NSF Engineering Research Center for Revolutionizing Metallic Biomaterials

NC A&T State University
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NEWSLETTER

SUMMER 2010

VOLUME I, ISSUE 2

SUMMER REU STUDENT PROFILES

Christopher Gardner

Christopher Gardner is a rising junior majoring in biomedical engineering with a minor in tissue engineering at NC State University in Raleigh. Under Dr. Yun, Chris is studying the biomedical applications multi-protein patterning on a cellular level. This sort of protein patterning can be used to mimic and observe the mechanisms of certain cell signaling interactions, such as the mechanism of the immunological synapse formed between the T-cell/Antigen Presenting Cell interface. This technology can be used to make smart coatings for biomedical implants with controlled rates of biodegradation and the potential to inhibit immune response to promote biocompatibility. Chris plans on pursuing a dual MD PhD degree in neurobiology or biomedical engineering after receiving his B.S. at NC State.

Dominique Tucker

Dominique Tucker-Roberson is a rising senior from Chicago Illinois who is pursuing a Bachelor of Science degree in Biology at Bennett College here in Greensboro. Dominique pursued the NSF Engineering Research Experience for Undergraduate (REU) program to explore more options of research. She wanted a research opportunity that was awarding and beneficial towards her academic career. Although the engineering research program is completely out my element and new to her, she hopes to open doors for more diverse career opportunities. Dominique wants to present her research at the HBCU-UP Conference in Washington DC. Presenting her research is truly what I hope to get back from this research opportunity. Dominique is currently working under Dr. Seongyuk Ko and claims it has been a learning experience to cherish.

David Meza

David Meza was born and raised in Los Angeles, California. He is currently pursuing his MS in Mechanical Engineering at California State University Los Angeles. He completed his undergraduate studies in Mathematics with a single subject teaching option also at CSULA. David pursued the REU at the NC A&T ERC to get firsthand experience of research in engineering. He also hopes to gain a better understanding of what he wants to specialize in during his graduate studies. He is happy to be working with Sonja Collins under the guidance of Dr. Sergey Yarmolenko.

Amy Wat

Amy Wat is a Mechanical Engineering student at California State University, Los Angeles who will graduate with a bachelor's degree in 2012. During her stay in NCAT, she will be working with Taril Gravely under Dr. Zhigang Xu. They will be creating an open-porous magnesium alloy that imitate the structure found in polyurethane foam by using a plaster mold. She hopes to produce a procedure to make the plaster mold and form one sample of an open-porous magnesium alloy by the end of this program. With this experience, she will have a better idea of materials science research, which is what she will pursue in graduate studies.

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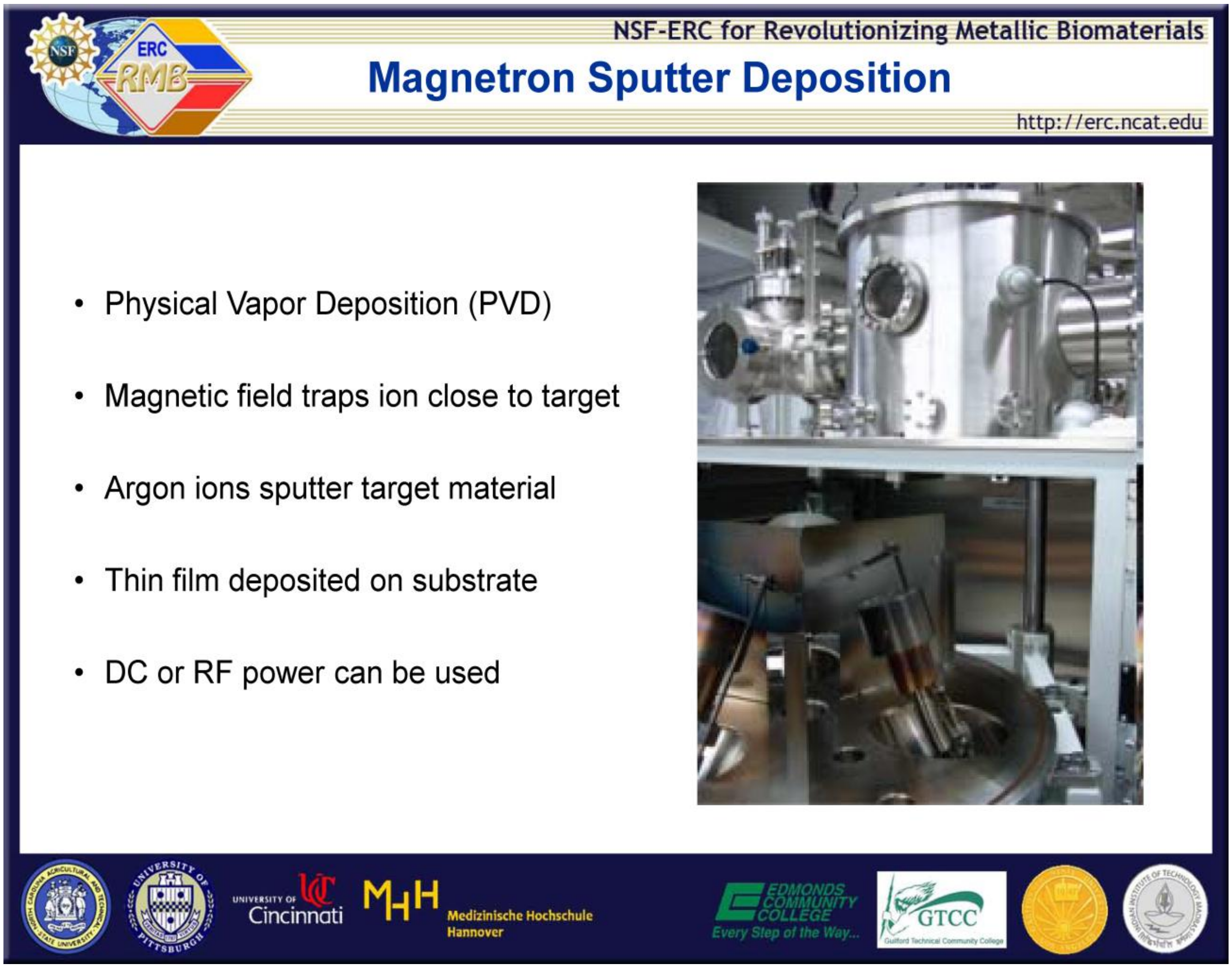
Example Newsletter



Example Weekly PowerPoint Slide

Weekly Journal: Week 1

Name: Pooja Sarin
Advisor: Dr. Dhanajay Kumar
Graduate Student: Kwadwo Mensah-Darkwa
Dates: June 28 – July 2, 2010

Magnesium alloys have attracted great attention in a number of industry applications because of their high special mechanical properties. Magnesium alloys have also been suggested for bone implant application due to their low density, inherent biocompatibility, and perfect mechanical properties. Magnesium is also one of the most important bivalent ions associated with the formation of bone and it can directly influence bone resorbing cells and be an important factor for bone metabolism. However, magnesium is a highly electronegative metal and thus is corroded relatively faster than other metallic materials, especially in the electrolytic aqueous environment. The key to manufacturing magnesium-based alloys that are suitable as biodegradable orthopedic implants is how to adjust their degradation rates and mechanical integrity in the physiological environment. Many measurements have been developed to improve the corrosion resistance properties of magnesium such as coating.

This project reports on the use of pulsed laser deposition (PLD) to modify the surface of Mg alloy with thin films of MgY alloy and Zn. This week's journal reports on the optimization of deposition parameters of Zn. (Temperature, Pressure, and Energy)

PLD is a physical vapor deposition method, in which, a pulsed laser beam is focused onto a target beyond the material's ablation threshold creating a plasma of the material (target) to expand/evaporate and deposited onto a substrate under vacuum or in the presence of a gas.

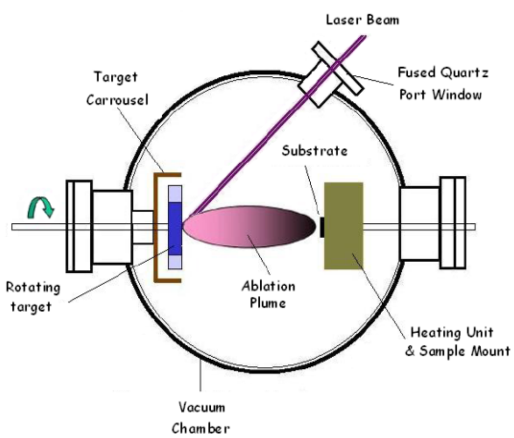


Figure 1. PLD Chamber Experimental Setup

The entire process of PLD simply begins with a pulsed laser which lasts for some nanoseconds. For our experiments, a KrF ExciMer laser fires pulses at 248 nm wavelength lasting for 30 ns per pulse at some rate of repetition in Hertz. The laser is incidented on the target (Zn) and has an associated value of energy per cross-sectional area defined as laser fluence

(J/cm^2). As the laser incidents on the target, a percentage of the light radiation is absorbed into the material while the rest is reflected. If the absorbed energy is sufficient enough to break the chemical bonds in the material, then the ablation threshold of the material has been surpassed and instantaneously a cloud of ionized gas or plume of the target material propagates from the target surface to the substrate. All these are illustrated in Figure 1 above.

<u>Experimental Parameters</u>
Target: 99.99% pure Zinc
Substrates: Silicon (100), C-Plane sapphire Al_2O_3 (0001), Glass
Number of pulses: 20,000 pulses of Zinc
Substrate Temperature (^oC): 25, 100, 200

<u>Sample Preparation</u>
The substrates must be cleaned, first by ultrasonic cleaning and then by vapor cleaning. The substrates are placed into a beaker of acetone and put into the ultrasonic cleaning machine, which uses sonic waves to clean the surfaces, for 15 minutes. After ultrasonic cleaning, the substrates are vapor cleaned, in this process the substrates are held at a 45^o angle with tweezers over the vapor of boiling acetone until the surface is clean. The target is lapped on sandpaper and mounted into the chamber. Then, the substrates are mounted onto the substrate mount, which also acts as the heater, with silver paint.

The chamber is evacuated to high vacuum of magnitude x10^{-7} torr, before deposition, the chamber is filled with 100 mtorr of Argon gas.

During the experiments, the average laser energy was recorded to be 500 mJ on the panel with an expected 197 mJ inside the chamber and the laser spot size incident on the target was 0.0539 cm^2. This yields approximately 3.65 J/cm^2 for laser fluence.

<u>Future Plans</u>
I plan on beginning Zn characterizations next week by using profilometer for thickness analysis, XRD to study the crystal structure, SEM to study the surface morphology, corrosion analysis and EDX for composition analysis on the samples we have so far. Subsequently, we will coat MgZnCa alloys that have been fabricated by Dr. Xu's group with MgY alloy and Zn and characterize these samples as well and prepare them for biological testing.

Example Weekly Reflection Journal (Page 2 of 3)

Weekly Reflection: Week 1

Name: Pooja Sarin
Dates: June 28 – July 2, 2010

I learned a lot this week by performing several different hands-on techniques. All the graduate students and Dr. Kumar have taught me a great deal about the different research they are conducting.

I learned about the differences in substrates, thin films and nanowires and the effect each has on the samples created during pulse laser deposition. I also learned how to conduct x-ray diffraction using the XRD machine and how to read and comprehend the peaks produced from XRD. I also used the profilometer to measure the thickness of a TiN sample and MgO sample. I also learned about the SEM, which is a scanning electron microscope that captures images of a sample's surface by using a high-energy beam of electrons. It was really exciting to see how the process of PLD works, from cleaning substrates and the target to watching the pulsed laser to the different characterization techniques used to assess the samples made.

I am really looking forward to learning about the other characterization techniques of EDX, the corrosion analysis and using cell cultures to evaluate the samples.

Example Weekly Reflection Journal (Page 3 of 3)

REU Summer 2010 Weekly Newsletter
July 12-13

Published by: Amy Wat and Dominique D. Tucker-Roberson

REU Research Profiles:

Dominique D. Tucker-Roberson

I am working in lab with Dr. Ko and my RET Michael Banner. In my lab we are observing the corrosion process of each sample of magnesium. The sample I am working with is pure Magnesium (Mg) and 96% Magnesium 3% Aluminum and 1% Zinc (AZ31). Each day I emerge a sample in the solution that I prepared for that particular sample. We have six different solutions and each solution shows something different each time. The six solutions consist of distilled water (Control) (SBF #2) solid body fluid and (FBS) Fetal Bovine Serum. We are trying to determine if we could use magnesium and other alloys as a biodegradable material medical implant. Instead of using screws; the surgeon will implant the magnesium. However, the biodegradable sample of magnesium is corroding faster than the healing process so in my lab we are observing how fast it takes the sample to complete the corrosion process. This research will let us know if we are able to use magnesium as a biodegradable material as a medical implant. I like my work in my lab and my team and I thing the research is very interesting.

Amy Wat

Dr. Zhigeng Xu and I are working on a new procedure to create an open cellular magnesium alloy by using a positive plaster mold. The purpose of having an open cellular magnesium alloy is to allow the flow of bodily fluids through the implant, which in turn allows the tissues to regrow on the implant itself. Currently, we are testing different types of plasters used for the mold for the magnesium alloy. We also have to test different procedures for the different plasters since we need to know what are the parameters that must be accounted for when mixing the plasters. We determine the best plaster by checking for cracks, shrinkage, and porosity of the mold with the scanning electron microscope. I am enjoying my project as it allows me to experience several things like metal casting and electron microscopy. It also poses several challenges since the decisions made in this experiment determines the quality and effectiveness of the bulk magnesium alloy that would be used in the future. This project has been difficult, but very exciting and I am happy to have had this opportunity to work with Dr. Xu.

Christopher A Gardner

Under Dr. Yun, I am working on silanizing glass subtrates with APTES (aminopropyltriethoxysilane) and spincoating a biotinylated photoresist polymer PNMP (poly o-nitrobenzyl methacrylate methyl methacrylate poly(ethylene glycol) methacrylate) uniformly across the surface of the substrate. Using this substrate, I am attempting to pattern the fluorescent proteins streptavidin Texas Red (SAv-TR) and streptavidin fluorescein isothiocyanate conjugate (SAv-FITC) in a micron-level array using a novel photolithographical technique. So far, Dr. Yun and I have encountered multiple obstacles, such as an unusual translucent color of the biotinylated PNMP coating, that when processed in phosphate buffered saline (PBS) with a pH of 7.4, dissolves entirely, regardless of UV exposure. Currently, I have just begun preparing magnesium alloy substrates for patterning and Dr. Yun and I are anticipating positive results.

David Meza

My lab team consists of Dr. Sergey Yarmolenko, Rueben, Maliq, and Sonja Collins. In my lab we are depositing a thin film of vanadium nitride on a silicon substrate by the magnetron sputtering method. Sputtering ejects atoms from a target material which on our case is vanadium. High energy ions bombard the target material which causes the material to sputter off and coat the silicon substrate. Once we have our thin film we measure its thickness by either using the profilometer or X-Ray Reflectrometry. We also check to if the material is amorphous or if it has an ordered crystal structure by using the x-ray diffractometer. The overall goal is to create a multilayer coating consisting of vanadium nitride, aluminum nitride, and titanium nitride. We are trying to improve wear resistance and fracture toughness.

Pooja Sarin

During my REU experience, I have been working with pulsed laser depositions (PLD). PLD is a physical vapor deposition method, in which, a pulsed laser beam creates a plasma of the target to expand or evaporate and is deposited onto a substrate under vacuum or in the presence of a gas. I am using a 99.99% pure Zinc target on Silicon (100), C-Plane sapphire Al_2O_3 (0001) and Glass substrates. At 20,000 pulses of Zinc, I have deposited samples at 25, 100 and 200C. After depositing several samples, I began the Zn characterizations. The various characterization methods include using the profilometer for thickness analysis, XRD to study the crystal structure, SEM to study the surface morphology, corrosion analysis and EDX for composition analysis on the samples we have so far.