad and Tobago in Japan during a short-term semester study at Sophia University, one of the top three Universities in Japan. There I was given the opportunity to study the Japanese Language, their Education system, Culture and Society. At the UWI St Augustine campus, I was one of the top ten students to have been a recipient of the prestigious UWI STAR Scholarship Award in 2018 for excellent academic and co-curricular performance.

Presently, I am a Faculty of Science and Technology Peer Advisor at UWI St Augustine Campus as I complete my final year of my Bachelor of Science degree in Physics with a minor in Materials Science. My passion is research, teaching and language learning as I continue my studies in Japanese language at the Center for Language Learning (CLL). Most recently, I was awarded a very highly esteemed opportunity by NIHERST and NASA to represent Trinidad and Tobago at the NIHERST/NASA International Internship program at the NASA Ames Research Center in the United States. After gaining more research insight at NASA, I am happy to share about my project and experience at NASA Ames Research Center. I strongly encourage others interested in developing their self, research skills and our country of Trinidad and Tobago to apply for this amazing once in a lifetime opportunity to be a NASA intern. Aim for the stars!

NASA Experience

A snapshot of the beauty at the NASA Ames Research Park - a 100% unedited photo. In the background you get a glimpse of the massive hanger. In the sky you get an idea of the high frequency of jets always flying overhead. At most I spotted 6 aircraft all at once doing its own thing overhead. Sometimes pilots test fly as well. Amazing.

I was very taken aback by the immense size of the NASA Ames Complex. It is a very massive place with many roads and many buildings spanning the complex, with high security. Sometimes, I would go walking with friends around the huge base. At nighttime, the stars looked really beautiful and the scenery was really calm after a busy day is over. A peaceful feeling. The Ames branch of NASA where I worked as an intern for 10 weeks has two sections. There is a section where interns live and also which nationals can visit for public events - even Ubers

can drive in once they have a California licence plate, so beware of that if you are ordering an Uber! Uber was our main form of transportation - really expensive.

Then there is the other section, where strict clearance and authorization is needed to get in - it requires FBI background checks and all that jazz - that is the place where we worked, no Ubers allowed in there. So as you can only imagine, one of the most exciting days was when I collected my NASA identification card. I felt very official and important as now it meant I was contributing to a much greater cause - to the future of mankind in their race to become a space fearing people. Another upside, was that it also meant that I could visit Megabites cafe anytime I wanted! That is the food place of the inner high security section at NASA. The best thing about Megabites is that it was literally across the street from my building where I worked everyday - so convenient.

The Research Center for Nanotechnology and Mars Exploration.

building where I worked.

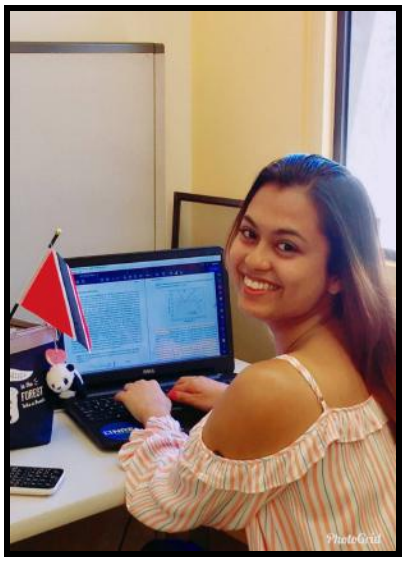
However, Megabites was really expensive so look out for that! One meal there can cost anything starting from $70.00 TT. Megabites is a really beautiful spot though. Many times me and my friends enjoyed our home cooked meals or bought lunches under the sun (of course because it was freezing) at the picnic tables outside the building near beautiful trees. If you were wondering, yes inside the cafe was even more freezing than outside.

Having lunch with my co-workers and friends at the outdoor Megabites picnic tables!

One of the most shocking things about being in California was the weather. I have always thought that it is sunny and hot like Trinidad at this time of year. Although it was 'summertime' in California, 90% of the days I spent there was absolutely freezing! The sun would be hot but the wind is really chilly so I was literally going to work looking like winter was happening although the sun was shining. If you are thinking about going there for the summer internship - maybe it will be best to pack some warm clothes just in case.

As an intern at the Center for Nanotechnology, I did research alongside my Korean mentor, Dr. Dongil Lee. Our research was done as part of the NASA In-Space Manufacturing project (ISM). Our objective was to improve the sensing capabilities of the 3-D Printable Zinc Oxide Ultra-Violet Sensor on 3-D Printable Thermoplastic Polyurethane Substrate which would be used on the International Space Station (ISS) so that real world testing could be done allowing it to then be used by astronauts to aid in space exploration on other planets such as Mars and beyond in the future. This project involved utilizing various design and testing computer software as well as printing and testing equipment which spanned three different laboratories of the building, the ground floor, the third floor and the fourth floor, yes, a whole lot of steps to climb. Luckily, we had an elevator so it was not so difficult but my mentor really liked using the stairs so I did too!

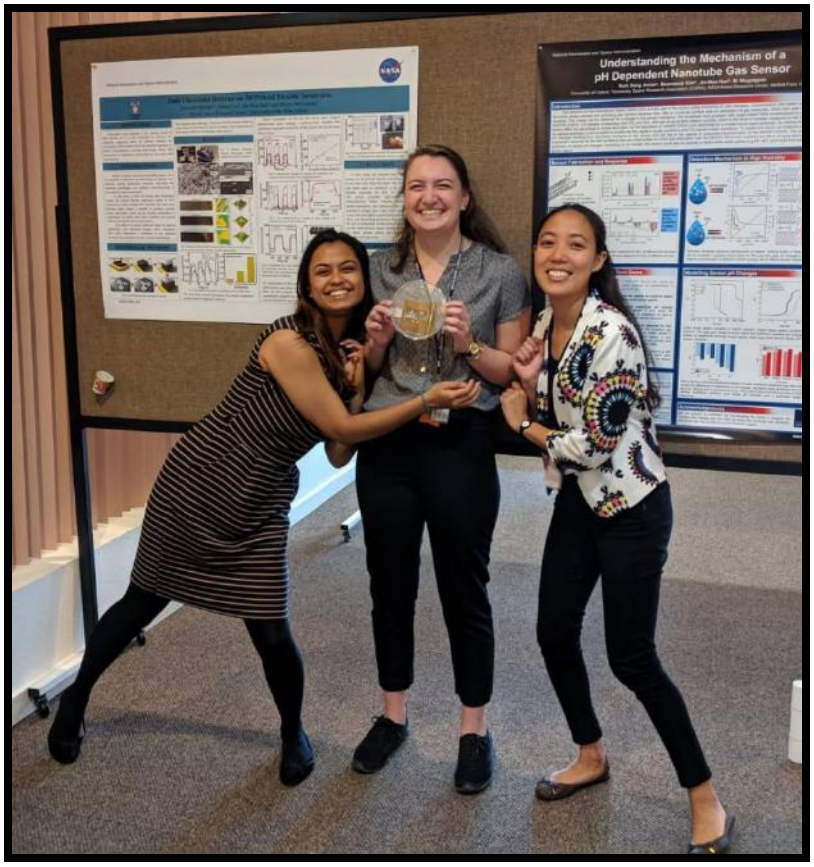
My desk! Yup, I picked the window desk. From there I could see the solar panels outside my window as well as the massive hanger! The best part about my desk though I think was my seat! Really loved and appreciated my mentor giving me such a comfee chair which made me enthusiastic about research papers all day.



My office was shared with my mentor and my two coworkers, Ruth and Becca also working on research related to the same ISM project, two of my best friends throughout the summer! We had lots of fun together. At first, my project seemed really difficult to get on top of, so the first two weeks were spent on really researching about this topic which was relatively more in depth than what my general BSc Physics degree and minor in Materials science covered. However, I realized the project was based in Optoelectronics as well as other Physics and Materials Science concepts which meant that I gained the right background at UWI to take on such a project. I had to build on my knowledge and used what I knew to help the project. We were applying knowledge to make our experiments work. As the weeks passed, I successfully finished the project within just 7 weeks. With the remaining 3 weeks I was able to help my mentor with his research paper, so I was able to learn even more and got trained even more in the lab - at one point I was even troubleshooting and fixing the 3-D printer!

Me troubleshooting the 3-D printer on fourth floor lab (left) and my mentor testing the upgraded UV sensor on the ground floor lab in the last week (right).

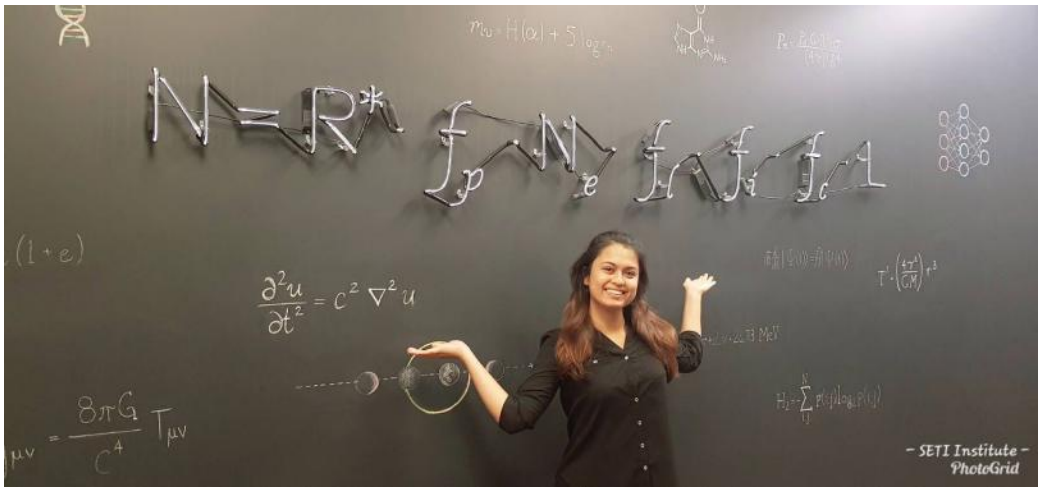
Some Highlights:



We (me, Becca and Ruth- seen above) had a poster presentation session together in the last week where we got to explain our research to the public and to other interns (seen below) at the Summer NASA Poster Symposium 2019.

<u>I got to meet the famous Katie Bouman!!! :O</u>

She gave a Black hole lecture at NASA Ames.

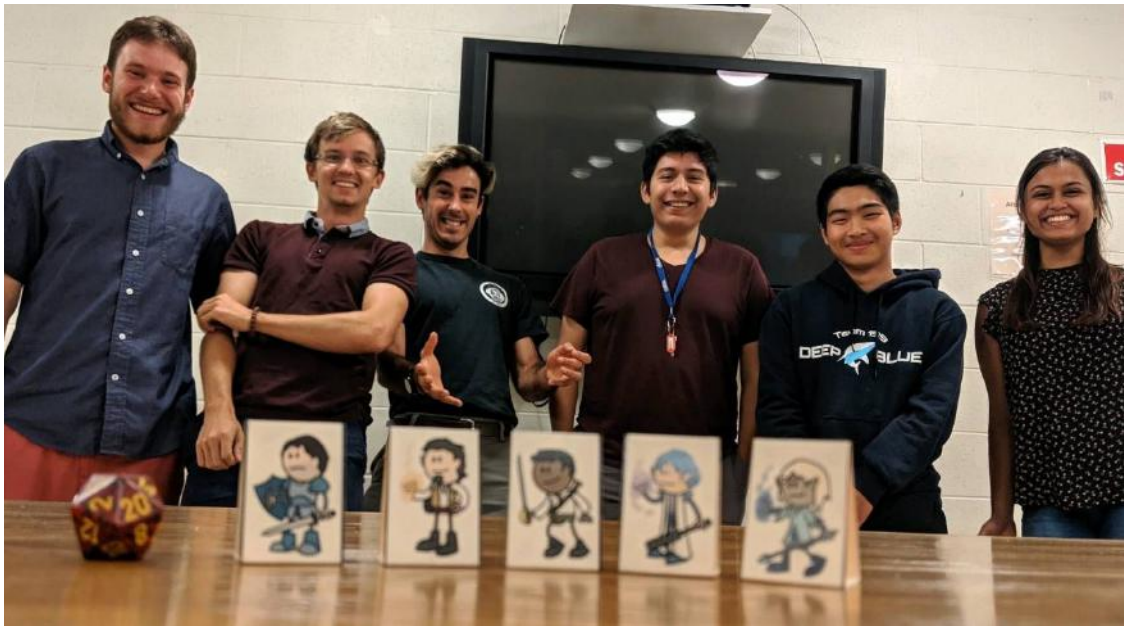


I got to visit the renowned SETI Institute - the search for aliens is on!

The famous Drake's Equation is in the background.

Made lots of friends and ate a lot of great food =)

Made friends from the United States, Thailand, Taiwan, Australia, England, Canada, Korea, China and Portugal to name a few! Tasted different types of food such as Korean, Chinese, Japanese, Tai, Italian, Mexican, Indian and Jewish foods to name a few!



Having a D&D Crew!

The thing that led me to do Physics - BIG BANG THEORY - in which they always played Dungeons and Dragons. One night we actually had karaoke in the laundry room as well - who knew the laundry room could be so versatile!

Mentor and Mentee group Escape room challenge!

WE WON the HEIST, what a proud moment =)

Hiking MUIR Woods to see these MASSIVE trees.

NEXTFLEX Science Innovation Day 2019.

Future Work and Goals

Since coming to NASA as a research intern, I have learnt so much; many lessons and experiences which I will never forget. Now I understand experimental research much better. My research background at UWI is in Radio Astronomy which utilized VLASS data and was more in the realm of computer data processing and analysis of that data. However, at NASA, I had the opportunity to experience a different style of research. This research was along the lines of design, fabricate, test and improve which involved a nice balance between lab and desk work. There was a lot of work to be done in labs for the fabrication and testing of our sensor which was balanced by desk work which involved design, research and understanding the obtained results on the computer using various software.

I loved learning how to use all the new software and doing work in the laboratory because I felt more capable and also that my skill set was increasing continuously. I really like this method of research because there is always something exciting to work on, think of and it is always thrilling to see the outcome of the experiments. Different experiments can be done and therefore multiple hypotheses can be tested as improvements are continuously made. My project at NASA naturally progressed throughout the internship with the guidance of my mentor. The best part about doing experiments was when the hypothesis was right after testing and obtaining results after doing much troubleshooting and trying many solutions and finally, eureka it works!

Software and equipment used in this research project can be applied to improve our techniques locally. Future application of these technologies can advance Trinidad and Tobago's Science and Technology fields. For example, locally we may have some amount of 3-D printing facilities however, more accessible 3-D printing fab-labs can become available for use by students for the purpose of University level research projects. 3-D printing should be normalized at the University level. Perhaps, our Universities can start training more science students to use this equipment during routine lab sessions since with 3-D printing, the applications become limitless. Research projects can now enter a new dimension, the third dimension and explore previously uncharted theory. Perhaps instead of ordering complicated parts for a project, they can 3-D print it instead which can dramatically cut the cost of "sciencing". This may be of particular use and great interest in the Biomedical Technology field since I have seen its application at the NEXTFLEX Innovation Day 2019.

The Voltera should be introduced similarly to the 3-D printer since its applications in Electronics is wide. Students can be trained in using this equipment, then slowly industries would understand the importance and ease of using this technology since circuits can be easily printed and ink be altered to suit various applications requiring different conductivities. In this way every part of a circuit can be controlled, modified and edited as necessary in an instant. There would be a new industry made locally where ink manufacturers would become necessary and this can create more jobs and more training areas. Using new technology is the way forward to advance science. Technology is there to save time and money. Science and Technology will always go hand in hand.

With all the knowledge and laboratory experience I have gained while researching at NASA, safety trainings provided by NASA, the teachings of my NASA mentor as well as the connections I have formed being at NASA, I am now confident about approaching new levels in academia. My goal is now to move onto the next step of my academic career, which is to study for a Masters in Materials Science. Through this rich experience, I have become more independent and brave, able to function as part of a bigger organization which strives toward a common goal. I have gained travelling and cultural exchange experience. I have faced the language barrier and thrived in that situation when most others might have become frustrated and quit. Tolerance and respect for all others and international friendships were formed. Now having friends all around the world, I can have future travels to visit my friends all around the world, I am never alone.

There are *four ideologies* which I learned along my journey whilst at NASA Ames that will stick with me forever. This is also my advice to future interns:

1) You are never 'just' anything in life.

I was doing some testing on the ground floor lab when someone who looked official walked in and questioned me about something but I unfortunately did not know the answer. Around this time, these laboratories were being safety checked so I assumed he was one of those personnel. So I responded, "Sorry I'm just an intern here so I don't know", to which he responded with the biggest smile ever, "Nobody in life is ever JUST ...anything in life. You are always SOMEthing ...and never JUST anything," then we talked for a little and with that he left the lab. Turns out he was a technician for some of the equipment we were using, but

definitely from that moment I knew he wasn't just a technician and I was not just an intern. He was right.

2) Just keep going.

I have met many older folks distinguished in their fields at NASA and elsewhere who found themselves on NASA compound doing NASA related work, and each time their stories sounded the same. What they studied at University is not what they are doing now, their fields always changed for the better. They went with the flow and it turned out well. I was one of the lucky ones - My mentor invited me home to have lunch with him and his wife and baby. Home cooked Korean food! Just simply delicious. His wife is a really good cook. Upon leaving after thanking him, I asked him for one last piece of advice. My mentor told me, "Just keep going". So that is exactly what I will do. The sky's the limit.

3) You never know unless you try.

When I met Katie Bouman, my first question for her, how did she end up in such a project for which she was now world wide renowned for by all scientists? One that seemed to make her the center of attention of the world although she always stressed the importance of their large crew which made the Black hole image possible. With a smile and the ever so slightly ease of a very tiny shrug of her shoulders she said, "well I heard of the project and I was interested so I just joined." I realized at that point, 'Wow, you never really know where you could end up when you start.' I also wondered how did she know what to do in the project, so I asked her. She said at first she did not know much about it but she never gave up and kept on learning until her knowledge about it increased so much, and it was

her algorithm that allowed us to capture evidence of the black hole existence. Therefore, you will never know unless you try it. Just start and let curiosity lead you.

4) You are good enough even if others dont see it yet, show them.

Sometimes in life, some people really believe in you but others may not or never will. Never let that hold you back from your dreams. Do the impossible. Show everyone you are capable and you are blessed. You will amaze yourself. You are indeed good enough :)

I am proud to have represented my nation of Trinidad and Tobago at NASA.

You can too!

Overview of my NASA In-Space Manufacturing Project

Introduction and Project Objective

TECHNICAL ABSTRACT

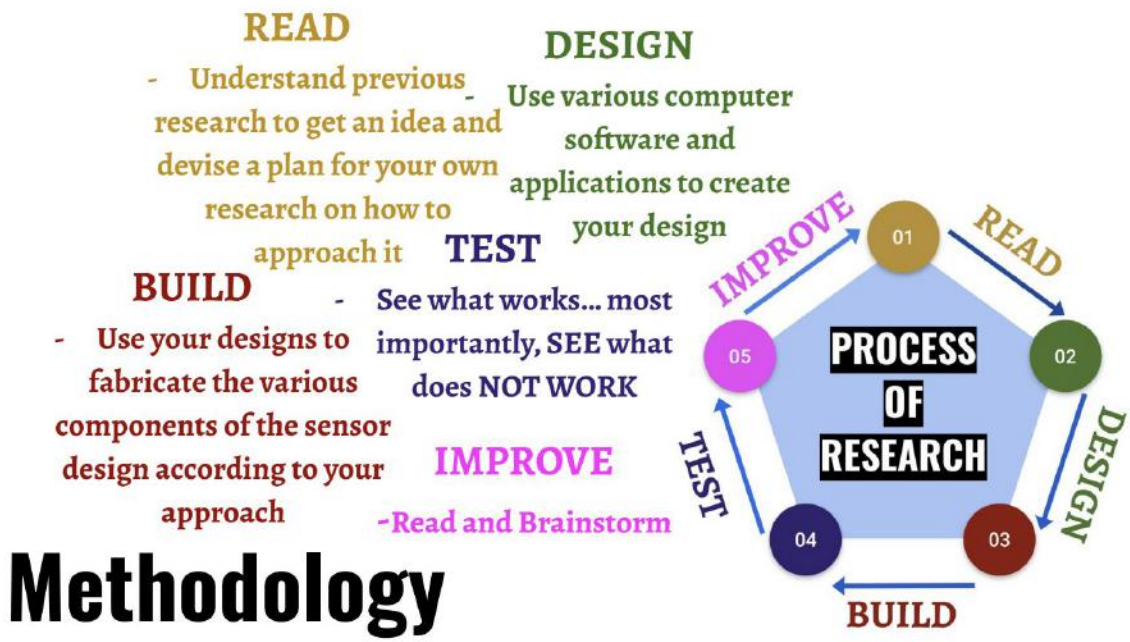
ZnO Ultraviolet Sensor on 3D Printed Flexible Substrates

Ultra-violet (UV) radiation is the leading cause of skin cancer, so it is very important to monitor UV radiation exposure when on planets without an atmosphere that protects from this harmful radiation. Until now, UV radiation sensors have been manufactured on earth and sent to space. Also, most UV sensors are based on off-the-shelf substrates like rigid Silicon and Polyimide, which are difficult to 3D print. Therefore, NASA's In-Space Manufacturing (ISM) Project aims to provide on-demand manufacturing of sensors and devices during exploration missions. Printing technology allows the fabrication of electronic components at any time and any location. Furthermore, 3D Printing technology is cost-effective, less time-consuming, produces less material waste, flexible, thin, lightweight, bendable products, which are therefore wearable. In these circumstances, one-step 3D printing technology (i.e., additive manufacturing) is essential for space exploration. Fully 3D printable, flexible, ZnO UV sensors can be worn on wristbands or sunglasses by astronauts for this purpose. This 3D printing technique has potential for use in production at the point-of-demand on the International Space Station (ISS) and on other planets where the logistics is complex and expensive. In this work, we have developed ZnO UV sensor using 3D printed flexible substrates made of TPU covered by water-soluble PVA materials. The layer free process used, makes it possible to produce printed silver electrodes which can be directly embedded in substrates, on which ZnO active materials are placed without any performance degradation. Effects of various types of layered substrates, electrode designs and sensing layer thicknesses were evaluated. This work represents a milestone in the pathway towards the utilization of other sensors and devices.

Methodology and Design

Aim:

To improve sensing capabilities of the ZnO UV sensor on flexible substrate by observing the effects of different types of layered substrates, ZnO thickness and electrode designs to obtain the best configuration with the highest sensing capability results.



Mechanism:

Direct absorption of UV on the active layer creates electron-hole pairs causing a photocurrent which can be measured.

Methodology

Part 1

- The substrate was designed using SketchUp then imported into Simplify 3D to fine-tune design details so it is suitable and compatible for 3D printing using the Prusa Research 3D Printer, the best brand. By this process, the substrate design was altered to have no-PVA layer, rough PVA layer and smooth PVA layer substrate configurations as necessary.

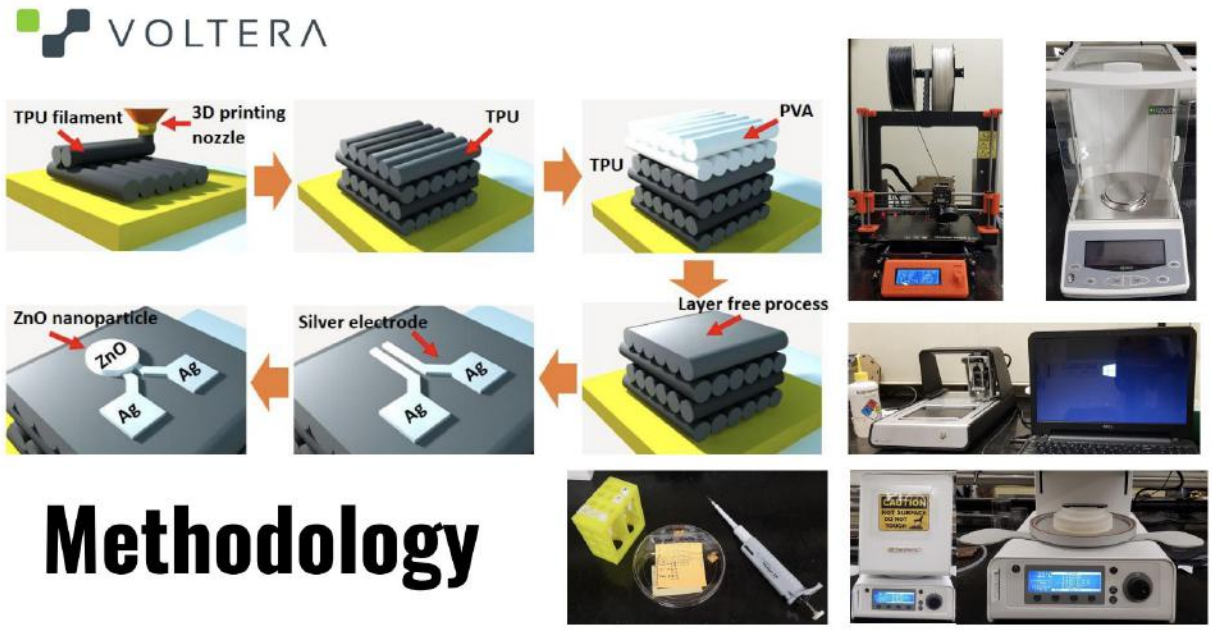
Part 2

- After the substrate was printed using TPU, Layout was used to design the silver electrodes and imported into Eagle to make it into a Voltera friendly file which could then be used on the Voltera program which controlled the Voltera printer. The appropriate conductor ink was selected and the design was printed onto the substrate. By this process, the electrode design was altered into near, far and branching electrode configurations as required.

Part 3

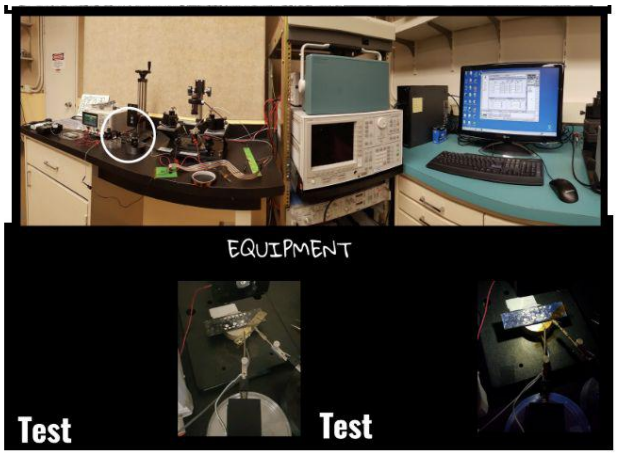
- The ZnO nanoparticle solution was mixed using a solid ZnO nanoparticle and special solvent, using a balance for measuring solid particles, a Vortex Genie for mixing the

solution and Sonicator to ensure a well rounded consistency ZnO solution. Then a pipette was used to create the ZnO sensing layer on the electrode. See photo, bottom row left.



Part 4

- The Voltera printed electrode, and ZnO layer see second row, left, had to be baked-dried before testing using the baking machine seen in the bottom row photo to the right.
- Layer free process, using the machine seen in the top row left most photo, was done to create the smoothened PVA layer, see second row middle photo.



The equipment for testing photocurrent of the samples. UV testing actually occured at the white circle.

The UV light was turned ON and OFF in cycles to observed properties of the samples.

Results and Conclusion

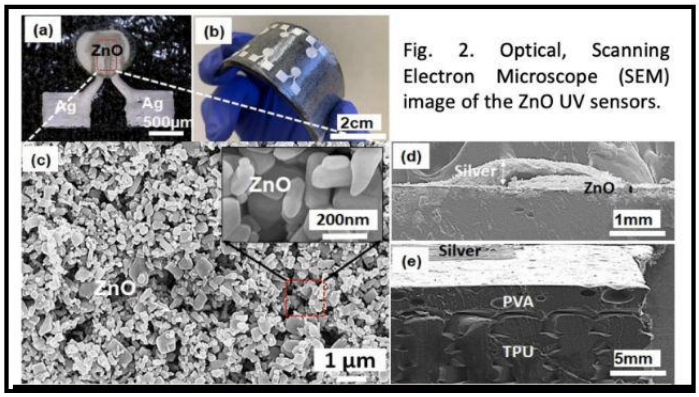


Fig. 2. Optical, Scanning Electron Microscope (SEM) image of the ZnO UV sensors.

The structure of the layers were observed using SEM.

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Graphing & Analysis

Varied: The Substrate Type

Smooth PVA substrates improved sensitivity of the sensor due to the layer free process.

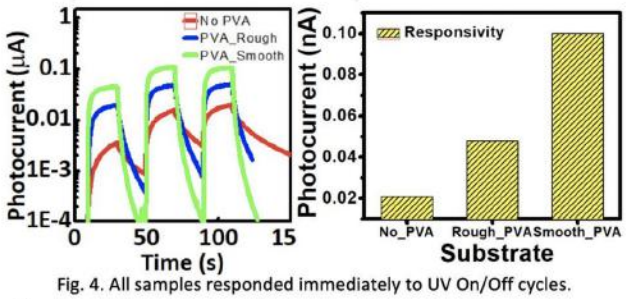

Fig. 4. All samples responded immediately to UV On/Off cycles.

The layer free process decreases the contact resistance as the surface roughness reduced.

Results

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Graphing & Analysis

Varied: The Intensity

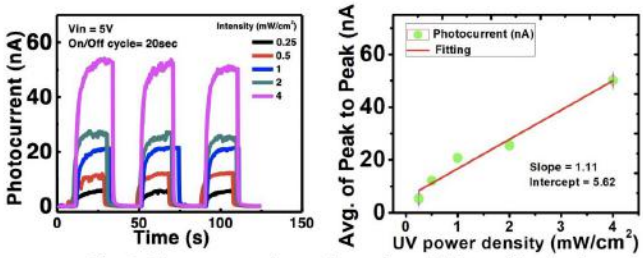

Fig. 5. Photocurrent change for various UV intensities, and response versus intensity curve showing linearity.

Results

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Graphing & Analysis

Varied: Voltage

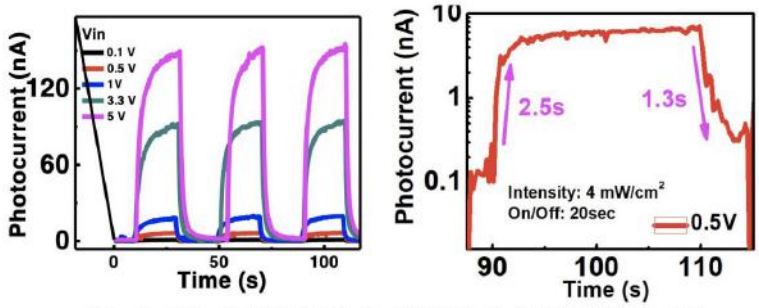

Fig. 6. The photocurrent to change of input voltage and response time were also measured.

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Graphing & Analysis

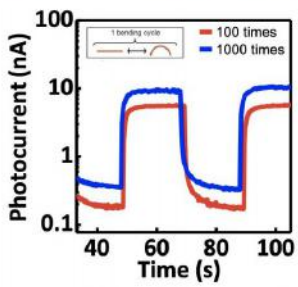

Fig. 7. A durability test was conducted by repeatedly bending sensor up to 1000 times. The on/off performance of the sensor was not affected.

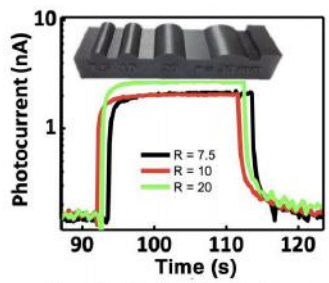

Fig. 8. A bending test was conducted by varying the bending ratio. The on/off performance of the sensor was not affected.

An assessment of the sensor's reliability under mechanical deformation was done as shown in fig 7 and 8. This shows that the ZnO smooth PVA-TPU substrate sensor can be successfully adapted for wearable applications. The sensor can be tailored for use in wristbands.

It was found that :

- ➔ a branching electrode,
- ➔ with a thicker layer of ZnO
- ➔ on a PVA Smoothened surface

performed the best as expected and the sensing capability performance of the UV sensor increased by 0.2 to 2.0 µm.

Conclusion

ISM ZINC OXIDE UV SENSOR PROJECT SUMMARY

In this work, a ZnO UV sensor was developed using 3D printed flexible substrates made of TPU covered by water-soluble PVA material. The layer free process made it possible to produce printed silver electrodes which can be directly embedded in flexible substrates, on which ZnO active materials were placed. This work represents a milestone in the pathway towards the utilization of other sensors and devices.

Researcher:

Thank you for reading.
I hope it helped.
Any Questions?
Feel free to email.
*All the best to you ^.^*

Contact

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EXTRAS!

Thank you to Dongil, Becca, Ruth, for great hangouts, lunches, office and lab days! See you again!