Office of the Chief Technologist
Space Technology Program

An Overview: NASA OCT Space Technology Research Grants Program

NAC Technology and Innovation Committee Meeting

November 15, 2012

Claudia Meyer
Space Technology Research Grants Program Executive

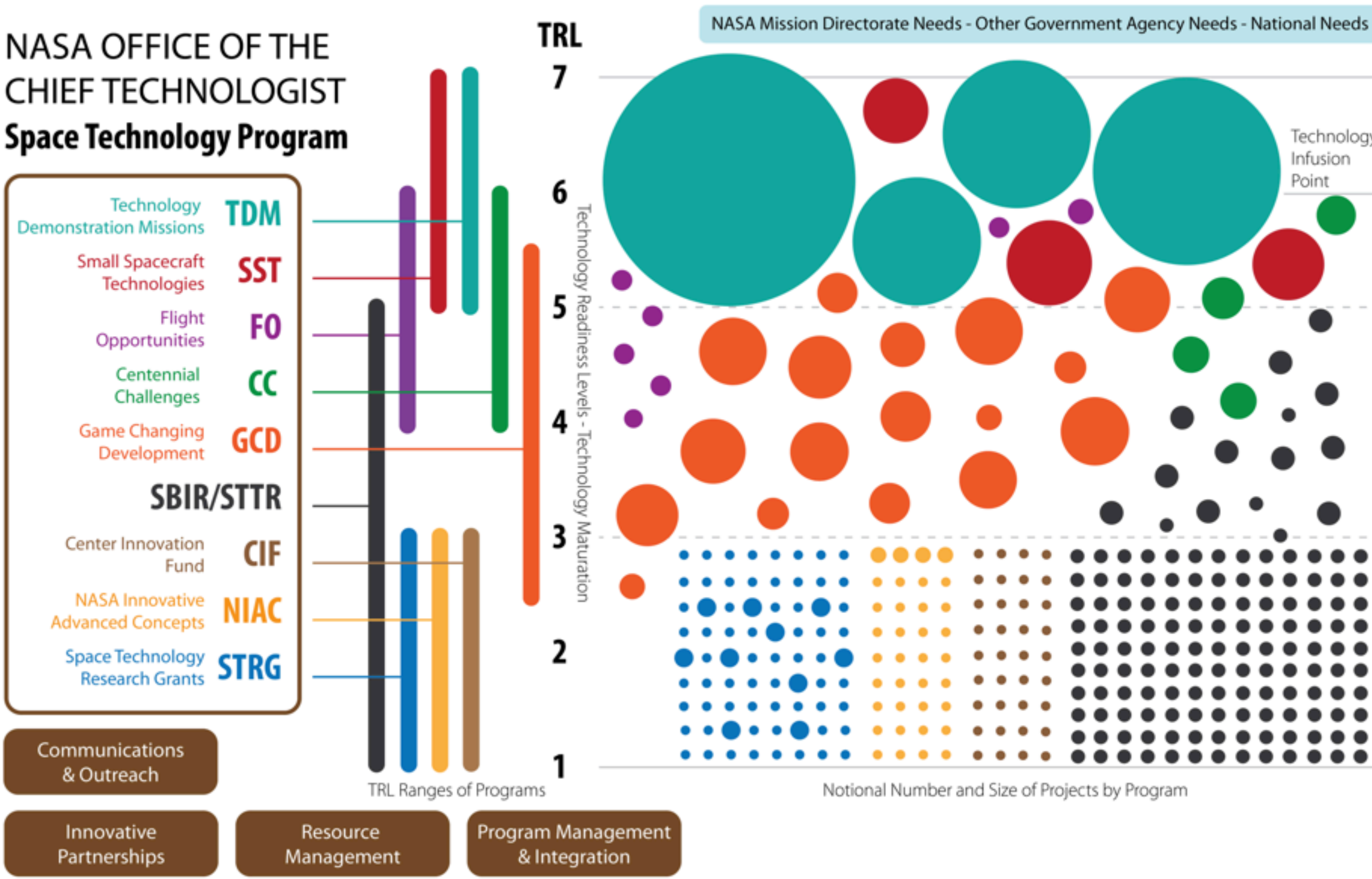
A Lot Has Happened Since We Last Met!

STRO NSTRF

- The NSTRF11 Class completed on-site experiences
- The NSTRF11 Class is generating research results
- The NSTRF12 Class was selected, awarded and each member was paired with a mentor
- The NSTRF13 solicitation was released

- The inaugural *Space Technology Research Opportunities for Early Career Faculty* solicitation was
  - Released
  - Selected
  - Awarded
- The inaugural *Space Technology Research Opportunities – Early Stage Innovations* solicitation was
  - Released
  - Selected
  - and is almost Awarded

Space Technology Programs: High-Level View



Space Technology Research Grants Program

Level II Program Office: GRC

Objective

Accelerate the development of push technologies through innovative efforts with high risk/high payoff

- **Space Technology Research Opportunities:** Early stage innovation technology portfolio of groundbreaking research in advanced space technology
- **NASA Space Technology Research Fellowships (NSTRF):** Competitive selection of U.S Citizen / permanent resident graduate students developing promising technologies in support of future NASA missions and strategic goals

Acquisition Strategy

- **STRO-ESI**: NRA solicitation(s) expected annually. Awards are grants, cooperative agreements, contracts or intra-agency transfers, depending on the scope and focus of the solicitation.
- **NSTRF:** Annual solicitation consistent with academic calendar. Awards are training grants to accredited U.S. universities. Selected candidates perform graduate student research on their respective campuses, at NASA Centers and not-for-profit Research and Development (R&D) labs.

Awards

- **STRO-ESI**: One year awards with possible renewals; ~$200K/year
- **NSTRF:** 80 Fellows in inaugural class; NSTRF12 class of 48 is now in place.

Collaboration

- **STRO-ESI:** Solicitations will vary in terms of eligibility and scope; collaboration will be encouraged
- **NSTRF:** Each student is matched with a professional advisor at NASA Centers or R&D Lab

STRGP Motivation

Improving America's Technological and Economic Competitiveness

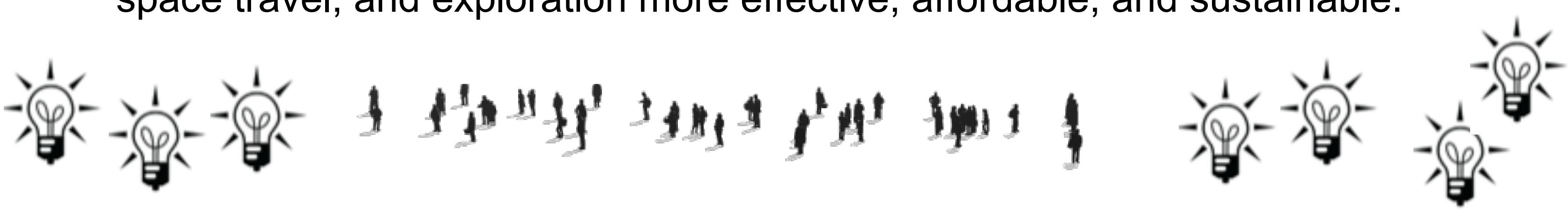
WHY? ➢ Our Nation's universities couple fundamental research with education, encouraging a culture of innovation based on the discovery of knowledge.

ALSO… ➢ Universities are ideally positioned to both conduct fundamental space technology research and diffuse newly-found knowledge into society at large.

- graduate students
- faculty
- industrial, government and other partnerships

SO… ➢ OCT investments in space technology research at U.S. academic institutions will promote the continued leadership of our universities as an international symbol of the country's scientific innovation, engineering creativity, and technological skill.

HOW? ➢ Tap into the talent base, challenging faculty and graduate students to examine the theoretical feasibility of ideas and approaches that are critical to making science, space travel, and exploration more effective, affordable, and sustainable.



The Space Technology Research Grants Program endeavors will reinvigorate the pipeline of low TRL technologies and future technological leaders.

STRGP Portfolio

STRO

Space Technology Research Opportunities Program Element

Annual Solicitation(s)

- FY11 – None
- FY12
  - STRO-Early Career Faculty
  - STRO-Early Stage Innovations

2012 STRO Solicitations: Technical Considerations

As part of STRO's contributions to NASA OCT/Space Technology's sustained, deliberate investment in a low TRL portfolio, these solicitations (ECF and ESI) exclusively sought space technologies that have the potential to lead to dramatic improvements at the system level - performance, weight, cost, reliability, operational simplicity or other figures of merit associated with space flight hardware or missions.

- Directly responds to one or more of the published topic areas
- Is between TRL 1 and 3 at the start of the investigation
- Will advance our understanding or advance the maturity of a technology or concept
- Will investigate a unique, disruptive or transformational space technology or concept

OCT/ST is not seeking literature searches, survey activities, or incremental improvements of an existing technology or concept.

2012 STRO Solicitations: General Information

Early Career Faculty

Key Dates
Release Date: March 8, 2012
Notices of Intent Due: March 30, 2012
Proposals Due: May 3, 2012
Selection Announcement: July 30, 2012 (Target)
Award Date: September 15, 2012 (Target)

Selection Process
Independent Peer Review

Award Details
Award duration: maximum of three years: one initial year with two possible 1-year renewals. Expected Typical Award Amount: $200K/per year

Selecting Official
NASA Space Technology Program Director or designee

Type of Instrument to Be Used for Awards
Grants

Early Stage Innovations

Key Dates
Release Date: May 31, 2012
Notices of Intent Due: June 21, 2012
Proposals Due: July 12, 2012
Selection Announcement: September 14, 2012 (Target)
Award Date: by late October 2012 (Target)

Selection Process
Independent Peer Review

Award Details
Award duration: maximum of two years: one initial year with one possible 1-year renewal. Typical Award Amount: $250K/per year

Selecting Official
NASA Space Technology Program Director or designee

Type of Instrument to Be Used for Awards
Grants and cooperative agreements

2012 STRO-ECF Solicitations: Applicant Eligibility

Only accredited U.S. universities are eligible to submit proposals on behalf of their outstanding new faculty members who intend to develop academic careers related to space technology.

The proposed research project must be led by a single, eligible Principal Investigator (PI).

- PI must be a recent Ph.D. recipient, defined as having graduated on or after January 1 of the year that is no more than seven years before the issuance date of this STRO-ECF NRA (i.e., after January 1, 2005).
- PI must be an **untenured** Assistant Professor on the tenure track at the sponsoring U.S. university at the time of award.
- PI must be a U.S. citizen or have lawful status of permanent residency (i.e., holder of a U.S. Permanent Resident Card, also referred to as a Green Card).
- PI may submit only one proposal in response to this solicitation. Multiple submissions may result in all being deemed non-compliant.
- PI must be the primary researcher on the effort. Co-Investigators are not permitted. Collaborators are permitted. As specified in the *NASA Guidebook for Proposers*, a collaborator is less critical to the proposal than a Co-Investigator would be; specifically, a collaborator is committed to providing a focused but unfunded contribution for a specific task.
- PI may not be a current or former recipient of a PECASE award.

2012 STRO-ESI Solicitations: Applicant Eligibility

Only accredited U.S. universities may submit proposals to this solicitation. Teaming or collaboration with other academic institutions, industry, not-for-profit entities, NASA Centers, other government agencies, and Federally Funded Research and Development Centers (FFRDCs) is permitted, subject to the following restrictions:

1. The Principal Investigator (PI) must be from the proposing university
2. At least 50% of the proposed budget must go to the proposing university
3. At least 70% of the proposed budget must go to academic institutions
4. NASA Centers, other government agencies, and FFRDCs are permitted to collaborate only.

- Co-Investigators and collaborators are permitted.
- In order to facilitate broad, nationwide participation in this program, a proposal PI or Co-Investigator (Co-I) may participate in no more than two proposals in response to this solicitation.
- When more than one proposal is submitted on behalf of a PI or Co-I, each proposal must be a separate, stand-alone, complete document for evaluation purposes. More than two submissions may result in all being deemed non-compliant.
- There is no limit on the number of proposals which may be submitted by an accredited U.S. university.
- Historically Black Colleges and Universities (HBCU) and Other Minority Universities (OMU) are encouraged to apply.
- Collaboration by non-U.S. organizations in proposed efforts is permitted but subject to NASA's policy on foreign participation. (Please note that NASA is accepting proposals from accredited U.S. universities only.)

2012 STRO Solicitations: Technology Areas/Topics

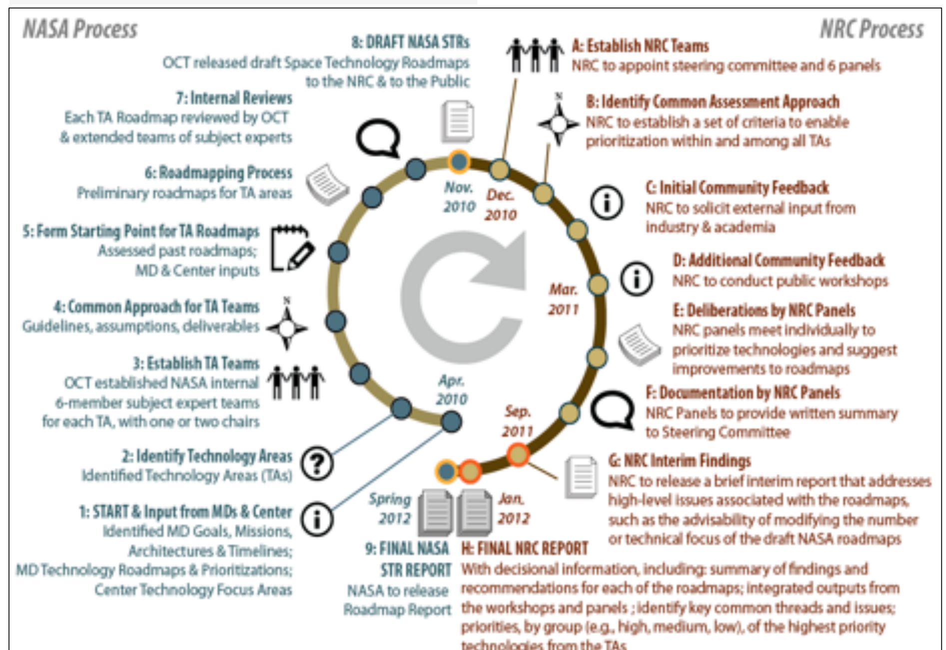
Early Career Faculty

TA05	**Communication and Navigation Systems**
5.3.2	Adaptive Network Topology
5.4.1	Timekeeping and Time Distribution
5.4.3	Onboard Autonomous Navigation and Maneuvering Systems
TA06	**Human Health, Life Support, and Habitation Systems**
6.1.3	Environmental Control and Life Support Systems: Waste Management
6.1.4	Habitation
6.5.3	Radiation Protection Systems
6.5.5	Radiation Monitoring Technology
TA07	**Human Exploration Destination Systems**
7.1.2	In-Situ Resource Utilization (ISRU) Resource Acquisition
7.1.3	ISRU Products/Production
7.1.4	ISRU Manufacturing & Infrastructure Emplacement
TA12	**Materials, Structures, Mechanical Systems, and Manufacturing**
12.1.1	Materials: Lightweight Structure
12.2.1	Structures: Lightweight Concepts
12.2.2	Structures: Design and Certification Methods
12.3.5	Mechanical Systems: Reliability / Life Assessment / Health Monitoring

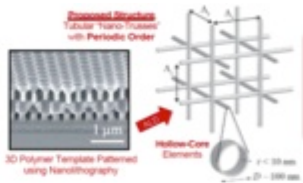
Early Stage Innovations

TA06	**Space Radiation**
6.5.3	Topic 1 - Radiation Protection Systems
6.5.5	Topic 2 - Radiation Monitoring Technology
TA14	**Thermal Management Systems**
14.1.2	Topic 3 - Active Thermal Control of Cryogenic Systems
14.2.3	Topic 4 - Heat Rejection
TA08	**Optical Systems**
8.1.3	Topic 5 – Active Wavefront Control
8.1.3	Topic 6 – Grazing-Incidence Optical Systems

Topic selection guided by…

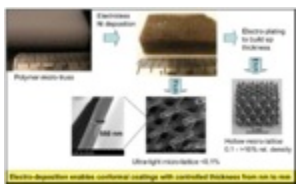


STRO-ECF (2012) Portfolio

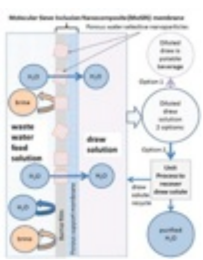


Ultralight Nanolattices with Co-Optimized Mechanical, Thermal, and Optical Properties
Chih-Hao Chang NC STATE UNIVERSITY

Autonomous Food Production
Nikolaus Correll Colorado University of Colorado Boulder

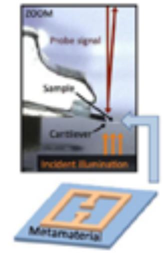


Development of Lightweight, Radiation- and Damage-Tolerant Micro-trusses
Julia R. Greer Caltech



Development of Corrosion-resistant Molecular Sieve Inclusion Nanocomposite (MoSIN) Membranes to Recover Water from Urine Through Osmotic Processes
Mary Laura Lind ASU Arizona State University

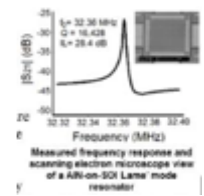
Self-repair and Damage Mitigation of Metallic Structures
Michele Manuel UF University of Florida



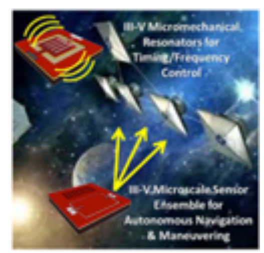
Radiation Pressure on Tunable Optical Metamaterials for Propulsion and Steering Without Moving Parts
Jeremy Munday University of Maryland

Figure 3: Stanford's space robotics facility

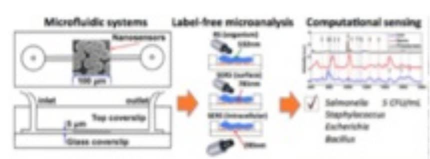
Algorithmic Foundations for Real-Time and Dependable Spacecraft Motion Planning
Marco Pavone Stanford University



Chip-Scale Precision Timing Unit for PicoSatellites
Mina Raies-Zadeh University of Michigan

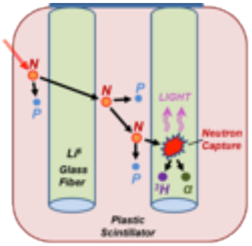


III-V Microsystems Components for Positioning, Navigation and Timing in Extreme Harsh Environments
Debbie Senesky Stanford University

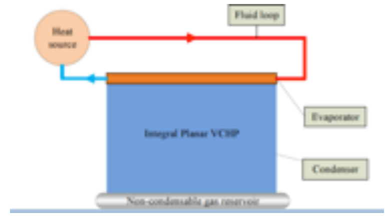


Environmental Control & Life-Support Systems
Wei-Chuan Shih University of Houston

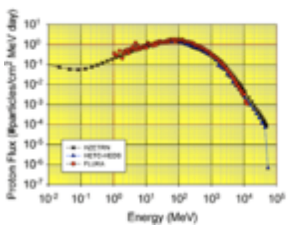
STRO-ESI (2012) Portfolio



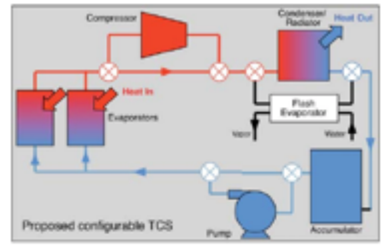
Advanced Scintillating Fiber Technology in High Energy Neutron Spectrometers for Exploration
James Adams
UAHuntsville
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE



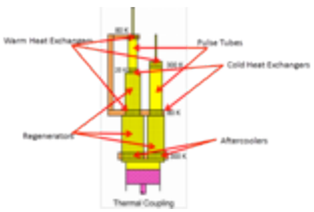
Heat Rejection System for Thermal Management in Space Utilizing a Planar Variable-Conductance Heat Pipe
Yasuhiro Kamotani
CASE WESTERN RESERVE UNIVERSITY



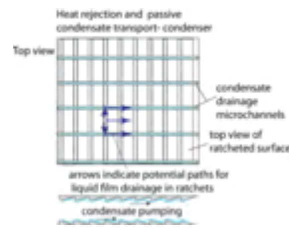
Computational Approaches for Developing Active Radiation Dosimeters for Space Applications Based on New Paradigms for Risk Assessment
Thomas Borak
Colorado State University



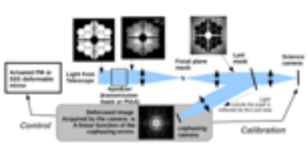
Adaptable Single Active Loop Thermal Control System (TCS) for Future Space Missions
Issam Mudawar
PURDUE UNIVERSITY



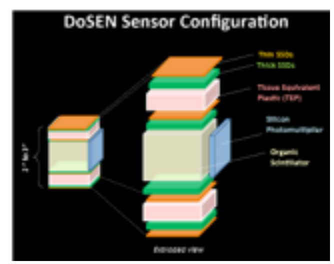
Light Weight, 20 K Pulse Tube Cryocooler for Active Thermal Control on Future Space Exploration Missions
Seyed Ghiaasiaan
Georgia Institute of Technology



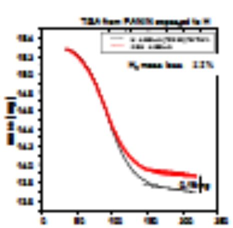
Enabling Self-Propelled Condensate Flow During Phase-Change Heat Rejection Using Surface Texturing
Vinod Narayanan
Oregon State UNIVERSITY OSU



Wavefront Control for High Performance Coronagraphy on Segmented and Centrally Obscured Telescopes
Olivier Guyon
THE UNIVERSITY OF ARIZONA



Small Active Readout Device for Dose Spectra from Energetic Particles and Neutrons (Dosen)
Nathan Schwadron
UNIVERSITY of NEW HAMPSHIRE



High Hydrogen Content Nanostructured Polymer Radiation Protection System
Alex Ignatiev
UNIVERSITY of HOUSTON

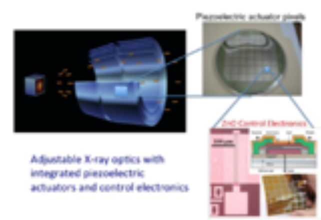


Fig. 1: Grazing incidence optics with piezoelectric actuation and integrated control electronics

Integrated Control Electronics for Adjustable X-Ray Optics
Susan Trolier-Mckinstry
PENNSTATE

NSTRF

NASA Space Technology Research Fellowships

Annual Solicitation

- **FY11 - NSTRF11**
- **FY12 - NSTRF12**
- **FY13 - NSTRF13**

NSTRF13: Application Components

Minimum Eligibility Requirements for NSTRF13

1. Pursuing or seeking to pursue advanced STEM degrees.
2. U.S. citizens or permanent residents of the U.S.
3. Have or will have a bachelor's degree prior to the fall of 2013.
4. Are or will be enrolled in a full-time master's or doctoral degree program at an accredited U.S. university in fall 2013 (awards may not be deferred).
5. In general, students who have completed one or more years in their current master's program (as of October 10, 2012) and doctoral students who have completed three or more years of graduate school (as of October 10, 2012) are not eligible to apply.

The student shall be the principal author of the Project Narrative, with minimal assistance from the current/prospective faculty advisor.

1 Proposal Cover Page
- Completed online at NSPIRES
- 43 Program Specific Data Questions

2 Personal Statement
- explain space technology academic and career goals
- rationale in applying to or selecting the university(ies)
- leadership and collaborative potential, communication ability, and potential for investigation and engagement in space technology problems and their solutions
- pertinent background information

3 Project Narrative
- summary of educational program objectives
- research interests with associated relevant hypotheses and possible approaches
- benefits of proposed research
- benefits of on-site R&D lab experience

4 Degree Program Schedule
- proposed start and completion dates
- anticipated milestones

5 Curriculum Vitae (two pages)
- student

6 Transcripts
- undergraduate
- graduate

7 GRE general test scores

8 Three letters of recommendation
- from academic advisor
- from other faculty members or professionals with detailed knowledge of student's abilities

*NSTRF**11** (inaugural year) documents are available at http://tinyurl.com/NSTRF11-OCT.*
*NSTRF**12** documents are available at http://tinyurl.com/NSTRF12-OCT.*
*NSTRF**13** documents are available at http://tinyurl.com/NSTRF13.*

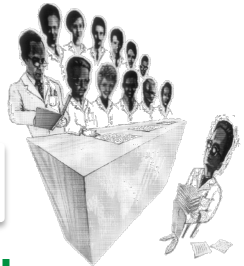
NSTRF13: Annual Award Values

Category	Maximum value *
Student Stipend	$36,000
Faculty Advisor Allowance	$9,000
On-site NASA Center/R&D lab experience Allowance	$10,000
Health Insurance Allowance	$1,000
Tuition and Fees Allowance	$12,000
TOTAL	**$68,000**

** from NSTRF13 solicitation*

- A fellowship award is issued as a training grant to the student's host university.
- Separate from the awards, the Program has allocated resources to cover mentor time and costs associated with hosting/interacting with the Fellow.

NSTRF13: Evaluation Criteria



All eligible fellowship applications undergo a technical review by experts.

1. Academic excellence, potential, and commitment to space technology

- Organizational, analytical, and written skills;
- Scientific curiosity, creativity, acumen, and potential for success in research environment as indicated in planned course of study;
- Potential for success in attaining an advanced degree in a space technology-related field; and
- Demonstrated commitment to space technology, a strong potential for pursuing a space technology career and/or potential for leadership in the space technology arena.

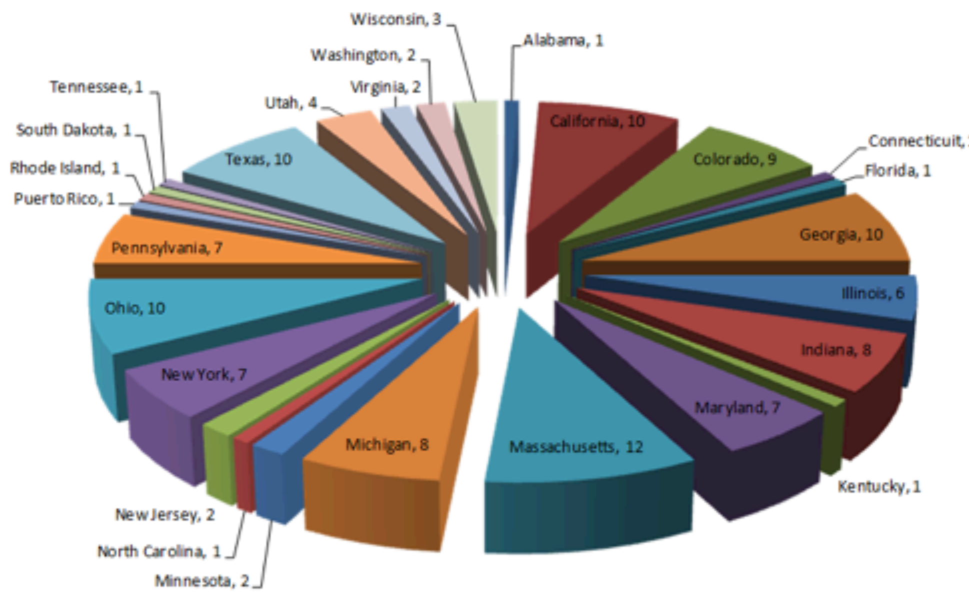
2. Relevance and Technical Merit of the student applicant's Project Narrative

- Merit of the space technology research area description and knowledge of relevant research literature;
- Relevance of the proposed plan to the student applicant-selected technology area;
- Potential impact of the on-site experience on the student applicant's academic/research plans;
- Appropriateness of the student applicant's choice(s) of institution(s) relative to the proposed plan for graduate study;
- Extent to which the proposed activity represents a potentially innovative space technology idea.

NSTRF: Current Portfolio

Covering 13 Technology Areas

26 states, 1 U.S. territory… and 50 universities



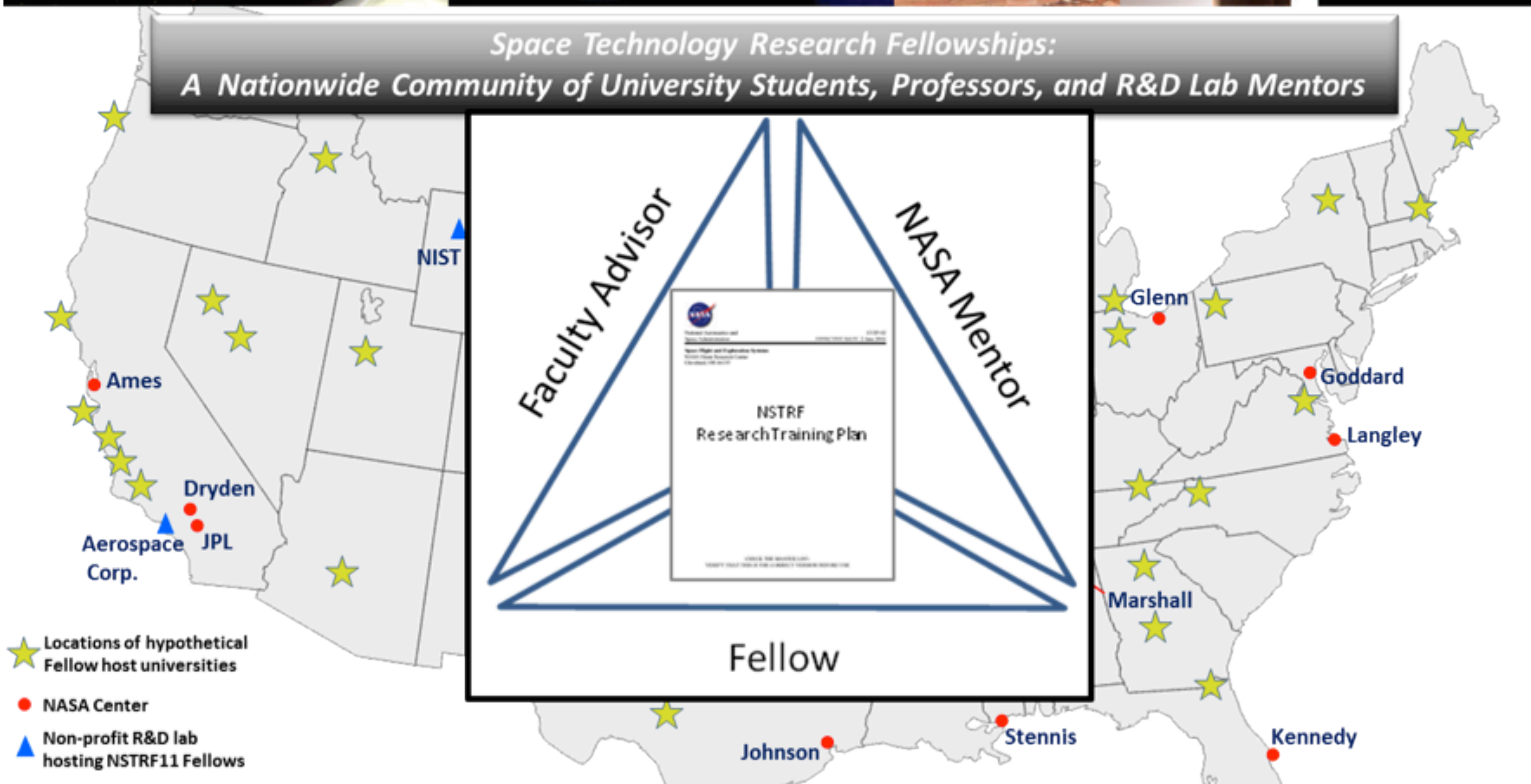
NSTRF 11 and 12

128 graduate students conducting space technology research

Auburn
Boston U
Brigham Young
Brown
Cal Tech
Carnegie Mellon
Case Western Reserve
Colorado State University
Columbia
Cornell
Duke
Georgia Tech
Illinois Institute of Tech
Johns Hopkins
Michigan State
MIT
Northwestern
Ohio State
Penn State
Princeton
Purdue
Rice
Rochester Institute of Tech
SD School of Mines
Stanford

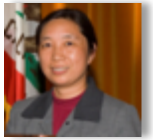
SUNY – Stony Brook
Texas A&M
U of Cal – Irvine
U of Cal – Santa Barbara
U of Colorado – Boulder
U of Florida
U of Illinois
U of Kentucky
U of Maryland
U of Massachusetts
U of Michigan
U of Minnesota
U of Pennsylvania
U of Puerto Rico
U of Rochester
U of Southern California
U of Tennessee - Knoxville
U of Texas – Austin
U of Utah
U of Washington
U of Wisconsin
Utah State
Virginia
Virginia Tech
Yale

NSTRF: Implementation Philosophy



NSTRF: On-Site Experience Reports

I obtained specialized training and analyzed my nanomaterials using state of the art instrumentation: High Resolution Transmission Electron Microscopy (HRTEM), Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM). In addition, I gained a great deal of knowledge on gas sensors from my mentor, Dr. Jing Li, a well known leader in the gas sensing field, and her team. During this time I obtained publishable results on the ultralow detection of chlorine gas at room temperature using gas sensors fabricated from some of the naonomaterials I had previously synthesized. ***--Adriana***



ARC: **Jing Li**

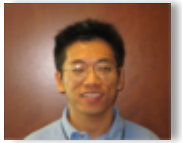
Adriana Popa
Case Western Reserve U.

JPL: **Mimi Aung**

Eric Trumbauer
U. of California, Irvine

Completion of the proof-of-concept design tool… includes the recent integration of a rapid differential corrector into the main program, rather than the use of a previous, stand-alone corrector with a much larger runtime. This would not have been possible without the direction of the team assembled by mentor Mimi Aung, and was an immediate benefit of the on-site portion of the fellowship. ***--Eric***

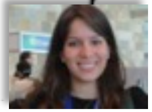
Recent work has taken place at GRC during my site visit. I have been assigned the task of preparing the High-speed Axial Reciprocating Probe (HARP) system. It is one of the milestones for the Electric Propulsion group at Glenn to demonstrate high-speed plasma diagnostics inside of the thruster channel. Probing within the thruster channel is difficult given that most materials will be quickly ablated by the plasma. I have learned how to operate the HARP stage and have created a LabView program to operate the HARP and the thruster motion stages. I have also assisted with the mechanical buildup within VF5. The HARP has demonstrated high speeds allowing for the probes to be inside the discharge channel for ~100 ms or less. The familiarity gained with operation of Hall thrusters and the NASA vacuum facilities will be invaluable towards the overall goal of my fellowship. ***--Brian***



GRC: **Wensheng Huang**

Brian Lee
Colorado State U.

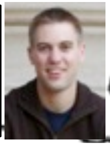
LaRC: **Mia Siochi**



Jennifer Carpena
U. of Puerto Rico

I worked with Lindsay Aitchison, Amy Ross, and others in the Space Suit Assembly (SSA) Group on several projects of current interest to the team. I supported an initial investigation into an inertial measurement unit (IMU) body tracking system for ultimate use of tracking limb movements of subjects in future space suit range-of-motion testing. I performed a statistical analysis to develop a new heuristic for predicting soft-good suit component preference based on known anthropometric measurements. I also was given the opportunity to be a test subject in both the Mark-III and EMU; it was an incredible experience to simply try out the space hardware that I've spent years studying and assessing. ***--Brad***

JSC: **Lindsay Aitchison**



Brad Holschuh
MIT

Mechanical testing of pristine, acetone treated, amorphous carbon (a-C) modified, heated, stretched and metal decorated CNT paper, tape and yarn has been conducted with a micron-sized-sample tensile tester that can be carried out in air as well as in the chamber of an SEM. These experiments were performed at NASA LaRC. Visualization of the mechanical performance of the CNT paper, tape and yarn is of great importance to the CNT-based composite fabrication team at NASA LaRC, as it allows them to focus their efforts on the modification of the samples to achieve the target mechanical properties for structural aerospace applications. --Jennifer

NSTRF: Infusion Potential Snapshot

armd

Hypersonics

Supersonics

Subsonic Fixed Wing

Environmentally Responsible Aviation Project

"The NSTRF Fellow is performing research and development of computer-aided design tools for multiphysics optimization. This is a cross-disciplinary project that potentially benefits several of the areas in which my organization is actively supporting agency programs…under ARMD (Fundamental Aeronautics, Aviation Safety, and Airspace Systems programs), HEOMD, SMD and OCT. Under the NSTRF program, the Fellow is seeking to advance optimization capabilities in ways that would achieve significant savings in the system design cycle, and would thus improve our ability to rapidly respond to Agency program needs…we intend to pursue proposal opportunities jointly as the technology becomes ready."

(as of spring 2012)

heomd

ON-OFF Adhesive Feet for Crawling Inspection Robots

Deep Space Network

International Space Station (ISS) Research

Use of Nanoparticle Enhanced Fluids for Active Thermal Control of Spacecraft

Space Communications and Navigation (SCaN)

Launch Abort System

Space Launch System (SLS)

Physical Science Research

ISS VASIMR Flight Experiment (VFE)

Composites for Exploration Project

Rocket Exhaust Interacting with Soil

While I was not aware of Dr. Quinn and his student's work before this, they are doing very relevant work and I'm already learning a lot from interacting with them. This is going to be an excellent long-term partnership.

oct

Manufacturing Innovation Project

Entry, Descent, and Landing Technology

Laser Communications Relay Demonstration

Nanotechnology

In Space Propulsion

Human Robotics Systems

Cryogenic Propellant and Storage Technology (CPST)

Lightweight Materials and Structures (LMS)

Nuclear Systems

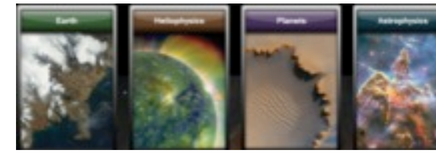
Space Synthetic Biology

Composite Cryogenic Tank Project

Center of Innovation Fund

Human Exploration Telerobotics

High Power Hall Thruster



smd

Landsat Data Continuity Mission

James Webb Space Telescope

Large Arrays of UV to Near-IR Lumped Element Kinetic Inductance Detectors

X-ray Astrophysics

Mars Atmosphere and Volatile Evolution Mission (MAVEN)

Wilkinson Microwave Anisotropy Probe

Instrument Incubator Program

High Voltage Hall Accelerator

Solar Probe

Solar Wind Electrons Alphas and Protons (SWEAP)

Soil Moisture Active Passive (SMAP)

Planetary Science

Gravity Wave Observatory Study

Microwave Radiometer Instrument

MEDLI Reconstruction

NASA's Evolutionary Xenon Thruster (NEXT)

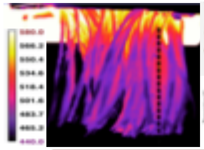
UAV-Synthetic Aperture Radar (UAVSAR)

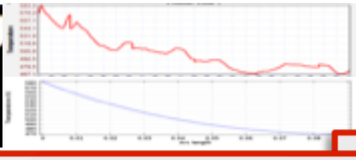
Transiting Exoplanet Survey Satellite

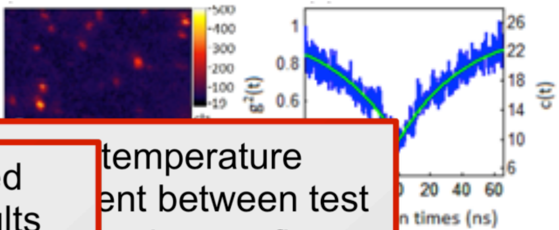
Gravity Recovery and Interior Laboratory (GRAIL)

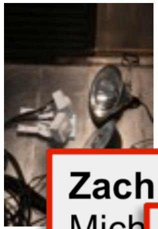
MMEEV Technology Development

NSTRF: Technical Accomplishments









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Microgravity testing on airplane yielded
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"A Survey of Communication Sub-systems for Intersatellite Linked Systems," Journal of Communications, Vol. 7, No. 4, 2012. (**Paul Muri**,
University of Florida)

Zach Kier (University of
Mich
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Completed design, construction, testing, and calibration of a position-sensitive diode sun sensor for EBEX. (**Kyle Helson**, Brown University)

ry redesign tool.
tiple transfers
c Trumbauer,
University of California, Irvine)

Princeton University and **Benjamin Schmitt**, University of Pennsylvania)

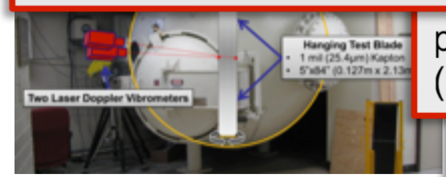
Schlieren and PLIF images
Orion Capsule model at Mach 5. (**Christopher Combs**, University of Texas, Austin)

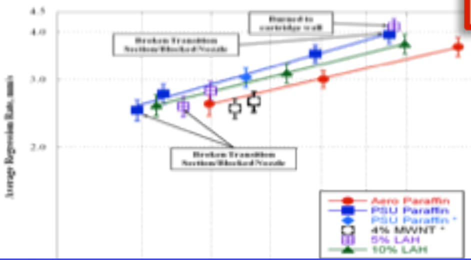
elic
(D
Boulder)

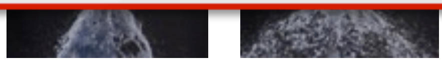
nts from cold-flow and hot-fire
with fabricated hypergolic pintle
o.com/47469840
Kan, Purdue University)

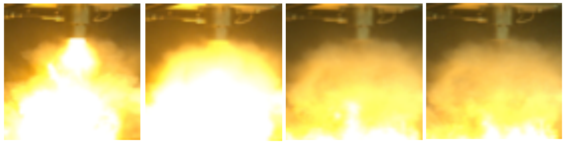
freezes to cryogenic temperature and performed subsequent burn in tests without error. (**Ethan Minogue**, Carnegie Mellon University)

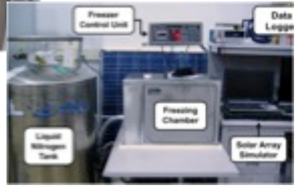
enhanced regression rates. (**Dan La**
Penn State University)











NSTRF Priority: Presenting Results at Technical Conferences

AAS/AIAA Space Flight Mechanics Meeting
Charleston, SC

Ablation Workshop
Lexington, KY

AIAA Atmospheric Flight Mechanics Conference
Minneapolis, MN

AIAA Fluid Dynamics Conference
New Orleans, LA

AIAA Guidance, Navigation, and Control Conference
Minneapolis, MN

AIAA Space Conference and Exposition
Pasadena, CA

AIAA Structures, Structural Dynamics and Materials Conference
Honolulu, HI

AIAA, Aerospace Sciences Meeting
Nashville, TN

AIAA/AAS Astrodynamics Specialists Conference
Minneapolis, MN

AIAA/AMSE/SAE/ASEE Joint Propulsion Conference & Exhibit
Atlanta, GA

AIAA/Utah State University Small Satellite Conference
Logan, UT

AIChE Annual Meeting
Pittsburgh, PA

American Astronautical Society Guidance, Navigation and Control Conference
Breckenridge, CO

American Astronomical Society (AAS) Conference
Austin, TX

American Society Composites Annual Technical Conference
American Vacuum Society International Symposium and Exhibition
Tampa, FL

Annual International Conference & Exposition on Advanced Ceramics & Composites (ICACC)
Daytona Beach, FL

Annual Materials Science & Technology Conference (MS&T)
Pittsburgh, PA

Annual Meeting of the APS Division of Fluid Dynamics
San Diego, CA

ANS Annual Meeting "Nuclear Science and Technology: Managing the Global Impact of Economic and Natural Events"
Chicago, IL

ANS Winter Meeting and Nuclear Technology Expo.
San Diego, CA

Applied Superconductivity Conference
Portland, OR

ASME International Design Engineering Conference
Chicago, IL

ASME International Mechanical Engineering Congress and Exposition
Denver, CO

ASME International Mechanical Engineering Congress and Exposition
Houston, TX

ASME Summer Heat Transfer Conference 2012
Puerto Rico, USA

Case Western Reserve University Chemistry Retreat
Cleveland, OH

Central States Section Combustion Meeting
Dayton, OH

Computational and Theoretical Biology Symposium (CTBS)
Bioscience Research Collaborative (BRC)
Rice University

Conference on Lasers and Electro-Optics (CLEO)
San Jose, CA

CubeSat Developers' Workshop
San Luis Obispo, CA

Earth and Space 2012 Conference
Pasadena, CA

Electrochemical Society Spring Meeting
Seattle, WA

Electronic Materials Conference
The Penn Stater – Pennsylvania State University

European Physical Society Conference on Plasma Physics and the International Congress on Plasma Physics
Stockholm, Sweden

Frontiers in Optics/XXVIII Laser Science Conference
Rochester NY

HyspIRI Workshop
Pasadena, CA

IAA Conference on Dynamics and Controls of Space Systems
Porto, Portugal

ICMSE 2012
Xiamen, China

IEEE Aerospace Conference
Big Sky, MT

IEEE AEROSPACE International Conference on Microwaves, Radar Wireless Communications
Warsaw, Poland

IEEE APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC)
Cape Town, WP, South Africa

IEEE Bipolar/BiCMOS Circuits and Technology Meeting (BCTM) 2012
Portland, OR

IEEE ICRA conference
St. Paul, MN

IEEE INTERNATIONAL SYMPOSIUM ON ANTENNAS AND PROPAGATION & USNC/URSI NATIONAL RADIO SCIENCE MEETING
Chicago, IL

IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
International Astronautical Congress
Naples, Italy

International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)
Valencia, Spain

International Conference on Diffusion in Solids and Liquids, DSL2012
Istanbul, Turkey

International Conference on Two-Phase Systems for Ground and Space Applications
Beijing, China

International Congress on Ceramics (ICC4)
Chicago, IL

International Planetary Probe Workshop (IPPW-9)
Toulouse, France

International Symposium on Experimental Robotics (ISER)
Quebec City, Canada

International Symposium on Rarefied Gas Dynamics
Zaragoza, Spain

International Symposium on Special Topics in Chemical Propulsion (9-ISICP)
Québec City, Canada

International Union of Radio Science (URSI) National Radio Science Meeting
Boulder, CO

ION GNSS 2012
Nashville, TN

IUPAC World Polymer Congress
Virginia Tech

Joint Army Navy NASA Air Force (JANNAF), 6th Spacecraft Propulsion Joint Subcommittee Meeting
Monterey, CA

Lunar Superconductor Applications 2nd International Workshop (LSA)
Houston, TX

Materials Research Society (MRS) meeting
Boston, MA

Materials Research Society Spring Meeting
San Francisco, CA

Military Communications Conference (Milcom) 2012
Logan, UT

National Space and Missiles Materials Symposium (NSMMS)
Tampa, FL

Neuroethology 2012
College Park, MD

New Diamond and Nano Carbon Conference
San Juan, Puerto Rico

NSMMS 2012
Tampa, FL

Planetary Probe Workshop
Toulouse, France

Puerto Rico Interdisciplinary Scientific Meeting/Junior Technical Meeting
Carolina, Puerto Rico

Robotics: Science and Systems
Australia

SAMPE 2012
Baltimore, MD

Scientific and Clinical Applications of Magnetic Carriers
Minneapolis, MN

Space Propulsion 2012
Bordeaux, France

Spacecraft Charging Technology Conference
Kitakyushu, Japan

SPIE Astronomical Instrumentation Conference
Amsterdam

SPIE International Conference for Security and Defence
Edinburgh, United Kingdom

SPIE Smart Structures/NDE conference
San Diego, CA

Surface Mount Technology Association (SMTA) International Conference on Soldering and Reliability (ICSR)
Toronto, Ontario

USNC-URSI National Radio Science Meeting
Boulder, CO

Virginia Space Grant Consortium Conference

Blue text = multiple NSTRF researchers planned to attend

SpaceTechConnect

Virtual community of space technology researchers

- Collaborative, web-based community.
- Means to reach and interact with like-minded Fellows and their advisor/mentor teams.
  - Discussion forums
  - Resource sharing
    - **Papers**
    - **Presentations**
    - **Data sets**
- All 128 NSTRF projects are loaded. Students are the administrators of their own projects.
- Program Corner features reporting templates, terms and conditions documents, a customizable calendar and a conference locator.
- STRO-ECF and STRO-ESI are being added.

Office of the Chief Technologist
Space Technology Program

Example of an NSTRF Task

Next-Generation Electronic Systems for Innovative New Space Technologies and for the Nation's Science, Exploration and Economic Future

Jaemi Herzberger, University of Maryland
NSTRF Student Fellow - 2011 Class

Carlton Faller, JSC, mentor
Abhijit Dasgupta, University of Maryland, faculty advisor
Jean-Marie Denis, GSFC Parts Analysis Lab, operations manager

GSFC Collaboration with NSTRF

- The GSFC PA lab provides the following services:
  - Failure analyses of electrical and electromechanical parts and assemblies
  - Destructive physical analyses
  - Incoming test and inspection
  - Screening/flight qualification and evaluation
- I was introduced to Ms. Herzberger in March 2012 as a NSTRF student performing research in my Lab under the guidance and leadership of her mentors Dr. Alexander Teverovsky, and Carlton Faller, and her PI Dr. Abhijit Dasgupta.
- The PA Lab teams with NSTRF by providing Ms. Herzberger the necessary tools required for her research.
- My lab provides Ms. Herzberger the opportunity to use our sophisticated laboratory equipment, i.e. high power microscopes, including our Scanning Electron Microscopy, 3-D X-Ray, XRF, and various other equipment for her research.
- Being an integral part of the PA Lab, Ms. Herzberger has developed necessary skills that directly lead to future job opportunities in the PA Lab.
- Her research is being compiled for the benefit of future space technology at NASA.

About Me

- University of Maryland Master's of Science Mechanical Engineering Candidate, Department of Mechanical Engineering
- Center for Advanced Life Cycle Engineering

- Participating in NSTRF program since 2011
- NSTRF has provided me with many opportunities
- Benefits from performing research at GSFC:

Learn from the leading experts in my field

State-of-the-art PA lab

Gain research experience

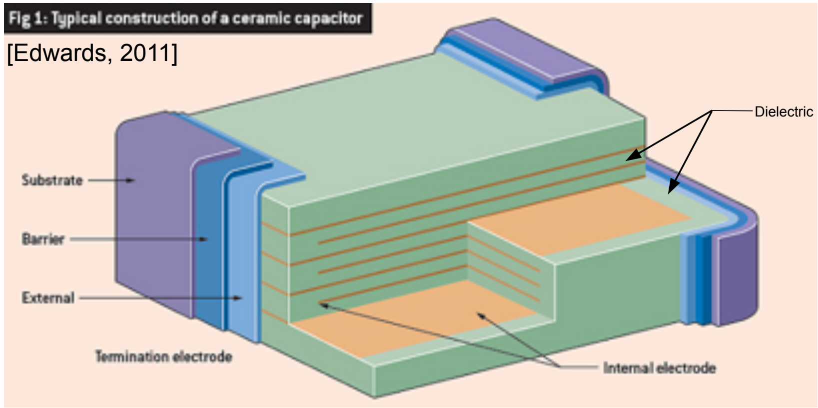
Develop the skills that I need for my future career

Directly contribute to NASA's strategic goals and missions

Research Description (chart 1 of 2)

Research Title: Electrochemical migration (ECM) and dendrite growth in PME and BME ceramic capacitors

Precious Metal Electrode (PME): Internal electrodes are silver-palladium (**Military**)



Base Metal Electrode (BME): Internal electrodes are nickel (**Commercial**)

NASA uses *thousands of capacitors* in a single electronic system, but they are responsible for more failures than any other component!

Failure Mechanism: Dielectric Cracking ➔ ECM and Dendrite Growth ➔ Short Circuit

Dendrite Growth: The formation of a conductive pathway through metallic filament migration in the presence of an electric field and an electrolytic solution

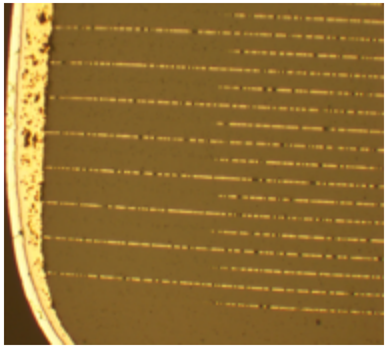


Fig. 2: Capacitor Pre-Test

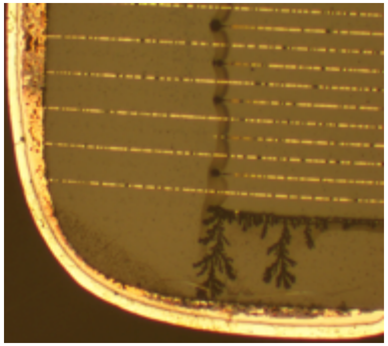


Fig. 3: Dendrite Growth

Research Description *(chart 2 of 2)*

Practical Need:

The most advanced capacitors today are produced with BMEs

- Higher Performance (Capacitance per Volume)
- Cheaper (Nickel vs. Silver-Palladium)

Background:

- Traditionally, for military PME capacitors, cracks in the dielectric are revealed through (Mil-PRF-123) a low-voltage (LV), steady-state (SS) humidity test using dendrite growth susceptibility
- BME capacitors are a newer technology and little is known about their dielectric crack detection and dendrite growth susceptibility

Research Goals:

1. Determine if the same test (Mil-PRF-123) can be used for the same purpose in BME capacitors
2. Compare processes of ECM and dendrite growth in PME and BME capacitors (which metals migrate under different conditions)

Procedure:

1. Expose cracked PME and BME capacitors to LV, SS, humidity tests to determine the time-to-failure (TTF)
2. One technique: Water layer test (WLT), which simulates the condensed moisture observed in dielectric cracks

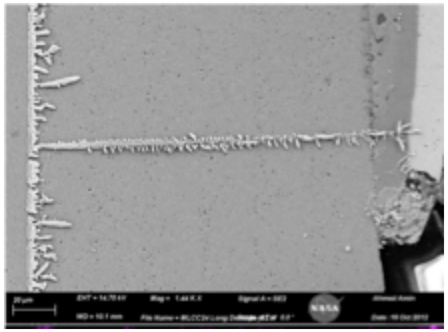


Fig. 4: Tin Dendrite (BME 0.8V WLT, 95 mins)

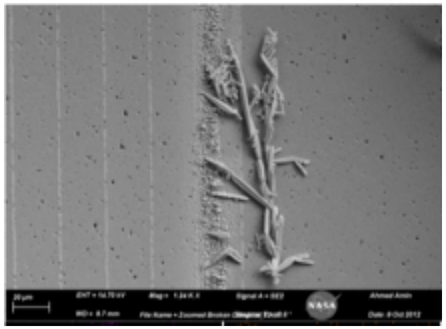


Fig. 5: Tin Dendrite (PME 0.8V WLT, 18 mins)

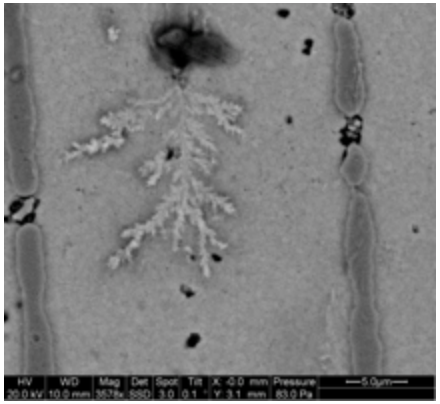
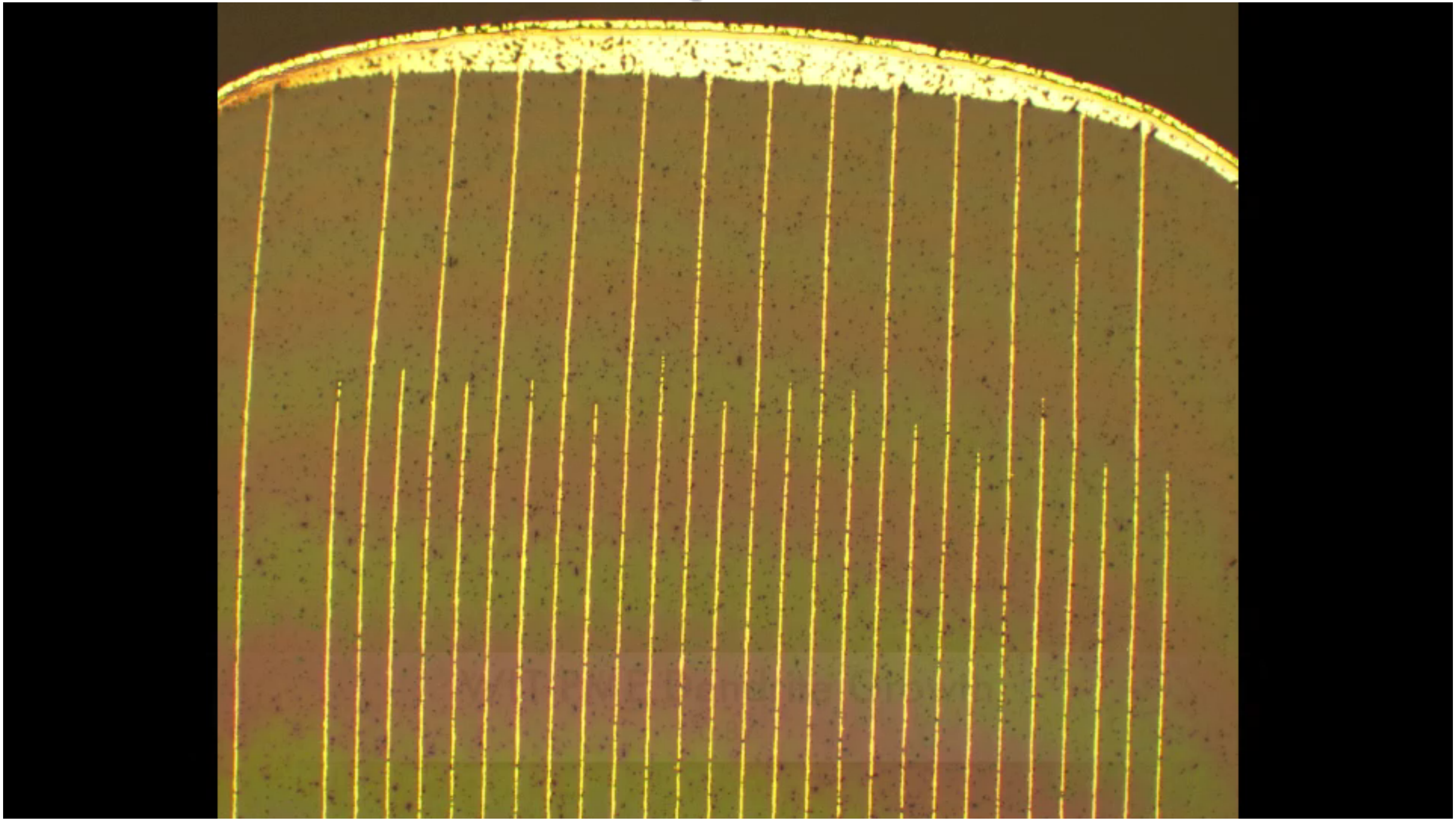


Fig. 6: Silver Dendrite (1.3V, 25°C/85% RH)

Optical Microscopy Results - Major Accomplishment



Captured exactly how dendrites grow in these conditions!

- Termination metals migrate instead of the electrode metals
- Travel long distances

Snapshots of Typical Dendrite Growth

- Typical Dendrite growth found in BME and PME MLCCs during WLTs
- Different metals migrate based on the use of solder, the substrate finish material, and the thickness of the moisture layer

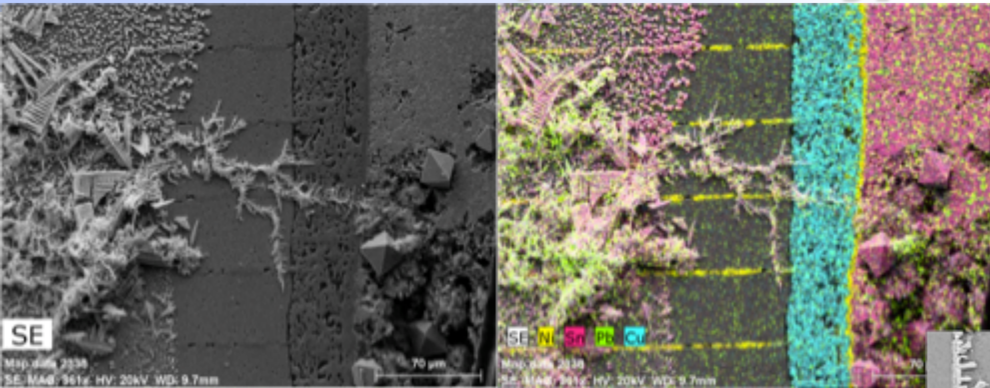


Fig. 9: Pb/Sn Solder Mixture Forming Dendrite Growth, 1.3V WLT

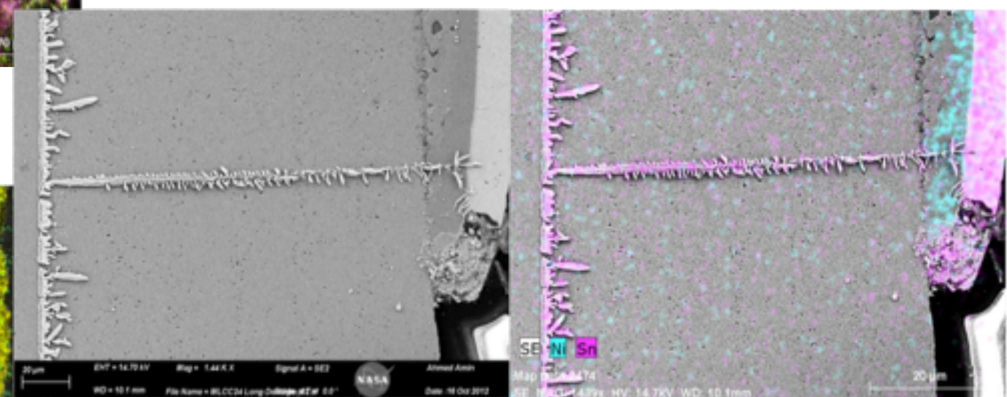


Fig. 10: Sn Dendrite Growth from Substrate 0.8V WLT

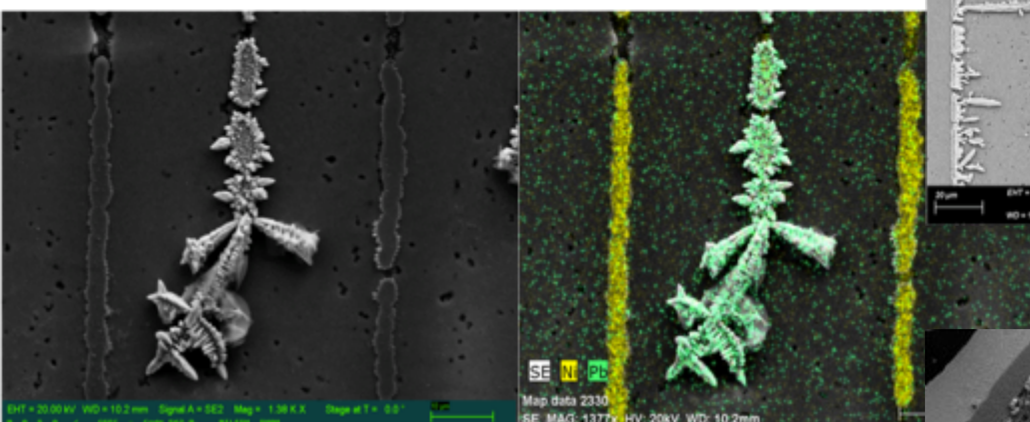


Fig. 11: Pb Dendrite Growth from Substrate, 1.3V WLT

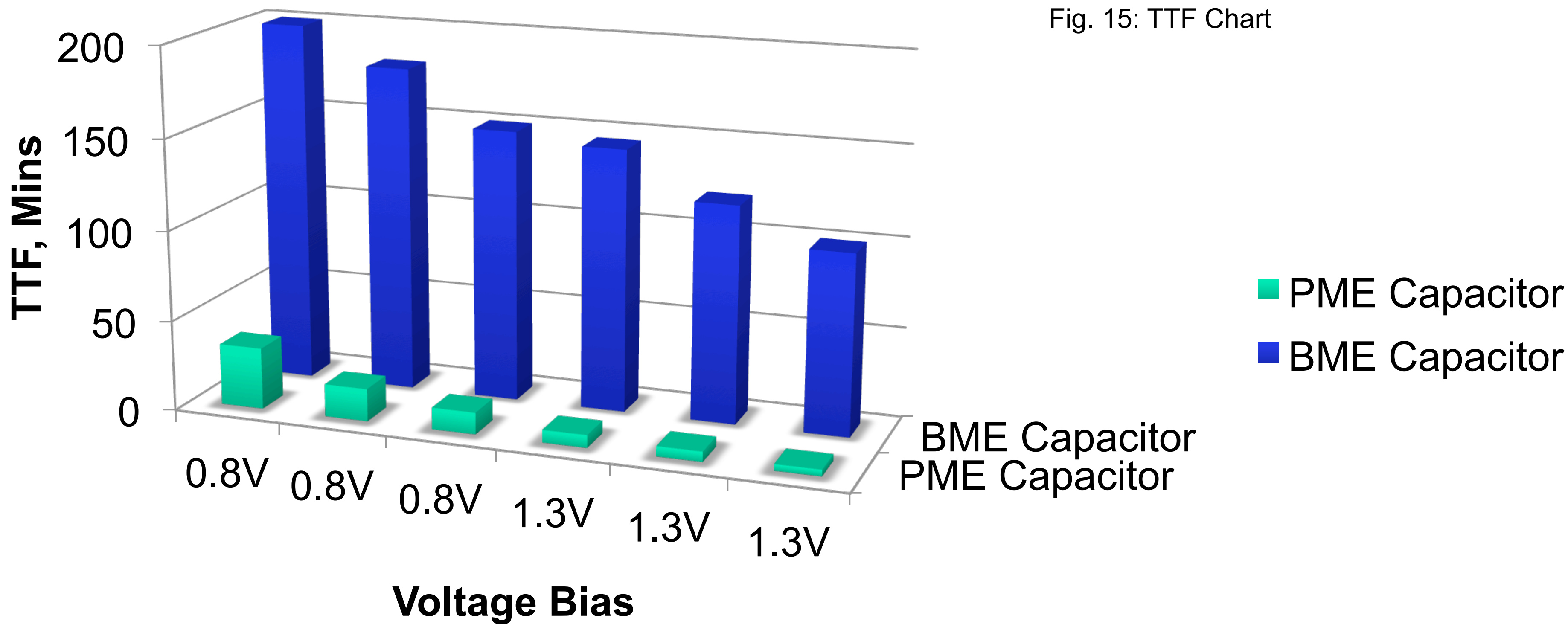
Fig. 12: Cu Dendrite Growth from External Layer in Termination, 1.3V WLT (Thick Moisture Layer)

SEM: Scanning Electron Microscopy

EDS: Electron Dispersive Spectroscopy

Time-to-Failure in PME and BME Capacitors due to Substrate Material (Pb/Sn or Sn) Dendrite Growth

Fig. 15: TTF Chart



Dendrite growth from substrate layer material dominates the migration process in WLTs.

- There is still a difference in the TTF between PMEs and BMEs.

Preliminary Conclusions/Where We are Now

1. In the current state, the LV, SS, humidity test (Mil-PRF-123) isn't an adequate test to reveal dielectric cracks in BME capacitors.
   - Developing Guidelines

2. Metals used to form terminations and solder have a higher propensity for ECM and dendrite growth than the electrode materials.
   - Defining which metals migrate in PME and BME capacitors under various operational and environmental conditions and their TTF

Humidity Test (33% Complete)

- PME vs. BME
- Manufacturers
- Voltage Levels
- Capacitance Values and Voltage Ratings
- Fracture Methods (Cleaving, Indenting, Cross-Sectioning)
- Test Conditions (22°C/85% RH, 85°C/85% RH)

WLT (50% Complete)

- PME vs. BME
- Manufacturers
- Moisture Film Thicknesses
- Voltage Levels
- Capacitance Values and Voltage Ratings

Thank you!

Office of the Chief Technologist

Goddard SPACE FLIGHT CENTER

UNIVERSITY OF MARYLAND 1856

Johnson Space Center

NSF Innovation Award Winner

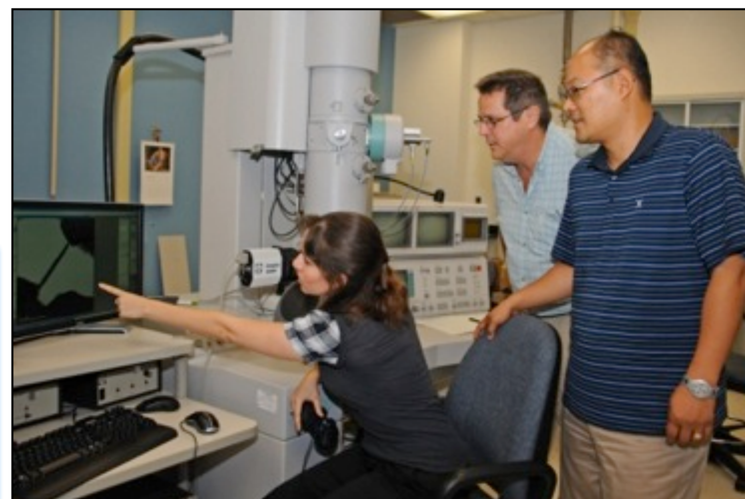
calce®
Center for Advanced Life Cycle Engineering

STRGP: 2013 Plans

- The STRG Program will continue its efforts to develop future technical leaders and facilitate new collaborations while sponsoring the development of new and emerging technologies of high priority to NASA and the aerospace community:
  - ***Early Career Faculty*** and ***Early Stage Innovations researchers*** will engage the NASA community through a series of seminars across the Agency.
  - ***NSTRF11 Fellows*** commence their second on-site experiences.
  - ***NSTRF12 Fellows*** commence their first on-site experiences.
  - ***NSTRF13 Fellows*** will be welcomed and paired with mentors.
  - ***STRGP researchers*** will present their findings at premier technical conferences world-wide.

Benjamin Schmitt at NIST, NSTRF Class of 2011

- New solicitations will target new, high priority technology areas, which, in turn, will increase both the number of participants engaged in space technology development, and the breadth of technologies being worked:
  - The ***NSTRF13 solicitation*** closes on December 4, 2012 at 6 PM Eastern Time.
  - STRGP plans to release another ***STRO-ESI solicitation*** early in CY2013.



Jennifer Carpena at LaRC, NSTRF Class of 2011

Contact the STRG Program Executive

Claudia Meyer
claudia.m.meyer@nasa.gov

BACKUP



Development and Testing of Compression Technologies Using Advanced Materials for Mechanical Counter-Pressure Planetary Exploration Suits

NSTRF Fellow: Brad Holschuh, MIT

Mentor: Lindsay Aitchison, JSC

Faculty Advisor: Dava Newman, MIT