NASA CYBERSECURITY

Maryam Amer, Old Dominion University

President Obama has identified cybersecurity as one of the most serious “economic and national security challenges we face as a nation, but one that we as a country are not adequately prepared to counter.” The national and economic security of the United States depends on the reliability and functionality of its critical infrastructure. Cybersecurity threats target NASA’s highly sought after network can harm the organization’s ability to innovate and gain customers, ultimately putting the Nation’s security, economy, public safety and health at risk. With over five thousand computer security incidents happening yearly on NASA’s systems alone, cybersecurity is becoming a real problem for our nation. After researching through a risk based economic and technical approach to monitoring critical software patches and technical vulnerabilities for NASA computers, five major challenges were discovered, including a lack of full awareness of Agency-wide IT security posture, shortcomings in implementing a continuous monitoring approach to IT security, slow pace of encryption for NASA laptop computers and other mobile devices, ability to combat sophisticated cyber attacks, and transition to cloud computing.

BLOWOUT CHARACTERIZATION OF A SCRAMJET COMBUSTOR USING PARTICLE IMAGE VELOCIMETRY

April Anlage, University of Virginia

Supersonic combustion ramjets (scramjets) present significant advantages for future hypersonic flight. However, the operational limits of the engine must be well-understood before practical use. Using the University of Virginia scramjet combustion facility, study of one of the limits of scramjet operation, or blowout, is possible. One of the experimental techniques that can be used to study such phenomena is particle image velocimetry (PIV). The technique is used to image the center plane of the flow field using two distinct laser pulses that illuminate a field of seed particles. From the thousands of images acquired during a blowout event, computer software can determine particle velocity by matching two images of the same particles and applying the known time between the laser pulses. The objective of this study was to devise a triggering system, such that when precursors of blowout were detected, in this case a sharp decrease in flame luminosity, the image acquisition system was activated. Although planned testing has been delayed, the experiment is expected to produce novel velocity fields and turbulence intensity measurements of blowout.
BMP REGULATION OF COMPETITION FOR THE GERMLINE STEM CELL NICHE

Merci Best, Undergraduate STEM Bridge Scholar, The College of William and Mary

Stem cells are asymmetrically dividing cells that are vital for organogenesis, tissue regeneration and tissue homoeostasis. They reside within a stem cell niche and provide the functional cell types that are necessary for organogenesis, while maintaining a stem cell population that continuously replaces damaged and dying cells. Given their critical role in tissue maintenance, it is important to understanding how these cells first form. Surprisingly little, however, is known about stem cell development. The Drosophila testis, one of the most thoroughly studied systems for studying stem cell behavior in fully developed organs can be used to examine stem cell behavior in the developing stem cell niche. In this system, the stem cell niche is comprised of a tightly clustered group of cells which act as a signaling center to recruit GSCs from a small population of undifferentiated primordial germ cells (PGCs). Within the niche, the Bone Morphogenetic Protein (BMP) pathway has been shown to regulate GSC maintenance in the adult organism. This research examines the role of cell-to-cell interactions during the establishment of functional stem cell populations in developing Drosophila testis. Specifically, we examine the role of BMP signaling in controlling a GSC’s capacity to occupy the developing stem cell niche. As GSCs are required for continuous gamete production, these studies have implications for fertility and evolutionary fitness of subsequent generations.

EFFICIENT TURBOFAN DIAGNOSTICS TEST CELL CONFIGURATION

Matthew Ferguson, Virginia Tech

The turbofan test cell at Virginia Tech’s new Advanced Power and Propulsion Laboratory (APPL) is being outfitted to accommodate an AE3007a turbofan jet engine, as seen in Figure 1. The test cell will specialize in running advanced diagnostic tools and instrumentation being developed in other labs around the university on the turbofan. Much of the challenge in placing the engine in the APPL stems from the abnormally small size of the cell. As a result, exhaust circulation, inlet airflow, and engine noise will all behave differently than in a regularly sized test cell. The current test cell size creates dangerous noise levels and high heat conditions. In the following space, solutions for thermal and acoustic issues with the test cell are explored.

VERSATILE TRANSCEIVER FOR SMALL SATELLITE MISSIONS USING SOFTWARE DEFINED RADIO

Jason Harris, Old Dominion University

In this paper, we discuss some basics about FSK and OFDM transmissions. We describe how these could be implemented using a software defined radio platform and GNU Radio. We then implement an FSK transmitter using a conventional radio as the transmitter and a USRP as the receiver. We show that we could demodulate the transmitted signal successfully.
POLYIMIDE GRAPHENE OXIDE NANOCOMPOSITES WITH IMPROVED PERFORMANCE

Natalie Hudson-Smith, The College of William and Mary

Polyimides are a commercially useful material, typically used in air and space applications due to high heat resistance, impressive mechanical strength, and self-extinguishing properties. In recent years, graphene has come of interest in the material science world but is typically too hydrophobic to be used as a component in a polymer composite system. Focus has shifted to graphene oxide (GO); the honeycomb structure of graphene with oxygen-containing functional groups on the surface. Incorporation of GO into polyimides shows improved mechanical properties, increased gas barrier properties and increased solvent resistance (or decreased solvent uptake). Functionalization of GO sheets with monomer components of the chosen polymer results in further improvements of these properties and demonstrates that tailoring of GO composite materials is a valuable technique in enhancing properties.

MUSCLE UNLOADING INDUCED SEX-SPECIFIC NEUROPHYSIOLOGICAL AND MYOFIBER PROFILE ADAPTATIONS

Colleen Leathrum, The College of William and Mary

Hindlimb suspension affects a muscle’s ability to produce a contractile force and the muscle’s ability to resist fatigue. The objective of this project was to investigate the differences between males and females and their neurophysiological adaptations to hindlimb suspension. Thirty nine young adult Wistar rats were divided into the following four groups: 1) male control, 2) female control, 3) male unloading, 4) female unloading. The unloading groups were subjected to a hindlimb suspension model. Soleus muscles were removed to quantify neuromuscular function, and fluorescent fiber type staining to quantify the cross-sectional area and fiber type composition. By varying stimulation protocols, muscle contraction was induced either directly or indirectly and muscular force was quantified by a force transducer. Fluorescent staining was used to determine myofiber profiles. The results showed that fatigue is greater in the nerve (indirect stimulation) than the muscle (direct stimulation), indicating that the muscle has more endurance than the neuron. Hindlimb suspension affected the females more than the men whether the muscle was stimulated directly or by the nerve. Unloading significantly increased the neuromuscular block over the five minute fatigue train only in the females. There was a significant myofiber atrophy in the unloaded groups, but no sex specific significant differences and no fiber type transitions. In summary, the muscle fatigue is likely due to fatigue in the neuron’s ability to stimulate the muscle, and females are more affected by the hindlimb suspension than males. There was also unloading induced myofiber atrophy which clearly affected maximal force production, but it was not sex specific.
INVESTIGATION OF VARIOUS HEAT TREATMENTS OF MAGNESIUM WE43

*Patrick McQuade, University of Virginia*

Various heat treatments of a Mg-Y-Nd alloy (WE43) were examined. The typical T5 temper was compared to the T6 temper, in which the alloy is solution treated prior to artificial aging at 210 °C. The T6 temper showed a higher peak hardness than the T5 temper, corresponding with a higher weight fraction of precipitates, as calculated with Rietveld refinement. Two T8 tempers, in which the material is strained after solution treatment and prior to artificial aging, were tested. The strain was done in RD tension and ND compression and the two tempers showed very similar aging behavior. Compared to the T6 treatment, the T8 tempers showed reduced peak hardness and shorter aging time. A two-step treatment in which the solution treated alloy was aged at 140 °C for 4 hours prior to aging at 210 °C. The two-step heat treatment achieves the same peak hardness as the T6 temper with lower aging time.

MAXIMIZING KINETIC EFFICIENCY OF DYE-SENSITIZED SOLAR CELLS

*John Rose, The College of William and Mary*

Dye-Sensitized Solar Cells (DSSCs) are a promising alternative for renewable energy, yet a deeper understanding of underlying kinetics is necessary to improve device efficiency. Single molecule spectroscopy is used in conjunction with the dye rhodamine 123 to probe the kinetic parameters governing forward electron transfer from the dye to its substrate and subsequent back electron transfer from substrate to dye. The photo-physical parameters for rhodamine 123 are examined on glass and TiO$_2$ substrates, and as a function of dye binding mode to the substrate. Single molecule data is analyzed using statistically robust methods and then related to functional distributions describing the kinetic processes in DSSCs. Preliminary results of dye on glass indicate a Gaussian distribution of energy barriers to back electron transfer and an exponential distribution of barriers to forward electron transfer. Further investigation of dye bound to TiO$_2$ is required and currently underway.
DESIGN, DEVELOPMENT, AND TESTING OF THE VIRGINIA TECH CUBESAT ATTITUDE CONTROL SIMULATOR

Nicholas R. Tibbetts, Virginia Tech

Spacecraft three-axis simulators are commonly used to simulate attitude control conditions prior to flight due to the near frictionless environment that they provide. However, most currently in use are too large to be conducive to testing CubeSat-class spacecraft. Due to their compact size and relative low cost, there has been an increased demand for the use of CubeSats as a platform for science and engineering research in space over the last decade. As more universities, industries, and even high schools develop CubeSats to expand the horizons of human understanding, the demand for test platforms to test, verify, and validate systems has increased. Currently, no public attitude control simulator exists that can support the new six and twelve unit CubeSats nor test all current CubeSat configurations. To solve these challenges, an economical black-box approach to CubeSat attitude determination and control (ADACS) simulation has been designed and fabricated at Virginia Tech’s Space System Simulation Laboratory. This inexpensive, next-generation platform will enable testing of any current and future CubeSat frame and ADACS system. The Virginia Tech CubeSat Attitude Control Simulator (CSACS) is a lightweight test platform with negligible inertia. Using commercial off the shelf (COTS) components, the system can dynamically balance and eliminate gravitational torque to provide a stable, realistic simulation system to test CubeSat ADACS. With an approximate platform cost of $2500, this system can be built by any university or business to promote the advancement of small satellite technology and advanced space science research.
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Colleen Leathrum, Michael Deschenes
Department of Kinesiology and Health Sciences, College of William and Mary

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The College of William and Mary
John Rose, Jenna Tan, Dr. Kristin Wustholz

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Design, Development, and Testing of the Virginia Tech CubeSat Attitude Control Simulator

Nicholas R. Tibbetts
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Abstract

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