NASA/TM—2001-211289

HBCUs/OMUs Research Conference Agenda and Abstracts

November 2001

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NASA/TM—2001-211289

HBCUs/OMUs Research Conference Agenda and Abstracts

Proceedings of a conference held at Ohio Aerospace Institute
and sponsored by NASA Glenn Research Center
Cleveland, Ohio
April 17–18, 2001

National Aeronautics and
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Glenn Research Center

November 2001

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GRC HBCU's/OMU's RESEARCH CONFERENCE

APRIL 17–18, 2001

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National Aeronautics and
Space Administration

John H. Glenn Research Center
Lewis Field
Cleveland, OH 44135-3191

Reply to Attn of:

The NASA John H. Glenn Research Center's (GRC) commitment to excellence continues to grow in terms of investment and support for Historically Black Colleges and Universities (HBCU's)/Other Minority Universities (OMU's). Our total research and development grant awards to HBCU's/OMU's continue to exceed our performance goal by a substantial margin.

GRC's HBCU's/OMU's Research Program is designed to utilize the capabilities of HBCU's/OMU's to conduct fundamental science and develop physical infrastructure related to NASA's disciplines. To reach our goals, we build partnerships with other Government agencies, industry, and academia. Our research partnerships with the Nation's HBCU's/OMU's are an integral part of our strategy.

The HBCU's/OMU's Research Conference is a critical element in ensuring the success of GRC's research programs. In addition, it provides a forum for showcasing the research capabilities of the participating HBCU's/OMU's.

It is with great pleasure that I welcome the participants and congratulate everyone associated with the NASA HBCU's/OMU's Research Conference.

Donald J. Campbell
Director

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Space Administration

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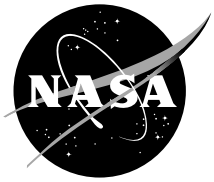

Reply to Attn of:

I extend my welcome to all attendees at this Historically Black Colleges and Universities (HBCU's)/Other Minority Universities (OMU's) Research Conference. This Conference provides the opportunity to showcase the high quality of the John H. Glenn Research Center (GRC)-sponsored research conducted at the Nation's HBCU's/OMU's. I congratulate the Principal Investigators, Student Researchers, and GRC Technical Monitors for your competence and contributions.

I invite all attendees to actively participate with your questions, comments, and suggestions concerning all aspects of the Conference. Your feedback and support are critical to the success of these Conferences.

Julian M. Earls
Deputy Director for Operations

HBCUs/OMUs RESEARCH CONFERENCE
April 17–18, 2001

AGENDA

Presiding: Dr. Sunil Dutta
SDB Program Manager

Tuesday, April 17, 2001

8:00–8:30 a.m.	Registration
8:30–9:00 a.m.	Introduction and Welcome
	Dr. Julian M. Earls Deputy Director for Operations NASA Glenn Research Center
	Mr. Donald J. Campbell Director NASA Glenn Research Center
9:00–10:15 a.m.	Oral Presentations
10:15–10:45 a.m.	Break
10:45–12:00 Noon	Oral Presentations
12:00–1:30 p.m.	Lunch (On Your Own)
1:30–2:45 p.m.	Oral Presentations
2:45–3:00 p.m.	Break
3:00–5:00 p.m.	Oral Presentations

Wednesday, April 18, 2001

8:30 a.m.–12:00 Noon	Poster Sessions
12:00–1:30 p.m.	Lunch (On Your Own)
1:30–3:30 p.m.	Individual Principal Investigator/Technical Monitor Meetings
3:30–4:30 p.m.	Remove Posters

HBCUs/OMUs Research Conference
List of Poster Papers
April 17–18, 2001

P1	Alabama A&M University	"Low Temperature Ohmic Contact Formation of Ni_2Si on N-type 4H-SiC and 6H-SiC"
P2	Alabama A&M University	"Raman and FTIR Studies of Silicon Carbide Surface Damage from Palladium Implantation in Presence of Hydrogen"
P3	Alabama A&M University	"Palladium Implanted Silicon Carbide for Hydrogen Sensing"
P4	Alabama A&M University	"Optical Sensors Based on Single Arm Thin Film Waveguide Interferometer"
P5	Alabama A&M University	"All-Optical Micro Motors Based on Moving Gratings in Photosensitive Media"
P6	City College of New York	"Remobilizing the Interface of Thermocapillary Driven Bubbles Retarded By the Adsorption of a Surfactant Impurity on the Bubble Surface"
P7	City College of New York	"Surfactant Facilitated Spreading of Aqueous Drops on Hydrophobic Surfaces"
P8	City College of New York	"Ultrasonic Assessment of Impact-Induced Damage and Microcracking in Polymer Matrix Composites"
P9	City College of New York	"Experiments With Turbulent Jets at Mach Number 0.9"
P10	Clark Atlanta University	"Substituent and Solvent Effects on Excited State Charge Transfer Behavior of Highly Fluorescent Dyes Containing Thiophenylimidazole-Based Aldehydes"
P11	Clark Atlanta University	"Liquid Fuels: Pyrolytic Degradation and Fire Spread Behavior as Influenced by Buoyancy"
P12	Clark Atlanta University	"Functionalized Carbon Nanotubes"
P13	Florida A&M University	"Robust Fault Detection Using Robust l_1 Estimation and Fuzzy Logic"
P14	Hampton University	"Advanced Methods for Aircraft Engine Thrust and Noise Benefits: Nozzle-Inlet Flow Analysis"
P15	Hampton University	"Numerical Simulation of One- and Two-Phase Flows in Propulsion Systems"
P16	Hampton University	"Design of Fiber Optic Sensors for Measuring Hydrodynamic Parameters"
P17	Hampton University	"The Fabrication of an Evanescent Field Sensor"

P18	Hampton University	“Radiation Losses Due to Tapering of a Double-Core Optical Waveguide”
P19	Hampton University	“Virtual Instrumentation for a Fiber-Optics-Based Artificial Nerve”
P20	Hampton University	“Fiber Bragg Grating Filter High Temperature Sensors”
P21	Jackson State University	“An Algorithm for Interactive Modeling of Space-Transportation Engine Simulations: a Constraint Satisfaction Approach”
P22	Norfolk State University	“Novel High Efficient Organic Photovoltaic Materials”
P23	Prairie View A&M University	“Radiation Effects on DC-DC Converters”
P24	Prairie View A&M University	“Research to Significantly Enhance Composite Survivability at 550 °F in Oxidative Environments”
P25	Prairie View A&M University	“UV Curable Polyimides”
P26	Southern University	“Accessibility of NASA Wisdom”
P27	Tuskegee University	“Durability and Damage Development in Woven Ceramic Matrix Composites”
P28	Tuskegee University	“Notch Sensitivity of Woven Ceramic Matrix Composites Under Tensile Loading—An Experimental, Analytical, and Finite Element Study”
P29	Tuskegee University	“Long-Term Creep and Creep Rupture Behavior of Woven Ceramic Matrix Composites”
P30	Tuskegee University	“Polyimide Based Nanocomposites for Affordable Space Transport”
P31	Tuskegee University	“Study of Electrical Contacts and Devices in Advanced Semiconductors”
P32	University of Texas at El Paso	“Kelvin Probe Measurements on Solar Cells and Other Thin Film Devices”
P33	University of Texas at El Paso	“Annealing of Solar Cells and Other Thin Film Devices”
P34	University of Texas at San Antonio	“Reliability of a Series Pipe Network”
P35	University of Texas at San Antonio	“Reliability of a Parallel Pipe Network”
P36	Winston-Salem State University	“Generic Divide and Conquer Internet-Based Computing”

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Low Temperature Ohmic Contact Formation of Ni_2Si on N-type 4H-SiC and 6H-SiC

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ABSTRACT

Nickel Silicide (Ni_2Si) is investigated as possible ohmic contact to heavily nitrogen-doped N-type 4H-SiC and 6H-SiC. Nickel Silicide was deposited via electron gun with various thicknesses on both Si and C faces of the SiC substrates. The Ni_2Si contacts were formed at room temperature as well as at elevated temperatures (400 to 1000 K). Contact resistivities and I-V characteristics were measured at temperatures between 100 and 700 °C. To investigate the electric properties, I-V characteristics were studied and the Transmission Line Method (TLM) was used to determine the specific contact resistance for the samples at each annealing temperature. Both Rutherford Backscattering Spectroscopy (RBS) and Auger Electron Spectroscopy (AES) were used for depth profiling of the Ni_2Si, Si, and C. X-ray Photoemission Spectroscopy (XPS) was used to study the chemical structure of the Ni_2Si/SiC interface.

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Raman and FTIR Studies of Silicon Carbide Surface Damage from Palladium Implantation in Presence of Hydrogen

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ABSTRACT

The ion implantation in a crystal such as silicon carbide will cause both damage in the ion track and in the substrate at the end of the ion track. We used both keV, and MeV Pd ions in fabricating electronic chemical sensors in silicon carbide, which can operate at elevated temperatures. In order to study the feasibility of fabricating an optical chemical sensor (litmus sensor), we need to understand the optical behaviour of the embedded damage in the presence of hydrogen, as well as the potential chemical interaction of silicon carbide broken lattice bonds with the hydrogen dissociated from gas by palladium. Implanted samples of silicon carbide were studied using both Raman spectroscopy and FTIR. The results of this work will be presented during the meeting.

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Palladium Implanted Silicon Carbide for Hydrogen Sensing

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ABSTRACT

Silicon carbide is intended for use in fabrication of high-temperature, efficient hydrogen sensors. Traditionally, when a palladium coating is applied on the exposed surface of SiC, the chemical reaction between palladium and hydrogen produces a detectable change in the surface chemical potential. We have produced both a palladium coated SiC as well as a palladium, ion implanted SiC sensor. The palladium implantation was done at 500 °C into the Si face of 6H, N-type SiC at various energies, and at various fluences. Then, we measured the hydrogen sensitivity response of each fabricated sensor by exposing them to hydrogen while monitoring the current flow across the p-n junction(s), with respect to time. The sensitivity of each sensor was measured at temperatures between 27 and 300 °C. The response of the SiC sensors produced by Pd implantation has revealed a completely different behaviour than the SiC sensors produced by Pd deposition. In the Pd-deposited SiC sensors as well as in the ones reported in the literature (1,2), the current rises in the presence of hydrogen at room temperature as well as at elevated temperatures. In the case of Pd-implanted SiC sensors, the current decreases in the presence of hydrogen whenever the temperature is rased above 100 °C. We will present the details and conclusions from the results obtained during this meeting.

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Optical Sensors Based on Single Arm Thin Film Waveguide Interferometer

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ABSTRACT

Single-arm double-mode double-order optical waveguide interferometer utilizes interference between two propagating modes of different orders. Sensing effect results from the change in propagation conditions of the modes caused by the environment. The waveguide is made as an open asymmetric slab structure containing a dye-doped polymer film onto a fused quartz substrate. It is more sensitive to the change of environment than its conventional polarimetric analog using orthogonal modes (TE and TM) of the same order. The sensor still preserves the option of operating in polarimetric regime using a variety of mode combinations such as TE_0/TM_0 (conventional), TE_0/TM_1, TE_1/TM_0, or TE_1/TM_1 but can also work in nonpolarimetric regime using combinations TE_0/TE_1 or TM_0/TM_1. Utilization of different mode combinations simultaneously makes the device more versatile. Application of the sensor to gas sensing is based on doping polymer film with an organic indicator dye sensitive to a particular gas. Change of optical absorption spectrum of the dye caused by the gaseous pollutant results change of the reactive index of the dye-doped polymer film that can be detected by the sensor. As an indicator dyes, we utilize Bromocresol Purple doped into polymer poly(methyl) methacrylate, which shows a reversible growth of the absorption peak neat 600 nm after exposure to wet ammonia. We have built a breadboard prototype of the sensor with He-Ne laser as a light source and with a single mode fiber input and a multimode fiber output. The prototype showed sensitivity to temperature change of the order of 2 °C per one full oscillation of the signal. The sensitivity of the sensor to the presence of wet ammonia is 200 ppm per one full oscillation of the signal. The further improvements include switching to a longer wavelength laser source (750-nm semiconductor laser), substitution of poly(methyl) methacrylate with hydrophilic high-temperature polyimide, and increase the doping rate of indicator dye. All these improvements are expected to bring sensitivity to 10 ppm of ammonia per one full oscillation of signal independent on the humidity of ambient air. The proposed sensor can be used as a robust and inexpensive stand-alone instrument for continuous environment pollution monitoring.

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GRC HBCU's/OMU's RESEARCH CONFERENCE

All-Optical Micro Motors Based on Moving Gratings in Photosensitive Media

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ABSTRACT

An all-optical micromotor with a rotor driven by a traveling wave of surface deformation of a stator being in contact with the rotor is being studied. Instead of an ultrasonic wave produced by an electrically driven piezoelectric actuator as in ultrasonic motors, the wave is a result of a photo-induced surface deformation of a photosensitive material produced by an incident radiation. A thin piezoelectric polymer will deform more easily $LiNbO_3$ or metal when irradiated with light. The type of photosensitive material studied are piezoelectric polymers with and without coatings for connecting electrodes. In order to be considered as a possible candidate for micromotors, the material should exhibit surface deformation produced by a laser beam of the order of 10 microns. This is compared to the deformations produced by static holographic gratings studied in photoreffactive crystals of $LiNbO_3$ using high vertical resolution surface profilometer Dektak 3 and surface interferometer WYKO. An experimental setup showing the oscillations has been developed. The setup uses a chopped beam from an Argon ion laser to produce the deformation while a probe beam is reflected by the thin film into a fiber which is then detected on an oscilloscope. A ramp voltage signal generator will drive the piezoelectric film in another experiment to determine the resonance of the film. A current is generated when light is incident upon the film and this current can be measured. The reverse process has already been demonstrated in other piezoelectric actuators. Changing voltage, polarity, and frequency of the signal can easily generate vibrations similar to those when light is incident on the film. This can be compared to the effects of laser interaction with light absorbing fluids such as solutions of 2,9,16,23-Tetrakis(phenylthio)-29H, 31H-phthalocyanine in chlorobenzene in capillary tubes. The possibility of using a liquid with the piezoelectric film would be a novel idea for a micromotor since the interaction of a single low power focused laser beam at 633 nm with such fluid produced an intensive circular motion.

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Remobilizing the Interface of Thermocapillary Driven Bubbles Retarded By the Adsorption of a Surfactant Impurity on the Bubble Surface

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ABSTRACT

Thermocapillary migration is a method for moving bubbles in space in the absence of buoyancy. A temperature gradient is the continuous phase in which a bubble is situated, and the applied gradient impressed on the bubble surface causes one pole of the drop to be cooler than the opposite pole. As the surface tension is a decreasing function of temperature, the cooler pole pulls at the warmer pole, creating a flow that propels the bubble in the direction of the warmer fluid. A major impediment to the practical use of thermocapillary to direct the movement of bubbles in space is the fact that surfactant impurities, which are unavoidably present in the continuous phase, can significantly reduce the migration velocity. A surfactant impurity adsorbed onto the bubble interface is swept to the trailing end of the bubble. When bulk concentrations are low (which is the case with an impurity), diffusion of surfactant to the front end is slow relative to convection, and surfactant collects at the back end of the bubble. Collection at the back lowers the surface tension relative to the front end setting up a reverse tension gradient. (This can also be the case if kinetic desorption of surfactant at the back end of the bubble is much slower than convection.) For buoyancy driven bubble motions in the absence of a thermocapillarity, the tension gradient opposes the surface flow, and reduces the surface and terminal velocities (the interface becomes more solid-like and bubbles translate as solid particles). When thermocapillary forces are present, the reverse tension gradient set up by the surfactant accumulation reduces the temperature-induced tension gradient, and can decrease to near zero the bubble's thermocapillary velocity. The objective of our research is to develop a method for enhancing the thermocapillary migration of bubbles which have be retarded by the adsorption onto the bubble surface of a surfactant impurity. Our remobilization theory proposes to use surfactant molecules which kinetically rapidly exchange between the bulk and the surface and are at high bulk concentrations. Because the remobilizing surfactant is present at much higher concentrations than the impurity, it adsorbs to the bubble surface much faster than the impurity when the bubble is formed, and thereby prevents the impurity from adsorbing onto the surface. In addition, the rapid kinetic exchange and high bulk concentration maintain a saturated surface with uniform surface concentrations. This prevents retarding surface tension gradients and keeps the thermocapillary velocity high. In our reports over the first 2 years, we presented numerical simulations of the bubble motion and surfactant transport which verified theoretically the concept of remobilization, and the development of an apparatus to track and measure the velocity of rising bubbles in a glycerol/water surfactant solution. This year, we detail experimental observations of remobilization. Two polyethylene oxide surfactants were studied, $C_{12}E_6$ ($CH_3(CH_2)_{11}(OCH_2CH_2)_6OH$) and $C_{10}E_8$ ($CH_3(CH_2)_4(OCH_2CH_2)_8OH$). Measurements of the kinetic exchange for these surfactants show that the one with the longer hydrophobe chain $C_{12}E_6$ has a lower rate of kinetic exchange. In addition, this surfactant is much less soluble in the glycerol/water mixture because of the shorter ethoxylate chain. As a result, we found that $C_{12}E_6$ had only a very limited ability to remobilize rising bubbles because of the limited kinetic exchange and reduced solubility. However, $C_{10}E_8$, with its higher solubility and more rapid exchange was found to dramatically remobilize rising bubbles. We also compared our theoretical calculations to the experimental measurements of velocity for both the non-remobilizing and remobilizing surfactants and found excellent agreement. We further observed that for $C_{10}E_8$ at high concentrations, which exceeded the critical micelle concentrations, additional remobilization was measured. In this case the rapid exchange of monomer between micelle and surfactant provides an additional mechanism for maintaining a uniform surface concentrations.

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Surfactant Facilitated Spreading of Aqueous Drops on Hydrophobic Surfaces

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ABSTRACT

Microgravity technologies often require aqueous phases to spread over nonwetting hydrophobic solid surfaces. Surfactants facilitate the wetting of water on hydrophobic surfaces by adsorbing on the water/air and hydrophobic solid/water interfaces and lowering the surface tensions of these interfaces. The tension reductions decrease the contact angle, which increases the equilibrium wetted area. Hydrocarbon surfactants (i.e., amphiphiles with a hydrophobic moiety consisting of an extended chain of (aliphatic) methylene -CH_2- groups attached to a large polar group to give aqueous solubility) are capable of reducing the contact angles on surfaces which are not very hydrophobic, but do not reduce significantly the contact angles of the very hydrophobic surfaces such as parafilm, polyethylene or self assembled monolayers. Trisiloxane surfactants (amphiphiles with a hydrophobe consisting of methyl groups linked to a trisiloxane backbone in the form of a disk (($CH_3)_3$-Si-O-Si-O-Si($CH_3)_3$)) and an extended ethoxylate (-($OCH_2CH_2)_a$-) polar group in the form of a chain with four or eight units) can significantly reduce the contact angle of water on a very hydrophobic surface and cause rapid and complete (or nearly complete) spreading (termed superspreading). The overall goal of the research described in this proposal is to establish and verify a theory for how trisiloxanes cause superspreading, and then use this knowledge as a guide to developing more general hydrocarbon based surfactant systems which superspread. We propose that the trisiloxane surfactants superspread because their structure allows them to strongly lower the high hydrophobic solid/aqueous tension when they adsorb to the solid surface. When the siloxane adsorbs, the hydrophobic disk parts of the molecule adsorb onto the surface removing the surface water. Since the cross-sectional area of the disk is larger than that of the extended ethoxylate chain, the disks can form a space-filling mat on the surface which removes a significant amount of the surface water. In this presentation, we report the results of measurements of the molecular packing and rates of kinetic exchange of the trisiloxane surfactants at the air/water interface in order to confirm our picture of trisiloxane packing, and provide additional insight into the superspreading process. We used the pendant bubble technique as a Langmuir trough to measure the trisiloxane equation of state which relates the tension to the surface concentration. From these measurements we obtain accurate values for the maximum packing density. We find that trisiloxanes with 4 and 8 ethoxylate groups have the same maximum packing concentration, indicating that the maximum packing is controlled by the cross section of the head group. For trisiloxanes with larger than eight ethoxylates, the maximum packing increases with ethoxylate number, indicating that the disposition of the ethoxylate chain (i.e., its effective size) is controlling. This supports our picture of superspreading: The superspreading ability of trisiloxanes decreases considerably for trisiloxanes with larger than eight ethoxylates; the packing measurements indicate that for the higher ethoxylate number trisiloxanes, the compact nonpolar head groups are pushed apart by the ethoxylate chain. They leave spaces of surface water on adsorption and do not lower the solid tension as much as their lower chain analogues. Finally the report measurements of the dynamic tension reduction accompanying the adsorption of trisiloxanes onto an initially clean interface using the pendant bubble technique, and we obtain from these relaxations, the equation of state and a mass transfer model, the rate constants for kinetic exchange. We find that the rate constants for desorption of trisiloxanes are generally much slower than for analogous aliphatic polyethoxylate surfactants with identical ethoxylate chain lengths. When an aqueous drop of a superspreader solution is placed on a hydrophobic surface and begins to spread, the lower desorption rates allows the tension at the drop center to remain reduced relative to the tension of the expanding periphery, thus strengthening Marangoni forces which can assist the spreading. Marangoni forces can be especially significant in the case of superspreaders because their maximum equilibrium reduction in tension is several dynes/cm lower than for aliphatic surfactants.

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Ultrasonic Assessment of Impact-Induced Damage and Microcracking in Polymer Matrix Composites

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ABSTRACT

The main objective of this NASA FAR project is to conduct ultrasonic assessment of impact-induced damage and microcracking in polymer matrix composites at various temperatures. It is believed that the proposed study of impact damage assessment on polymer matrix composites will benefit several NASA missions and current interests, such as ballistic impact testing of composite fan containment and high strain rate deformation modeling of polymer matrix composites. Impact-induced damage mechanisms in GLARE and ARALL fiber-metal laminates subject to instrumented drop-weight impacts at various temperatures were studied. GLARE and ARALL are hybrid composites made of alternating layers of aluminum and glass- (for GLARE) and aramid- (for ARALL) fiber-reinforced epoxy. Damage in pure aluminum panels impacted by foreign objects was mainly characterized by large plastic deformation surrounding a deep penetration dent. On the other hand, plastic deformation in fiber-metal laminates was often not as severe although the penetration dent was still produced. The more stiff fiber-reinforced epoxy layers provided better bending rigidity; thus, enhancing impact damage tolerance. Severe cracking, however, occurred due to the use of these more brittle fiber-reinforced epoxy layers. Fracture patterns, e.g., crack length and delamination size, were greatly affected by the lay-up configuration rather than by the number of layers, which implies that thickness effect was not significant for the panels tested in this study. Immersion ultrasound techniques were then used to assess damages generated by instrumented drop-weight impacts onto these fiber-metal laminate panels as well as 6061-T6 aluminum/cast acrylic sandwich plates adhered by epoxy. Depending on several parameters, such as impact velocity, mass, temperature, laminate configuration, sandwich construction, etc., various types of impact damage were observed, including plastic deformation, radiating cracks emanating from the impact site, ring cracks surrounding the impact site, partial and full delamination, and combinations of these damages.

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Experiments With Turbulent Jets at Mach Number 0.9

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ABSTRACT

A systematic investigation of the structure of turbulent jets before their interaction with shock or expansion waves was undertaken during the last year. In particular compressibility and density effects in circular jets issuing in still air were investigated experimentally. Jets with nitrogen, helium, and krypton gases at 0.3, 0.6, and 0.9 Mach numbers were investigated in detail. Particle Image Velocimetry technique was developed, tested, and used to obtain qualitative information of the two-dimensional velocity field on a plane inside the flow field, which was illuminated by a laser sheet. The motion of particles was recorded by a CCD camera, which was appropriately triggered to capture two images within a fraction of a microsecond. Statistical averaging of the data at each location reduced the large amount of acquired data. It was found that the spreading rate of the jets was reduced with increased Mach numbers or increased density ratio. It was also found that decay rates of centerline Mach numbers are higher in gases with reduced density ratio. Mach number fluctuations appear to decrease with increasing Mach number of the flow. It has been proposed that the reason for this behavior is the reduction of vortex stretching activities with increased Mach number.

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Substituent and Solvent Effects on Excited State Charge Transfer Behavior of Highly Fluorescent Dyes Containing Thiophenylimidazole-Based Aldehydes

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ABSTRACT

The excited state charge transfer for a series of highly fluorescent dyes containing thiophenylimidazole moiety was investigated. These systems follow the *Twisted Intramolecular Charge Transfer* (TICT) model. Dual fluorescence was observed for each substituted dye. X-ray structures analysis reveals a twisted ground state geometry for the donor substituted aryl on the 4 and 5 position at the imidazole ring. The excited state charge transfer was modeled by a linear solvation energy relationship using Taft's π^* and Dimroth's $E_T(30)$ as solvent parameters. There is linear relation between the energy of the fluorescence transition and solvent polarity. The degree of stabilization of the excited state charge transfer was found to be consistent with the intramolecular molecular charge transfer. Excited dipole moment was studied by utilizing the solvatochromic shift method.

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Liquid Fuels: Pyrolytic Degradation and Fire Spread Behavior as Influenced by Buoyancy

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ABSTRACT

This work is being conducted by the Combustion and Emission Control Lab in the Engineering Department at Clark Atlanta University under NASA Grant No. NCC3-707. The work aims at providing data to supplement the ongoing NASA research activities on fire spread across liquid pools by providing flow visualization and velocity measurements especially in the gas phase and gas-liquid interface. The fabrication, installation, and testing were completed during this reporting period. The system shakedown and detailed quantitative measurements with High Speed Video and Particle Image Velocimetry (PIV) systems using butanol as fuel were performed. New and interesting results, not previously reported in the literature, were obtained from the experiments using a modified NASA tray and butanol as fuel. Three distinct flame spread regimes, as previously reported, were observed. These were the pseudo-uniform regime below 20 °C, the pulsating regime between 22 and 30 °C and the uniform regime above about 31 °C. In the pulsating regime the jump velocity appeared to be independent of the pool temperature. However, the retreat velocity between jumps appeared to depend on the initial pool temperature. The flame retreated before surging forwards with increasing brightness. Previous literature reported this phenomenon only under microgravity conditions. However, we observed such behavior in our normal gravity experiments. Mini-pulsations behind the flame front were also observed. Two or three of these pulsations were observed within a single flame front pulsating time period. The velocity vector maps of the gas and liquid phases ahead, during, and behind the flame front were characterized. At least one recirculation cell was observed right below the flame front. The size of the liquid phase vortex (recirculation cell) below the flame front appeared to decrease with increasing initial pool temperature. The experiments also showed how multiple vortices developed in the liquid phase. A large recirculation cell, which generally spins counterclockwise as the flame spread from right to left, was observed ahead of and near the flame front in the gas phase. Detailed quantitative measurements will be undertaken with the LDV and PIV systems using the modified NASA tray and propanol.

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Functionalized Carbon Nanotubes

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ABSTRACT

Carbon nanotubes have created a great deal of excitement in the Materials Science community because of their outstanding mechanical, electrical, and thermal properties. Use of carbon nanotubes as reinforcements for polymers could lead to a new class of composite materials with properties, durability, and performance far exceeding that of conventional fiber reinforced composites. Organized arrays of carbon nanotubes, e.g., nanotube monolayers, could find applications as thermal management materials, light emitting devices, and sensor arrays. Carbon nanotubes could also be used as templates upon which nanotubes from other materials could be constructed. Successful use of carbon nanotubes in any of these potential applications requires the ability to control the interactions of nanotubes with each other and with other materials, e.g., a polymer matrix. One approach to achieving this control is to attach certain chemical groups to the ends and/or side-walls of the nanotubes. The nature of these chemical groups can be varied to achieve the desired result, such as better adhesion between the nanotubes and a polymer. Under a joint program between NASA Glenn, Clark Atlanta University, and Rice University, researchers are working on developing a chemistry "tool-kit" that will enable the functionalization of carbon nanotubes with a variety of chemical groups. Recent results of this effort will be discussed.

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Robust Fault Detection Using Robust l_1 Estimation and Fuzzy Logic

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ABSTRACT

This research considers the application of robust l_1 estimation in conjunction with fuzzy logic to robust fault detection for an aircraft fight control system. It begins with the development of robust l_1 estimators based on multiplier theory and then develops a fixed threshold approach to fault detection (FD). It then considers the use of fuzzy logic for robust residual evaluation and FD. Due to modeling errors and unmeasurable disturbances, it is difficult to distinguish between the effects of an actual fault and those caused by uncertainty and disturbance. Hence, it is the aim of a robust FD system to be sensitive to faults while remaining insensitive to uncertainty and disturbances. While fixed thresholds only allow a decision on whether a fault has or has not occurred, it is more valuable to have the residual evaluation lead to a conclusion related to the degree of, or probability of, a fault. Fuzzy logic is a viable means of determining the degree of a fault and allows the introduction of human observations that may not be incorporated in the rigorous threshold theory. Hence, fuzzy logic can provide a more reliable and informative fault detection process. Using an aircraft flight control system, the results of FD using robust l_1 estimation with a fixed threshold are demonstrated. FD that combines robust l_1 estimation and fuzzy logic is also demonstrated. It is seen that combining the robust estimator with fuzzy logic proves to be advantageous in increasing the sensitivity to smaller faults while remaining insensitive to uncertainty and disturbances.

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Advanced Methods for Aircraft Engine Thrust and Noise Benefits: Nozzle-Inlet Flow Analysis

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ABSTRACT

The Fluid Mechanics and Acoustics Laboratory at Hampton University (HU/FM&AL) jointly with the NASA Glenn Research Center has conducted four connected subprojects under the reporting project. Basically, the HU/FM&AL Team has been involved in joint research with the purpose of theoretical explanation of experimental facts and creation of accurate numerical simulation techniques and prediction theory for solution of current problems in propulsion systems of interest to the NAVY and NASA agencies. This work is also supported by joint research between the NASA GRC and the Institute of Mechanics at Moscow State University (IM/MSU) in Russia under a CRDF grant. The research is focused on a wide regime of problems in the propulsion field as well as in experimental testing and theoretical and numerical simulation analyses for advanced aircraft and rocket engines. The FM&AL Team uses analytical methods, numerical simulations and possible experimental tests at the Hampton University campus. The fundamental idea uniting these subprojects is to use nontraditional 3D corrugated and composite nozzle and inlet designs and additional methods for exhaust jet noise reduction without essential thrust loss and even with thrust augmentation. These subprojects are (A) Aeroperformance and acoustics of Bluebell-shaped and Telescope-shaped designs. (B) An analysis of sharp-edged nozzle exit designs for effective fuel injection into the flow stream in air-breathing engines: triangular-round, diamond-round and other nozzles. (C) Measurement technique improvement for the HU Low Speed Wind Tunnel; a new course in the field of aerodynamics, teaching and training of HU students; experimental tests of Möbius-shaped screws: research and training. (D) Supersonic inlet shape optimization. The main outcomes during this reporting period are(1) Publications: The AIAA Paper #00–3170 was presented at the 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, 17–19 June, 2000, Huntsville, AL. The AIAA Paper #01–1893 has been accepted for the AIAA/NAL-NASDA-ISAS 10th International Space Planes and Hypersonic Systems and Technologies Conference, 24–27 April 2001, Kyoto, Japan. The AIAA Paper #01–3204 has been accepted for presentation at the 37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, being held on 08–11 July, in Salt Lake City, UT. (2) A U.S. patent #6,082,635 was granted on July 4, 2000. (3) Grants and proposals: The HU/FM&AL was awarded the NASA grant NAG-3-2495 in October 2000 and the laboratory is a primary U.S. research team in a joint project under the CRDF award granted to the NASA GRC and IM/MSU (Russia) in July 2000. (4) Theory and numerical simulations: Analytical theory, numerical simulation, comparison of theoretical with experimental results, and modification of theoretical approaches, models, grids, etc., have been conducted for several complicated 2D and 3D nozzle and inlet designs using NASA, ICASE, and IM/MSU codes based on full Euler and Navier-Stokes solvers: CFL3D, FLUENT, and GODUNOV, and others (5) Experimental Tests: (a) A new course: "Advanced Aerodynamics and Aircraft Performance" presented in spring semester, 2001; training and experimental test research using the HU LSWT. (b) Small-scale Möbius-shaped screws were tested in different conditions and their application has shown essential benefits by comparison with traditional designs. (6) Installation in the FM&AL computer system: second software TECPLOT 8.0 for the UNIX SGI workstation and free TECPLOT 7.5 for the PC Dell computer, and 2D and 3D GRIDGEN (version 9) for the UNIX SGI as well as installation of two free NASA codes, 3D MAG and VULCAN. (7) Student Research Activity: Involvement of two undergraduate students as research assistants in the current research project.

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Numerical Simulation of One- and Two-Phase Flows in Propulsion Systems

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ABSTRACT

In this report, we present some results of problems investigated during joint research between the Hampton University Fluid Mechanics and Acoustics Laboratory (HU/FM&AL), NASA GRC, and the LaRC Hyper-X Program. This work is supported by joint research between the NASA GRC and the Institute of Mechanics at Moscow State University (IM/MSU) in Russia under a CRDF grant. The main areas of current scientific interest of the HU/FM&AL include an investigation of the proposed and patented advanced methods for aircraft engine thrust and noise benefits. These methods are based on nontraditional 3D corrugated and composite nozzle, inlet, propeller and screw designs such as a Bluebell and Telescope nozzle, Möbius-shaped screw, etc. This is the main subject of our other projects, of which one is presented at the current conference. Here we analyze additional methods for exhaust jet noise reduction without essential thrust loss and even with thrust augmentation. Such additional approaches are (a) to add some solid, fluid, or gas mass at discrete locations to the main supersonic gas stream to minimize the negative influence of strong shock waves formed in propulsion systems. This mass addition may be accompanied by heat addition to the main stream as a result of the fuel combustion or by cooling of this stream as a result of the liquid mass evaporation and boiling. (b) Use of porous or permeable nozzles and additional shells at the nozzle exit for preliminary cooling of the hot jet exhaust and pressure compensation for off-design conditions (so-called continuous ejector with small mass flow rate). And (c) to propose and analyze new effective methods fuel injection into the flow stream in air-breathing engines. The research is focused on a wide regime of problems in the propulsion field as well as in experimental testing and theoretical and numerical simulation analyses for advanced aircraft and rocket engines. The FM&AL Team uses analytical methods, numerical simulations, and experimental tests at the Hampton University campus, NASA, and IM/MSU. The main outcomes during this reporting period are (1) Publications: The AIAA Paper #01–1893 has been accepted for the AIAA/NAL-NASDA-ISAS 10th International Space Planes and Hypersonic Systems and Technologies Conference, 24–27 April 2001, Kyoto, Japan. The AIAA Paper #01–3204 has been accepted for presentation at the 37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference being held on 08–11 July, in Salt Lake City, UT. (2) Grants and proposals: The HU/FM&AL was awarded the NASA grant NAG3–2495 in October 2000 and the CRDF award was granted to the NASA GRC-HU FM&AL and IM/MSU (Russia) in July 2000. A solicited proposal was submitted for the NASA NRA–01GRC–02 competition and two unsolicited proposals to NASA are in preparation. (4) Theory and numerical simulations: Analytical theory, numerical simulation, comparison of theoretical with experimental results, and modification of theoretical approaches, models, grids, etc. Such investigations have been conducted for three main problems: (a) Combustion efficiency optimization in the half-duct combustor system, (b) Drag reduction effects for blunt bodies with solid needles, and (c) Solid particle injection from the butt-end against a supersonic flow. The NASA CFL3D, HU/FM&AL, and IM/MSU GODUNOV codes were used and modified for solution of these problems. The codes are based on full Euler and Navier-Stokes solvers with and without nonequilibrium oxygen-nitrogen and air-hydrogen chemical reactions in laminar and turbulent gas flow regimes. (5) Experimental tests: In the IM/MSU supersonic wind tunnel, experimental tests were conducted with different number, location, and geometric parameters of solid needles mounted at the front of the butt-end in supersonic flow. Optimal parameters were determined that provide minimal butt-end drag in the stationary flow regime. Experimental and numerical simulation results are in good agreement. (6) Student Research Activity: Involvement of one graduate and two undergraduate students as research assistants in the current project.

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Design of Fiber Optic Sensors for Measuring Hydrodynamic Parameters

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ABSTRACT

The science of optical hydrodynamics involves relating the optical properties to the fluid dynamic properties of a hydrodynamic system. Fiber-optic sensors are being designed for measuring the hydrodynamic parameters of various systems. As a flowing fluid makes an encounter with a flat surface, it forms a boundary layer near this surface. The region between the boundary layer and the flat plate contains information about parameters such as viscosity, compressibility, pressure, density, and velocity. An analytical model has been developed for examining the hydrodynamic parameters near the surface of a fiber-optic sensor. An analysis of the conservation of momentum, the continuity equation and the Navier-Stokes equation for compressible flow were used to develop expressions for the velocity $\vec{v}$ and the density as a function of the distance along the flow and above the surface. When examining the flow near the surface, these expressions are used to estimate the sensitivity required to perform direct optical measurements and to derive the shear force for indirect optical measurements. The derivation of this result permits the incorporation of better design parameters for other fiber-based sensors. Future work includes analyzing the optical parametric designs of fiber-optic sensors, modeling sensors to utilize the parameters for hydrodynamics and applying different mixtures of hydrodynamic flow. Finally, the fabrication of fiber-optic sensors for hydrodynamic flow applications of the type described in this presentation could enhance aerospace, submarine, and medical technology.

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The Fabrication of an Evanescent Field Sensor

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ABSTRACT

We present current results concerning novel sensor-based applications for tilted angle fiber Bragg gratings summarized in a recently filed patent. In addition, concepts involving the coupling of light out of the core region of an optical fiber using ablated corrugations to induce interactions with the surrounding media will also be discussed. The interactions between the media and the coupled light formulate the sensing mechanism for both of these devices. The research illustrated here is an extension of previous work that investigated the affects of intense UV radiation fields on both SiO_2 and Ge-doped SiO_2-based structures (specifically optical fibers and preforms). Finally, these sensors were devised in order to satisfy an experimental task set forth by NASA Glenn involving the production of a prototype evanescent field sensor capable of real-time, dynamic index of refraction measurements as well as early (ultra-high sensitivity) detection of icing on airplane wings.

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Radiation Losses Due to Tapering of a Double-Core Optical Waveguide

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ABSTRACT

The theoretical model we designed parameterizes the power losses as a function of the profile shape for a tapered, single mode, optical dielectric coupler. The focus of this project is to produce a working model that determines the power losses experienced by the fibers when light crosses a taper region. This phenomenon can be examined using coupled mode theory. The optical directional coupler consists of a parallel, dual-channel, waveguide with minimal spacing between the channels to permit energy exchange. Thus, power transfer is essentially a function of the taper profile. To find the fields in the fibers, the approach used was that of solving the Helmholtz equation in cylindrical coordinates involving Bessel and modified Bessel functions depending on the location. For modes inside the core the fields are

$$B_z = 0,\ B_\rho = -\frac{i\mu_1\varepsilon_1\omega}{c\gamma^2} mJ_m(\gamma_m\rho)e^{im\phi},\ B_\phi = \frac{i\mu_1\varepsilon_1\omega}{2c\gamma}\left\{J_{m-1}(\gamma_m\rho) - J_{m+1}(\gamma_m\rho)\right\}e^{im\phi},$$

$$E_z = J_m(\gamma_m\rho)e^{im\phi},\ E_\rho = -\frac{ik}{2\gamma}\left\{J_{m-1}(\gamma_m\rho) - J_{m+1}(\gamma_m\rho)\right\}e^{im\phi},\ E_\phi = -\frac{mk}{\gamma^2}J_m(\gamma_m\rho)e^{im\phi}$$. In the cladding the fields are $E_z = AK_m(\beta_{m,n}\rho)e^{im\phi},\ E_\phi = \frac{ik}{\beta^2_{m,n}}AK_m(\beta_{m,n}\rho)e^{im\phi},$

$$E_\rho = -\frac{ik}{2\beta_{m,n}}A\left\{K_{m-1}(\beta_{m,n}\rho) + K_{m+1}(\beta_{m,n}\rho)\right\}e^{im\phi},\ B_\rho = \frac{m\mu_2\varepsilon_2\omega}{c\beta^2}AK_m(\beta_{m,}\rho)e^{im\phi},$$

$B_\phi = -\frac{i\mu_2\varepsilon_2\omega}{2\beta_{m,n}c}A\left\{K_{m-1}(\beta_{m,n}\rho) + K_{m+1}(\beta_{m,n}\rho)\right\}e^{im\phi}$. The approach used in the taper region was that of solving Helmholtz's equation in oblate spheroidal coordinates in terms of η, ξ and ϕ. For a system with ϕ independence we have two coordinates

$(1-\xi^2)\frac{\partial^2\Sigma}{\partial\xi^2} - 2\xi\frac{\partial\Sigma}{\partial\xi} + \left[(ka\xi)^2 - \chi^2\right]\Sigma = 0$, and $(1+\eta^2)\frac{\partial^2 N}{\partial\eta^2} + 2\eta\frac{\partial N}{\partial\eta} + \left[(ka\eta)^2 + \lambda\right]N = 0$. We solve for appropriate functions in η and ξ coordinates. An analysis of slow and fast tapers is presented along with a detailed examination of radiation losses due to tapering.

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Virtual Instrumentation for a Fiber-Optics-Based Artificial Nerve

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ABSTRACT

A LabView-based computer interface for fiber-optic artificial nerves has been devised as a Masters thesis project. This project involves the use of outputs from wavelength multiplexed optical fiber sensors (artificial nerves), which are capable of producing dense optical data outputs for physical measurements. The potential advantages of using optical fiber sensors for sensory function restoration is the fact that well defined WDM-modulated signals can be transmitted to and from the sensing region allowing networked units to replace low-level nerve functions for persons desirous of "intelligent artificial limbs." Various FO sensors can be designed with high sensitivity and the ability to be interfaced with a wide range of devices including miniature shielded electrical conversion units. Our Virtual Instrument (VI) interface software package was developed using LabView's "Laboratory Virtual Instrument Engineering Workbench" package. The virtual instrument has been configured to arrange and encode the data to develop an intelligent response in the form of encoded digitized signal outputs. The architectural layout of our nervous system is such that different touch stimuli from different artificial fiber-optic nerve points correspond to gratings of a distinct resonant wavelength and physical location along the optical fiber. Thus, when an automated, tunable diode laser sends scans, the wavelength spectrum of the artificial nerve, it triggers responses that are encoded with different touch stimuli by way wavelength shifts in the reflected Bragg resonances. The reflected light is detected and a resulting analog signal is fed into ADC1 board and DAQ card. Finally, the software has been written such that the experimenter is able to set the response range during data acquisition.

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Fiber Bragg Grating Filter High Temperature Sensors

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ABSTRACT

We present a scaled-down method for determining high temperatures using fiber-based Bragg gratings. Bragg gratings are distributed along the length of the optical fiber, and have high reflectivities whenever the optical wavelength is twice the grating spacing. These spatially distinct Bragg regions (located in the core of a fiber) are sensitive to local temperature changes. Since these fibers are silica-based they are easily affected by localized changes in temperature, which results in changes to both the grating spacing and the wavelength reflectivity. We exploit the shift in wavelength reflectivity to measure the change in the local temperature. Note that the Bragg region (sensing area) is some distance away from where the temperature is being measured. This is done so that we can measure temperatures that are much higher than the damage threshold of the fiber. We do this by affixing the fiber with the Bragg sensor to a material with a well-known coefficient of thermal expansion, and model the heat gradient from the region of interest to the actual sensor. The research described in this paper will culminate in a working device as well as be the second portion of a publication pending submission to Optics Letters.

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An Algorithm for Interactive Modeling of Space-Transportation Engine Simulations: a Constraint Satisfaction Approach

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ABSTRACT

In this research we have developed an algorithm for the purpose of constraint processing by utilizing relational algebraic operators. Van Beek and others have investigated in the past this type of constraint processing from within a relational algebraic framework, producing some unique results. Apart from providing new theoretical angles, this approach also gives the opportunity to use the existing efficient implementations of relational database management systems as the underlying data structures for any relevant algorithm. Our algorithm here enhances that framework. The algorithm is quite general in its current form. Weak heuristics (like forward checking) developed within the *Constraint-satisfaction problem* (CSP) area could be also plugged easily within this algorithm for further enhancements of efficiency. The algorithm as developed here is targeted toward a component-oriented modeling problem that we are currently working on, namely, the problem of interactive modeling for batch-simulation of engineering systems (IMBSES). However, it could be adopted for many other CSP problems as well. The research addresses the algorithm and many aspects of the problem IMBSES that we are currently handling.

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Novel High Efficient Organic Photovoltaic Materials

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ABSTRACT

In man's mission to the outer space or a remote site, the most abundant, renewable, nonpolluting, and unlimited external energy source is light. Photovoltaic (PV) materials can convert light into electrical power. In order to generate appreciable electrical power in space or on the Earth, it is necessary to collect sunlight from large areas due to the low density of sunlight, and this would be very costly using current commercially available inorganic solar cells. Future organic or polymer based solar cells seemed very attractive due to several reasons. These include lightweight, flexible shape, ultra-fast optoelectronic response time (this also makes organic PV materials attractive for developing ultra-fast photo detectors), tunability of energy band-gaps via molecular design, versatile materials synthesis and device fabrication schemes, and much lower cost on large-scale industrial production. It has been predicted that nano-phase separated block copolymer systems containing electron rich donor blocks and electron deficient acceptor blocks will facilitate the charge separation and migration due to improved electronic ultrastructure and morphology in comparison to current polymer composite photovoltaic system. This presentation will describe our recent progress in the design, synthesis and characterization of a novel donor-bridge-acceptor block copolymer system for potential high-efficient organic optoelectronic applications. Specifically, the donor block contains an electron donating alkyloxy derivatized polyphenylenevinylene, the acceptor block contains an electron withdrawing alkyl-sulfone derivatized polyphenylenevinylene, and the bridge block contains an electronically neutral non-conjugated aliphatic hydrocarbon chain. The key synthetic strategy includes the synthesis of each individual block first, then couple the blocks together. While the donor block stabilizes the holes, the acceptor block stabilizes the electrons. The bridge block is designed to hinder the electron-hole recombination. Thus, improved charge separation is expected. In addition, charge migration will also be facilitated due to the expected nano-phase separated and highly ordered block copolymer ultrastructural. The combination of all these factors will result in significant overall enhancement of photovoltaic power conversion efficiency.

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Radiation Effects on DC-DC Converters

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ABSTRACT

In this work, several DC-DC converters were designed and built. The converters are Buck Buck-Boost, Cuk, Flyback, and full-bridge zero-voltage switched. The total ionizing dose radiation and single event effects on the converters were investigated. The experimental results for the TID effects tests show that the voltages of the Buck Buck-Boost, Cuk, and Flyback converters increase as total dose increased when using power MOSFET IRF250 as a switching transistor. The change in output voltage with total dose is highest for the Buck converter and the lowest for Flyback converter. The trend of increase in output voltages with total dose in the present work agrees with those of the literature. The trends of the experimental results also agree with those obtained from PSPICE simulation. For the full-bridge zero-voltage switch converter, it was observed that the dc-dc converter with IRF250 power MOSFET did not show a significant change of output voltage with total dose. In addition, for the dc-dc converter with FSF254R4 radiation-hardened power MOSFET, the output voltage did not change significantly with total dose. The experimental results were confirmed by PSPICE simulation that showed that FB-ZVS converter with IRF250 power MOSFET's was not affected with the increase in total ionizing dose. Single Event Effects (SEE) radiation tests were performed on FB-ZVS converters. It was observed that the FB-ZVS converter with the IRF250 power MOSFET, when the device was irradiated with Krypton ion with ion-energy of 150 MeV and LET of 41.3 MeV-cm^2/mg, the output voltage increased with the increase in fluence. However, for Krypton with ion-energy of 600 MeV and LET of 33.65 MeV-cm^2/mg, and two out of four transistors of the converter were permanently damaged. The dc-dc converter with FSF254R4 radiation hardened power MOSFET's did not show significant change at the output voltage with fluence while being irradiated by Krypton with ion energy of 1.20 GeV and LET of 25.97 MeV-cm^2/mg. This might be due to fact that the device is radiation hardened.

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Research to Significantly Enhance Composite Survivability at 550 °F in Oxidative Environments

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ABSTRACT

Prairie View A&M University using the NASA FAR grant has embarked on several paths to accomplish the initial goals of (1) synthesizing three ring aromatic diamines to be used as monomers in the synthesis of polyamide resins and (2) study hydrothermal aging behaviors and glass transition changes of composites synthesized at NASA Glenn Research Center. In establishing the synthesis of the three ring aromatic diamine, it has become necessary to conduct preliminary synthesis to include the nitration of diphenylmethane. The concentration and temperature were altered to assess the effect of purity of isomeric product distribution in such electrophilic aromatic substitution reaction. Products were analyzed using H and C-NMR, Thin Layer Chromatography, High Pressure Liquid Chromatography and GC-Mass Spectrometry (in progress). Results indicate that by varying the concentration of the reaction, a mixture of products can be obtained. Other electrophilic aromatic substitution reactions are also in progress such as Friedel Craft acylation reaction using diphenylmethane with 4-nitrobenzoyl chloride to afford other diamine products. Furthermore, PPVAMU has nearly completed the hydrothermal studies to assess the oxidative stability of DSP443B and DSP442A panels formulated at NASA Glenn Research Center.

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UV Curable Polyimides

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ABSTRACT

The development of UV curable polyimides for high-temperature applications is a growing area of research activity. The objective of this technology is an attempt to bypass many of the issues associated with "typical" high-temperature polymers. For example, the use of toxic or mutagenic monomers (i.e., many aromatic diamines) can be prevented. Also, it proves to be a viable means in circumventing the problems associated with high-processing temperature of polymers, which cause thermally induced processing stresses (i.e., microcracking). The approach that we have been pursuing is Diels-Alder Polymerization. In this approach, we are generating dienes with light instead of heat. This process is called photoenolization. Several bismaleimides and bisacrylates are used as the dienophiles. The method is fairly general and a wide variety of diketones and bismaleimides can be used. UV curability processes are advantageous due to the following: (1) With such a wide variety of monomers, it allows for the use of nontoxic/nonmutagenic monomers. (2) Polyimides cure at room temperature, which reduces thermally induced stresses. (3) It reduces processing and tooling cost. (4) There are many potential applications for this technology, i.e., thin films as alignment layers for LC displays, photoresists, and photonic material as well as a potential market for use as adhesives. Taken from work performed at NASA Glenn Research Center by Michael Meador, Mary Ann Meador, Jennifer Petkovsek, Thomas Oliver, Daniel Scheiman, Christopher Gariepy, Baochau Nguyen, and Ronald Eby.

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Accessibility of NASA Wisdom

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ABSTRACT

Our pursuit of knowledge to preserve has led to a number of retired GRC and Pratt engineers and to Lockheed Martin, Pratt & Whitney, and Boeing personnel. Information in text, audio and video formats has been stored and methods of presenting it in weblike format have been demonstrated. We have gathered from retirees at GRC, knowledge about the causes of launch vehicle failures. Recently through a grant from Marshall Space Flight Center, we have begun to put online several thousand failure analysis reports generated over the last 40 years. Southern University is responsible for incorporating full reports with images, and providing search capabilities. There is no need for commercial database software since a web browser already provides the ability to select text, images, audio, and video for display. We can fine tune the file structure and links and search criteria to the needs of the launch vehicle and propulsion specialists. We have ambitious plans to identify the subdisciplines within rocket propulsion in large bodies of text. A user should be able to specify a few keywords so that the system can identify documents likely to match the user's interest. Our motivation has been, mainly, to preserve rare knowledge of senior engineers who are near retirement. Historical value of such knowledge, and also of our tools, has been pointed out to us by historians. We now propose the application these tools to enhancing communication among groups that are working jointly on a project.

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Durability and Damage Development in Woven Ceramic Matrix Composites

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ABSTRACT

Damage development in woven SiC/SiNC ceramic matrix composites (CMC's) under tensile and cyclic loading both at room and elevated temperatures have been investigated for the exhaust nozzle of high-efficient turbine engines. The ultimate strength, failure strain, proportional limit and modulus data at a temperature range of 23 to 1250 °C are generated. The tensile strength of SiC/SiNC woven composites have been observed to increase with increased temperatures up to 1000 °C. The stress/strain plot shows a pseudo-yield point at 25 percent of the failure strain (ε_r) which indicates damage initiation in the form of matrix cracking. The evolution of damage beyond 0.25 ε_f both at room and elevated temperature comprises multiple matrix cracking, interfacial debonding, and fiber pullout. Although the nature of the stress/strain plot shows damage-tolerant behavior under static loading both at room and elevated temperature, the life expectancy of SiC/SiNC composites degrades significantly under cyclic loading at elevated temperature. This is mostly due to the interactions of fatigue damage caused by the mechanically induced plastic strain and the damage developed by the creep strain. The in situ damage evolutions are monitored by acoustic event parameters, ultrasonic C-scan and stiffness degradation. Rate equations for modulus degradation and fatigue life prediction of ceramic matrix composites both at room and elevated temperatures are developed. These rate equations are observed to show reasonable agreement with experimental results.

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Notch Sensitivity of Woven Ceramic Matrix Composites Under Tensile Loading—An Experimental, Analytical, and Finite Element Study

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ABSTRACT

The stress concentrations associated with circular notches and subjected to uniform tensile loading in woven ceramic matrix composites (CMC's) have been investigated for high-efficient turbine engine applications. The CMC's were composed of Nicalon silicon carbide woven fabric in SiNC matrix manufactured through polymer impregnation process (PIP). Several combinations of hole diameter/plate width ratios and ply orientations were considered in this study. ln the first part, the stress concentrations were calculated measuring strain distributions surrounding the hole using strain gages at different locations of the specimens during the initial portion of the stress-strain curve before any microdamage developed. The stress concentration was also calculated analytically using Lekhnitskii's solution for orthotropic plates. A finite-width correction factor for anisotropic and orthotropic composite plate was considered. The stress distributions surrounding the circular hole of a CMC's plate were further studied using finite element analysis. Both solid and shell elements were considered. The experimental results were compared with both the analytical and finite element solutions. Extensive optical and scanning electron microscopic examinations were carried out for identifying the fracture behavior and failure mechanisms of both the notched and unnotched specimens. The stress concentration factors (SCF) determined by analytical method overpredicted the experimental results. But the numerical solution underpredicted the experimental SCF. Stress concentration factors are shown to increase with enlarged hole size and the effects of ply orientations on stress concentration factors are observed to be negligible. In all the cases, the crack initiated at the notch edge and propagated along the width towards the edge of the specimens.

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Long-Term Creep and Creep Rupture Behavior of Woven Ceramic Matrix Composites

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ABSTRACT

Tensile creep behavior of SiC/SiNC ceramic matrix composites at elevated temperatures and at various stress levels have been investigated for turbine engine applications. The objective of this research is to present creep behavior of SiC/SiCN composites at stress levels above and below the monotonic proportional limit strength and predict the life at creep rupture conditions. Tensile creep-rupture tests were performed on an Instron 8502 servohydraulic testing machine at constant load conditions up to a temperature limit of 1000 °C. Individual creep curves indicate three stages such as primary, secondary, and tertiary. The creep rate increased linearly at an early stage and then gradually became exponential at higher strains. The stress exponent and activation energy were also obtained at 700 and 1000 °C. The specimen lifetime was observed to be 55 hrs at 121 MPa and at 700 °C. The life span reduced to 35 hrs at 143 MPa and at 1000 °C. Scanning electron microscopy observations revealed significant changes in the crystalline phases and creep damage development. Creep failures were accompanied by extensive fiber pullout, matrix cracking, and debonding along with fiber fracture. The creep data was applied to Time-Temperature-Stress superposition model and the Manson-Haferd parametric model for long-time life prediction.

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GRC HBCU's/OMU's RESEARCH CONFERENCE

Polyimide Based Nanocomposites for Affordable Space Transport

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ABSTRACT

In setting forth its strategic plan, NASA has indicated that low-cost access to space is the key to unleashing the commercial potential of space and greatly expanding space research and exploration. The development of advanced materials will be an enabling technology for this quest for low-cost space access. In this research program, we are attempting to address the need for new advanced materials by developing high-performance nanodispersed inorganic/organic and organic/organic polyimide composites utilizing specific interactions. Our goal is to systematically manipulate these interactions and investigate the resulting processing morphology-property relationships. Specifically, we will investigate three main parameters on these relationships. These include (1) the type of polyimide, (2) the structure of the inorganic nanoparticle being used, and (3) manipulation of the interfacial energy. During the first year of this effort, we have demonstrated the successful synthesis of PMR-15/layered silicate nanocomposites. Morphological studies indicate that exfoliated structures were obtained in most instances, with a mixture of exfoliated and intercalated structures being observed also. Significant enhancements of the onset of decomposition were obtained by varying the strength of the interaction between the nanoparticle and the polymer. Varying the amount of a specific nanoparticle also affected the decomposition temperatures. A slight catalytic effect of the nanoparticles on both the imidization and crosslinking reaction has been observed and will be presented. In addition, incorporation of the nanoparticles was found to increase the glass transition temperature and slightly broaden the breadth of this relaxation.

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Study of Electrical Contacts and Devices in Advanced Semiconductors

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ABSTRACT

Research conducted at Tuskegee University concentrates on electrical contacts to GaN films and their characterization with the objective of understanding contact formation and realizing low-resistance metal contacts. Contact properties are known to be strongly related to surface preparation. It appears that the as-received material had a thin oxide film on the surface of the GaN film. Various cleaning treatments were employed in order to render the surface contamination free and removal of the oxide film. Metal films were then deposited by e-beam evaporation. Electrical characteristics of these contacts indicated that the optimal treatment was an organic solvent cleaning followed by etching in buffered oxide solution. Contacts established with Al were observed to be ohmic in nature, whereas Au, Cr, Ti, and Pt exhibit rectifying contacts. Platinum contacts were almost ideal as shown by an ideality factor of 1.02.

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GRC HBCU's/OMU's RESEARCH CONFERENCE

Kelvin Probe Measurements on Solar Cells and Other Thin Film Devices

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ABSTRACT

The Kelvin Probe (KP) has been used for years to measure the surface potential of metals and semiconductors. The KP is an elegantly simple but powerful tool invented by Lord Kelvin around the turn of the century. Using changes in surface potentials as a result of changing the intensity and wavelength of illumination, the KP returns data on material parameters such as band gap energies and the energy levels of interface states. We have employed the KP in the study of CdTe-based solar cells and quantum dot-based solar cells, as well as other thin-film devices. We hope eventually that the KP will be used as an in-line testing station for a fabrication process so that unfinished devices that will not meet requirements can be thrown out before the processing is completed, thus saving resources. Results of these studies will be presented.

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GRC HBCU's/OMU's RESEARCH CONFERENCE

Annealing of Solar Cells and Other Thin Film Devices

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ABSTRACT

Annealing is a key step in most semiconductor fabrication processes, especially for thin films where annealing enhances performance by healing defects and increasing grain sizes. We have employed a new annealing oven for the annealing of CdTe-based solar cells and have been using this system in an attempt to grow CdS on top of CdTe by annealing in the presence of H_2S gas. Preliminary results of this process on CdT solar cells and other thin-film devices will be presented.

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GRC HBCU's/OMU's RESEARCH CONFERENCE

Reliability of a Series Pipe Network

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ABSTRACT

The goal of this NASA-funded research is to advance research and education objectives in theoretical and computational probabilistic structural analysis, reliability, and life prediction methods for improved aerospace and aircraft propulsion system components. Reliability methods are used to quantify response uncertainties due to inherent uncertainties in design variables. In this report, several reliability methods are applied to a series pipe network. The observed responses are the head delivered by a main pump and the line head at a desired flow rate. The probability that the flow rate in the line will be less than a specified minimum will be discussed.

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Reliability of a Parallel Pipe Network

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ABSTRACT

The goal of this NASA-funded research is to advance research and education objectives in theoretical and computational probabilistic structural analysis, reliability, and life prediction methods for improved aerospace and aircraft propulsion system components. Reliability methods are used to quantify response uncertainties due to inherent uncertainties in design variables. In this report, several reliability methods are applied to a parallel pipe network. The observed responses are the head delivered by a main pump and the head values of two parallel lines at certain flow rates. The probability that the flow rates in the lines will be less than their specified minimums will be discussed.

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Generic Divide and Conquer Internet-Based Computing

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ABSTRACT

The rapid growth of internet-based applications and the proliferation of networking technologies have been transforming traditional commercial application areas as well as computer and computational sciences and engineering. This growth stimulates the exploration of new, internet-oriented software technologies that can open new research and application opportunities not only for the commercial world, but also for the scientific and high-performance computing applications community. The general goal of this research project is to contribute to better understanding of the transition to internet-based high-performance computing and to develop solutions for some of the difficulties of this transition. More specifically, our goal is to design an architecture for generic divide and conquer internet-based computing, to develop a portable implementation of this architecture, to create an example library of high-performance divide-and-conquer computing agents that run on top of this architecture, and to evaluate the performance of these agents. We have been designing an architecture that incorporates a master task-pool server and utilizes satellite computational servers that operate on the Internet in a dynamically changing large configuration of lower-end nodes provided by volunteer contributors. Our designed architecture is intended to be complementary to and accessible from computational grids such as Globus, Legion, and Condor. Grids provide remote access to existing high-end computing resources; in contrast, our goal is to utilize idle processor time of lower-end internet nodes. Our project is focused on a generic divide-and-conquer paradigm and its applications that operate on a loose and ever changing pool of lower-end internet nodes.

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WHY COSTING IS IMPORTANT ON HBCU GRANTS

WHY IS COST IMPORTANT?

COST IS OUR ONLY FISCAL MEASURE OF ACTUAL WORK ACCOMPLISHMENT. IT CAN BE UTILIZED BY MANAGEMENT TO EVALUATE THE EFFICIENCY & EFFECTIVENESS OF BUDGET EXECUTION ON OUR PROGRAMS.

WHAT DOES FORWARD FUNDING MEAN?

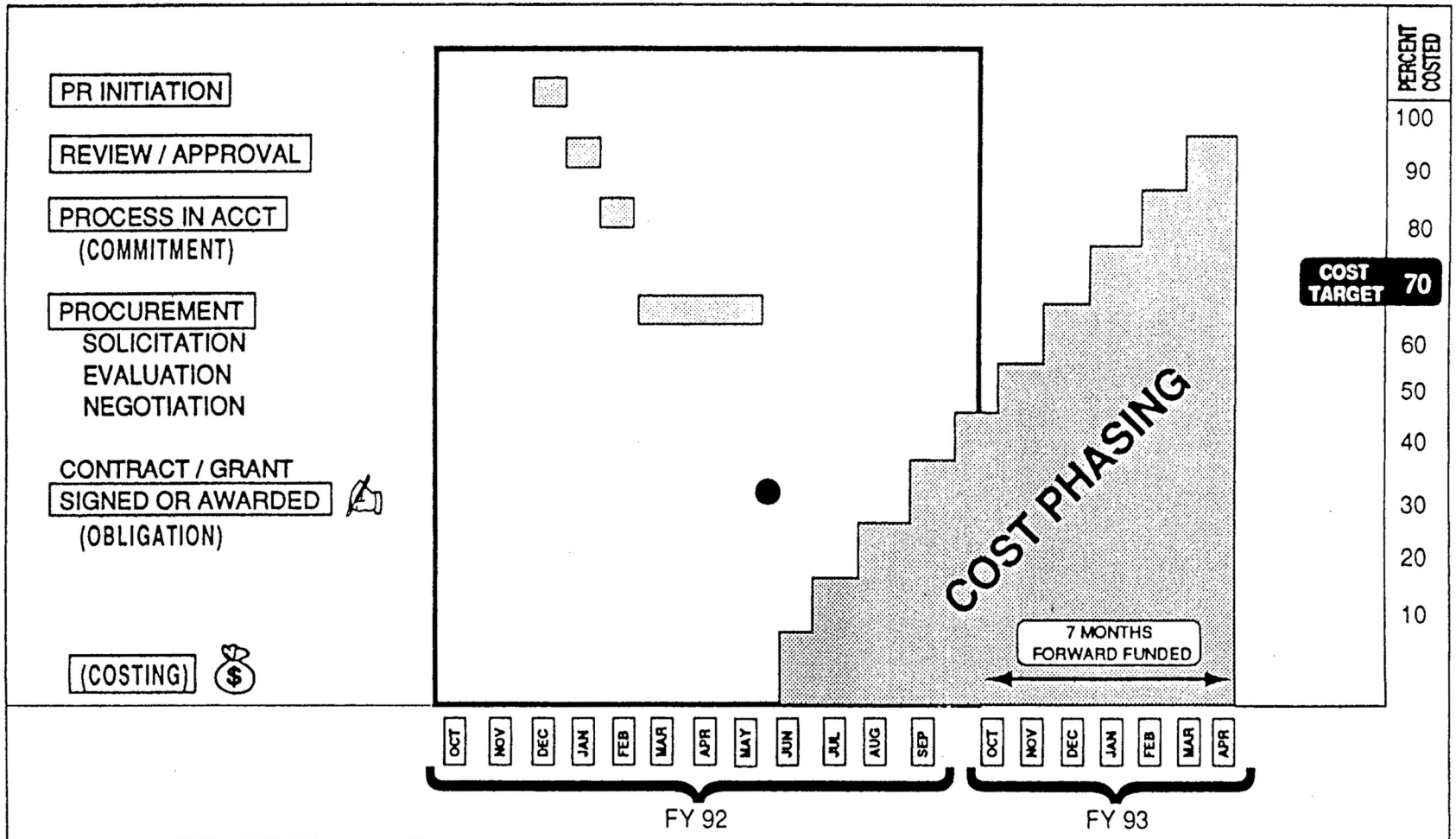
FORWARD FUNDING IS EXPRESSED AS EITHER

① THE AMOUNT OF FUNDING THAT ONE'S PROGRAM OR CONTRACT WILL NOT "COST" DURING THE CURRENT FISCAL YEAR. OR

② THE PERIOD OF TIME THAT YOUR CONTRACT IS FORWARD FUNDED INTO THE NEXT FISCAL YEAR. (NOTE: RB's GUIDELINE IS THAT FORWARD FUNDING BE LIMITED TO NO MORE THAN 2 MONTHS ON ALL OAST CONTRACTS)

WHY COSTING IS IMPORTANT ON HBCU GRANTS

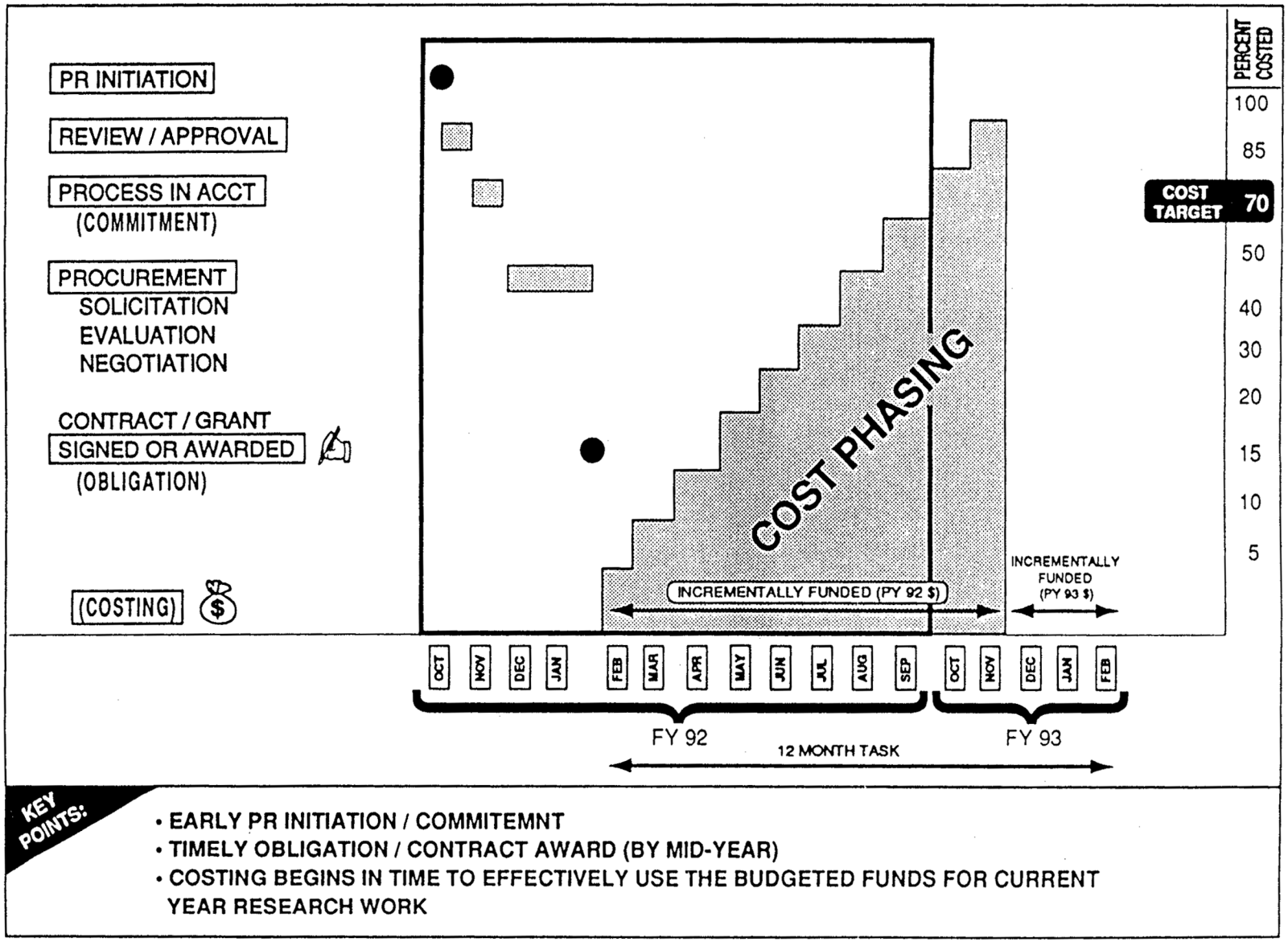
EXAMPLE OF POOR COST MANAGEMENT



KEY POINTS:

- EARLY RTOP APPROVAL AND EARLY 506 RELEASE NEED TO TRANSLATE INTO EARLY COMMITMENTS AND OBLIGATIONS
- YOU CAN'T COST FUNDS THAT ARE NOT OBLIGATED -- LATE FISCAL YEAR CONTRACT AWARDS EQUATE TO MINIMAL COST

EXAMPLE OF GOOD COST MANAGEMENT



KEY POINTS:

- EARLY PR INITIATION / COMMITEMNT
- TIMELY OBLIGATION / CONTRACT AWARD (BY MID-YEAR)
- COSTING BEGINS IN TIME TO EFFECTIVELY USE THE BUDGETED FUNDS FOR CURRENT YEAR RESEARCH WORK

COST MANAGEMENT

⚙ CHECKING ACCOUNT ANALOGY ⚙

- CODE R POLICY ALLOWS 2 MONTHS OF FORWARD FUNDING ON CONTRACTS (BEYOND 9/30) AND A CARRYOVER OF 30% OF YOUR BUDGET ALLOCATION TO COVER EXPENDITURES IN THE FOLLOWING FISCAL YEAR

- HOW MANY MONTHS OF FORWARD FUNDING DO YOU MAINTAIN IN YOUR PERSONAL CHECKING ACCOUNT?

- FLIGHT CENTERS AND MAJOR AGENCY PROGRAMS OPERATE WITH LESS THAN 2 WEEKS OF FORWARD FUNDING INTO THE FOLLOWING FISCAL YEAR

- EXTERNAL AUDIT ORGANIZATIONS CAN'T UNDERSTAND WHY WE ASK FOR FUNDS IN OUR BUDGET REQUEST THAT WE WON'T SPEND IN THE CURRENT FISCAL YEAR.

JJ/GF/1/4/93/NEW AERO AA

OFFICE OF EQUAL OPPORTUNITY PROGRAMS
MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAMS

Cost Management

- NASA MUREP
  - At least 80% of funds should be costed by the end of Federal fiscal year (September 30)
- NASA MUREP Grantees
  - Incremental funding of large $ value grants or cooperative agreements
  - Minimize forward funding beyond 2 months into the following fiscal year
  - 100% of funds should be encumbered by the end of the grant year; funds not encumbered will be deducted from the first incremental funding, actual carryover will be deducted from the second incremental funding

How Can I Improve My Program's Cost Performance

RB Recommendations

① Timelier initiation of procurements
- "Long leadtime" acquisitions (1st Qtr)
- Planning PR's / initiations use while awaiting 506 (1st Qtr)
- Small purchases / off-the-shelf buys (2nd Qtr)
- Tasks on Support Service Contracts (1st Half of Year)

② Expanded use of "Incremental Funding" of Contracts
- Recommended 2 actions per year (1-1st Qtr; 2-Midyear)
- Avoid multiyear / 100% funding up-front scenarios
- Use incremental funding on major fixed-price contracts also

③ Limit forward funding on incrementally-funded contracts (or major tasks on Support Service Contracts) to only one month

④ Implement a one-time adjustment to start dates on major grants / contracts that are not incrementally funded (startup in 1st Qtr, NOT 4th Qtr)

⑤ Ensuring that all legitimate accrued cost on your program is recorded in your Center fiscal systems in a timely and accurate manner

⑥ Base Budget Requests upon how much $ your program will be able to cost over the 12/1/97 - 12/1/98 time frame

RECOMMENDATION

- SUBMIT ALL NECESSARY INFORMATION BILLING TO YOUR COLLEGE FINANCE, ACCOUNTING, OR BILLING OFFICES ON A TIMELY BASIS (AT LEAST ONCE PER MONTH).

- INSURE THAT YOUR COLLEGE BILLING OFFICE SUBMITS REQUIRED BILLING INFORMATION TO NASA LEWIS EACH MONTH SO THAT LEWIS MAY PROPERLY REFLECT ACCURATE UP-TO-DATE COSTING ON YOUR HBCU GRANT.

Donald J. Campbell

Donald J. Campbell is Director of the National Aeronautics and Space Administration's Glenn Research Center in Cleveland, Ohio. He was appointed to this position by NASA Administrator Daniel Goldin on January 6, 1994.

As Director, Mr. Campbell is responsible for planning, organizing, and directing the activities required to accomplish the missions assigned to the Center. Glenn is engaged in research, technology, and systems development programs in aeronautical propulsion, space propulsion, space power, and space sciences/applications. Campbell is responsible for the day-to-day management of these programs, which involve an annual budget of approximately $1 billion, just under 2800 civil service employees and 2000 support service contractors, and more than 500 specialized research facilities located near Cleveland Hopkins International Airport and at Plum Brook Station in Sandusky, Ohio.

Campbell earned a bachelor's degree in mechanical engineering from Ohio Northern University, a master's degree in mechanical engineering and did predoctoral work at Ohio State University. He completed the Senior Executive Seminar in Management at Carnegie Mellon School of Urban and Public Affairs and the Federal Executive Institute Executive Leadership program. He also completed several senior management courses at Brookings Institute.

Campbell began his government career in 1960 as a test engineer for gas turbine engines and engine components in the Air Force Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio. He then worked as a project engineer and later as a program manager for advanced airbreathing propulsion systems.

From February to July 1986, Campbell was assigned as an interim Directorate Chief during the implementation of the National Aerospace Plane (NASP) Program Office, Wright-Patterson Air Force Base. He was Acting Director of the NASP Technology Maturation Directorate. In 1987, he became Acting Deputy Director of the Aero Propulsion Laboratory. In 1988, he was selected for the rank of Senior Executive Service and was appointed Deputy Program Director for the Propulsion System Program Office, Aeronautical Systems Division. He was the senior civilian executive for development and acquisition of new and derivative gas turbine engines for operational aircraft. In 1990, he was appointed Director of the Aero Propulsion and Power Laboratory. He was responsible for the Air Force propulsion and power research and development in the areas of gas turbine engines, ramjet engines, aerospace power systems, and fuels and lubricants.

In 1992, he was named Director of Science and Technology, Office of the Assistant Secretary of the Air Force for Acquisition, Washington, D.C. In this capacity he monitored the Air Force Science and Technology program and other selected research, development, technology, and engineering programs.

Campbell and his wife, Helen, have four children.

Dr. Julian M. Earls

Dr. Julian M. Earls, Deputy Director for Operations at the NASA John H. Glenn Research Center at Lewis Field, is a native of Portsmouth, Virginia. He earned the Bachelor's Degree, with distinction, in Physics from Norfolk State University; the Master's Degree in Radiation Physics from the University of Rochester School of Medicine; and the Doctorate Degree in Radiation Physics from the University of Michigan. He also earned the equivalent of a second Master's Degree in Environmental Health from the University of Michigan and is a graduate of the Harvard Business School's prestigious Program for Management Development. In addition, he was awarded the Honorary Doctor of Science degree by the College of Aeronautics in New York.

He has 21 publications, both technical and educational. He has been Distinguished Honors Visiting Professor at numerous universities throughout the Nation. On two separate occasions, he has been awarded NASA medals for exceptional achievement and outstanding leadership. In addition, he has received the Presidential Rank Award of Meritorious Executive. Dr. Earls is a Jennings Foundation Distinguished Scholar Lecturer.

Dr. Earls is co-founder of an organization whose members make personal contributions for scholarships to black students who attend historically black colleges and universities. He has served on many university Boards of Trustees and is a member of the Advisory Board for the Rock and Roll Hall of Fame. He was inducted into the inaugural class of the National Black College Alumni Hall of Fame, with such distinguished individuals as Dr. Martin Luther King, Jr., and Justice Thurgood Marshall.

He holds life memberships in the NMCP and Kappa Alpha Psi Fraternity. He is an avid runner who has run over 10,000 miles in the past 5 years and successfully completed 22 marathons, including the Boston Marathon.

Dr. Earls is married to the former Zenobia Gregory of Norfolk, Virginia, a former Reading Specialist in the Cleveland School System. They have two sons: Julian, Jr., is a neurologist who graduated from Howard University and Case Western Reserve University Medical School; Gregory is a filmmaker who graduated from Norfolk State University and the American Film Institute in Hollywood, California.

Dr. Sunil Dutta

Dr. Sunil Dutta is Program Manager for Small Disadvantaged Businesses (SDBs) at the National Aeronautics and Space Administration's Glenn Research Center, Cleveland, Ohio. Appointed to this position in 1992, he is responsible for implementing policies that ensure the Small Disadvantaged Businesses (SDBs) and Historically Black Colleges and Universities (HBCUs) are encouraged and afforded and equitable opportunity to compete for NASA contracts and research grants. The goal is to increase R&D contracts with SDBs and research grants with HBCUs at Glenn Research Center. Before assuming the present position, his career has been devoted to research and development of materials science and technology, particularly in the area of processing, characterization, and mechanical behavior of high performance ceramics and ceramics matrix composites, for heat engines and high speed civil transport applications. In addition, he monitored numerous R&D contracts and grants for more than 10 years as project/program manager.

Dr. Dutta joined NASA Glenn Research Center in 1976 after 8 years at the U.S. Army Technology Laboratory, Watertown, Massachusetts. Born in India, he received his B.Sc (Hons), and M.S. from Calcutta University, and M.S. and Ph.D. from the University of Sheffield, England. He also received an MBA degree from Babson College, Wellesley, Massachusetts.

Dr. Dutta has written more than 50 publications including 4 patents and 5 chapters in books.

He is a Fellow of the American Ceramic Society, and the Institute of Ceramics in England. He is listed in American Men and Women in Science, Who's Who in Engineering, and Who's Who in the United States.

Dr. Dutta was invited to Japan for one year as Nippon Steel Endowed Chair Visiting Full Professor, at the University of Tokyo's Research Center for Advanced Science & Technology. Since 1987, he visited Germany, Japan, Korea, Singapore, Australia, and India to present invited technical papers/lectures. Also, actively consulted for industry and government including the CSIR (Council of Scientific and Industrial Research) laboratories in India, under the United Nations Development Program (UNDP).

He has actively participated in Local School PTA programs, as Vice-president of Canterbury Homeowners Association, as President of India Association in Boston, Massachusetts, and in Cleveland, Ohio; and co-convener of 5th biennial National Convention of All Asian-Indians in North America.

Dr. Dutta and his wife Kabita reside in Westlake, Ohio. They have three children.

HBCUs/OMUs RESEARCH CONFERENCE
List of Attendees April 17–18, 2001

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The purpose of this Historically Black Colleges and Universities (HBCUs) Research Conference was to provide an opportunity for principal investigators and their students to present research progress reports. The abstracts included in this report indicate the range and quality of research topics such as aeropropulsion, space propulsion, space power, fluid dynamics, designs, structures and materials being funded through grants from Glenn Research Center to HBCUs. The conference generated extensive networking between students, principal investigators, Glenn technical monitors, and other Glenn researchers.

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