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Space Administration

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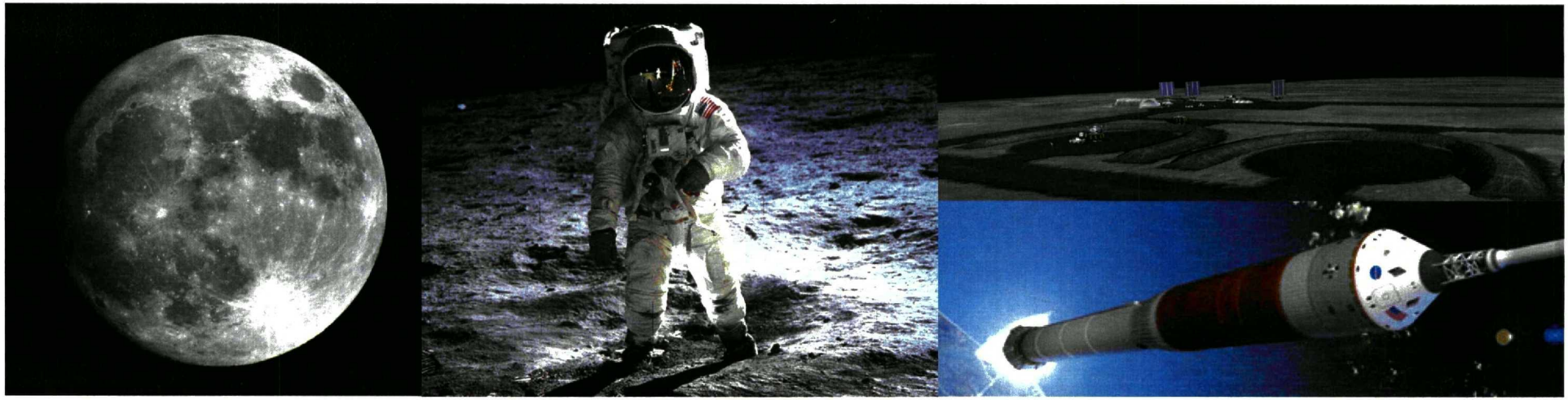


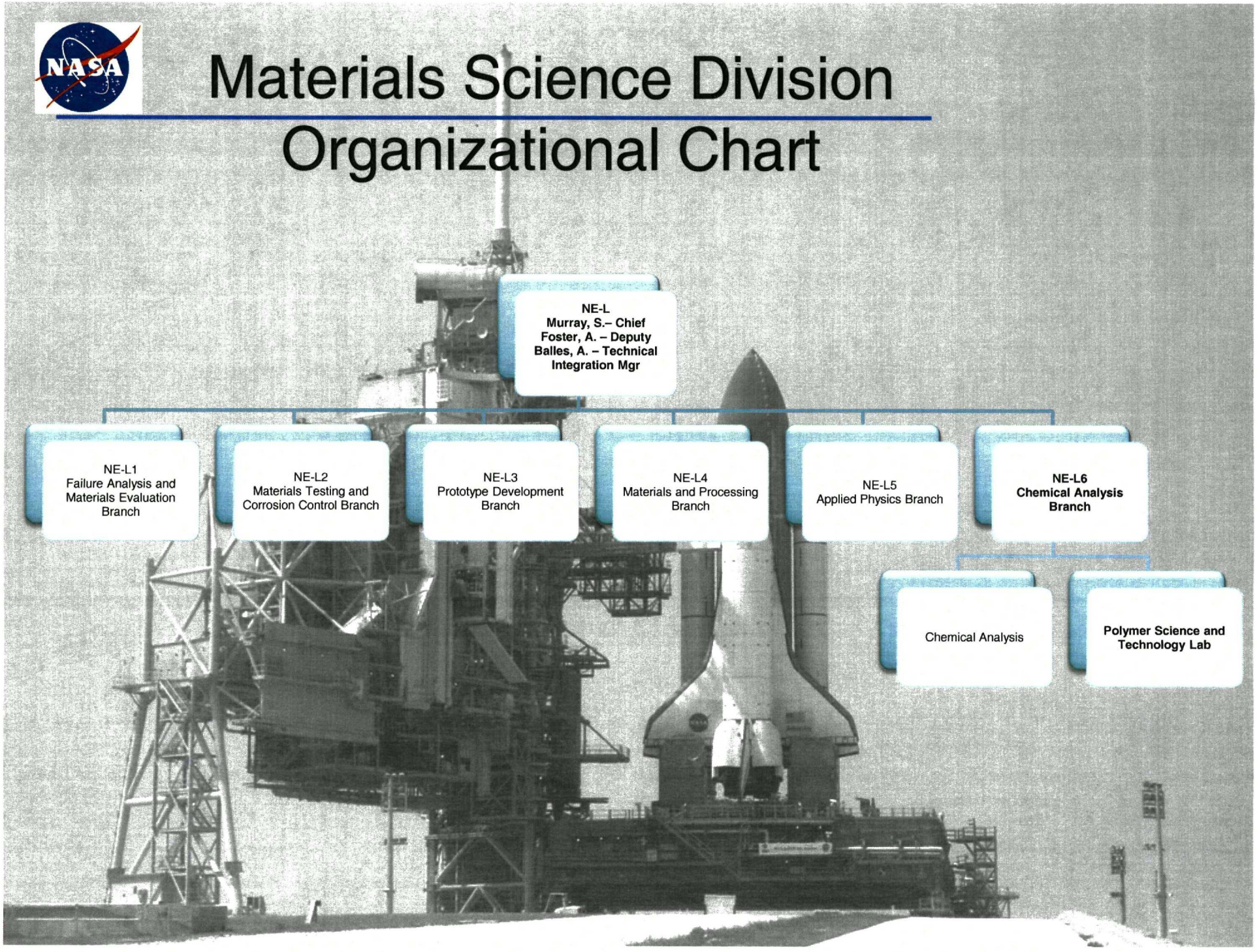
Materials for Space Exploration

Polymer Science and Technology Lab
Materials Science Division
Engineering Directorate
Kennedy Space Center, Florida

Dr. Luke Roberson
luke.b.roberson@nasa.gov

1/14/2010

Materials Science Division Organizational Chart



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Lab Overview

Mission

To develop and apply new technologies in polymer and material chemistry that benefit NASA's programs and mission

Team

2 NASA scientists, 1 co-op, and 4 contractors

Areas of Expertise

Polymer Nanocomposites
Next Generation Wire Materaials
Carbon Nanotube and Nanofiber Materials
Conductive Polymers
Polymer Processing
Fire and Polymers
Foam and Insulation Materials

Numerous Collaborative Efforts

NASA Centers *(JSC, LaRC, MSFC, GSFC, GRC)*
KSC Directorates *(Shuttle, Ares, Orion, Ground support operations)*
Academia *(Alberta, FIT, GT, Harding, Illinois-Urbana Champagne, UCF, UF, USF)*
Industry Space Act Agreements *(Thermax, DeWAL, Sharklet, Crosslink, Sabic, Amalgam)*
Industry Contracts *(ARCnano, Epner)*

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Testing and Processing Equipment

- Fire Testing
  - Cone Calorimeter
  - Oxygen Index**
  - UL94 fire test
  - NASA Std 6001 fire test
  - Radiant Panel*
  - NBS Smoke Chamber*
  - Two foot tunnel*
  - Glow wire ignition*
- Cryogenic Materials Testing
  - Cryogenic moisture uptake (CMU)**
  - Brittleness/Impact test **
  - Liquid helium cold finger test**
  - Single Pin-Socket Krytox Contamination Electrical Characterization under Cryogenic Conditions**
- Specialty Test Equipment

*in collaboration with Cryogenics Test Laboratory
**in collaboration with Florida Tech

- Cellular Solid Analysis
  - –Pycnometer (closed/open cell)**
  - –Surface area measurement**
- Thermal Analysis
  - –Thermogravimetric analysis (TGA)
  - –Differential Scanning Calorimetry (DSC)
  - –Dynamic Mechanical Analysis (DMA)
- Physical Testing
  - –Tensile Test
  - –Compressive Test
  - –Pull/Peel Test
- Electrical Testing
  - –4-point probe
  - –Surface /Volume resistance
- Polymer Processing capabilities
  - –Extrusion
  - –Injection molder
  - –Fiber spinning equipment
  - –Melt, ball, and high intensity mixers

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Chemochromic Hydrogen Sensors

In collaboration with UCF

A patent-pending irreversible color changing H_2 gas sensor was developed at KSC in partnership with UCF and ASRC.

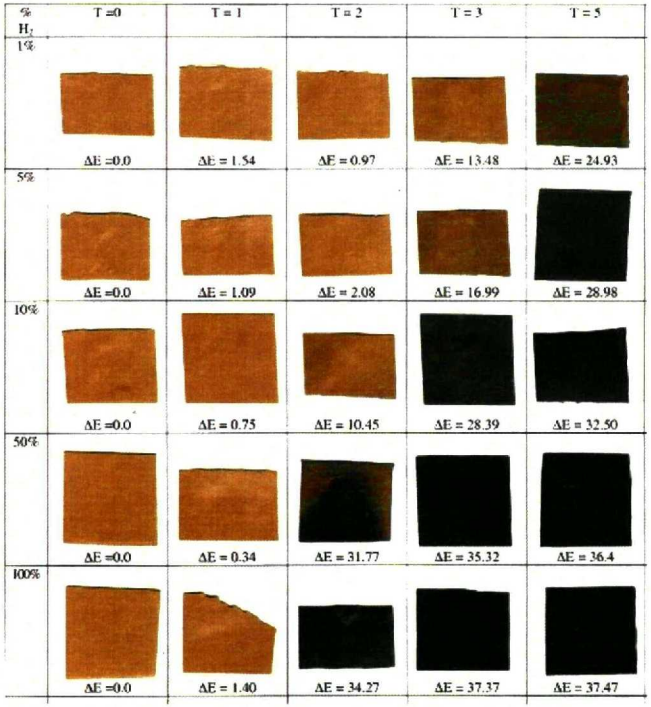
Changes color from a light tan to black in the presence of H_2.

Can be manufactured into any polymer part, tape, fiber, or fabric material for unlimited potential uses.

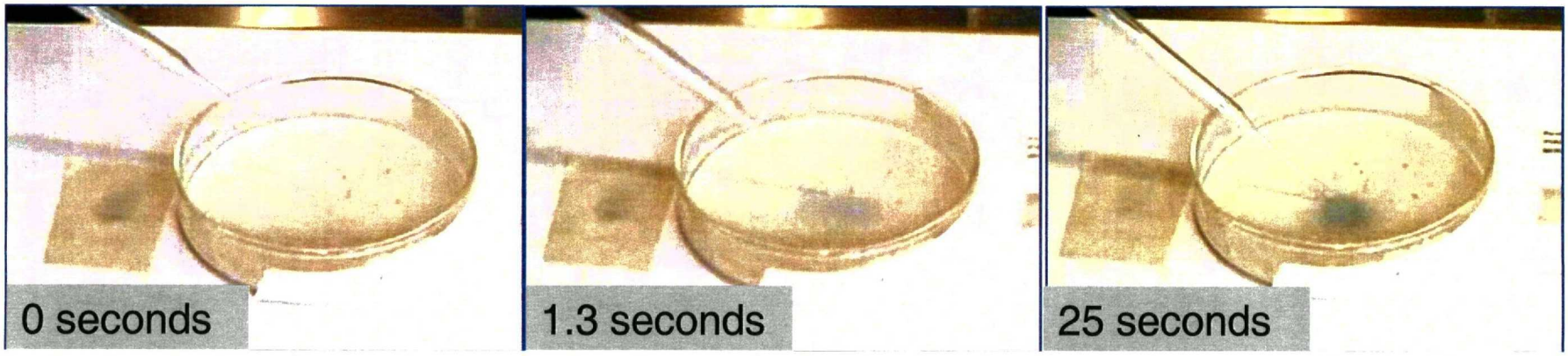
- Paint, Gloves, Coveralls, PPE

Operates under ambient and cryogenic temperatures.

Irreversible Sensor



Reversible Sensor



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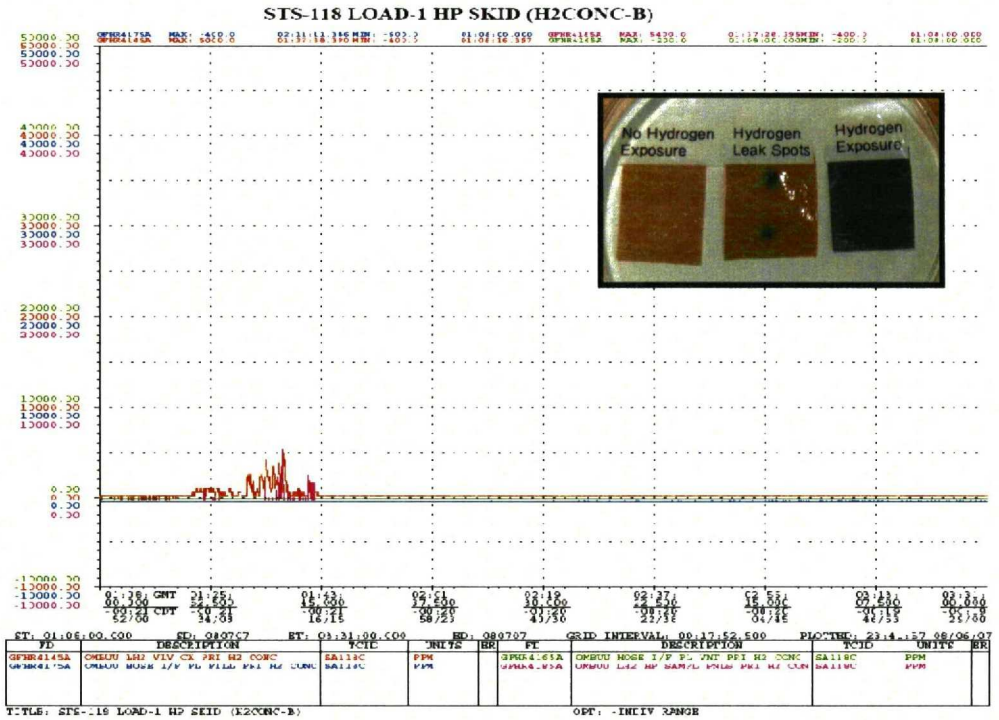
Chemochromic Hydrogen Sensors

STS-129 Transfer Line

LPA OMBUU Deployment for STS 117, 118, 120, 122, 123



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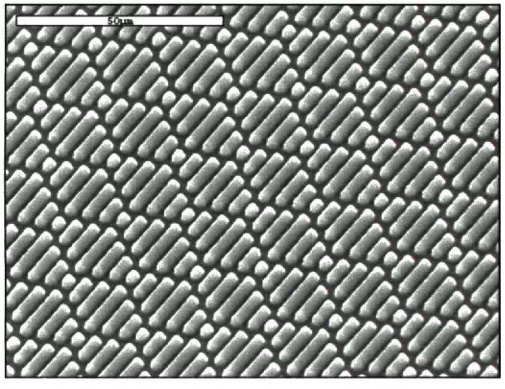
Antimicrobial Materials

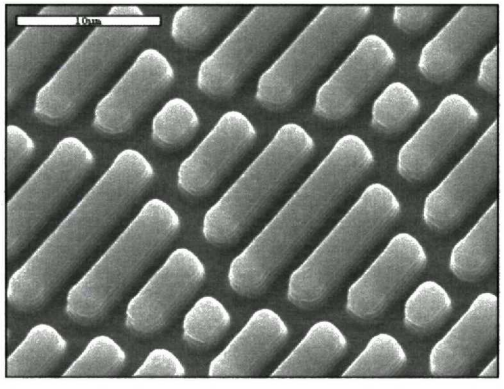
In collaboration with Sharklet Technologies and UF

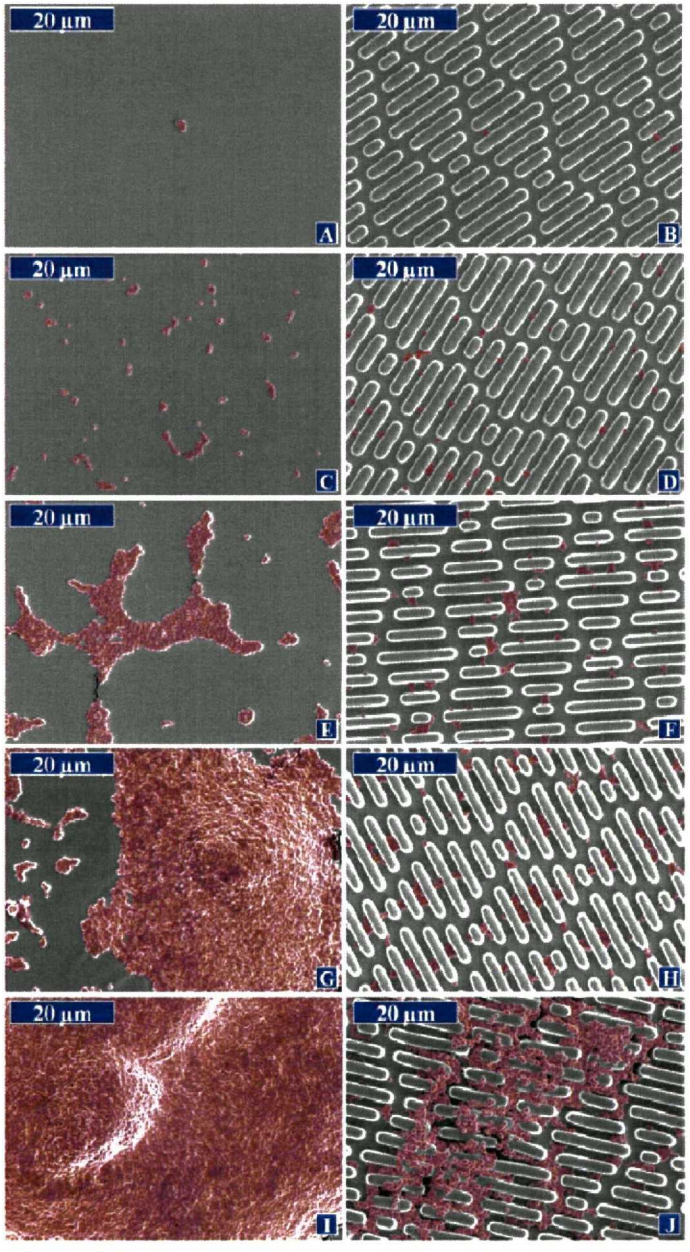
Orion Potable Water

5 Inconel 718 Tanks (14.3 gal)
Miles of Titanium water lines

- Efficacy studies after 21 days decreases biofilm formation
- Easy to imprint during manufacture of polymer articles through a coining process
- Can be used in conjunction with antimicrobial polymers







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Antimicrobial Materials

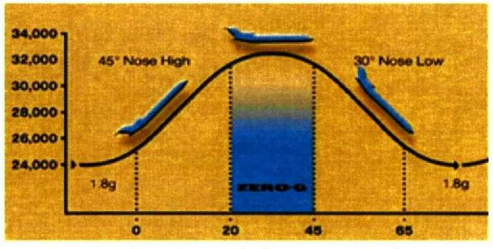
In collaboration with University of Alberta and Sharklet

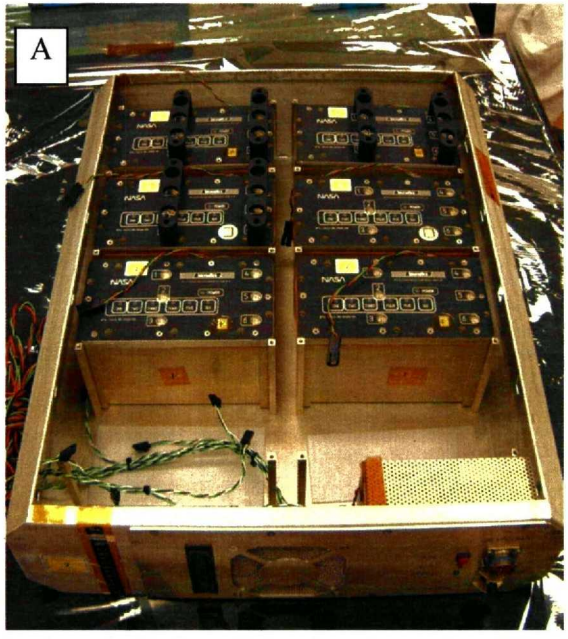
Microgravity Flight Experiments

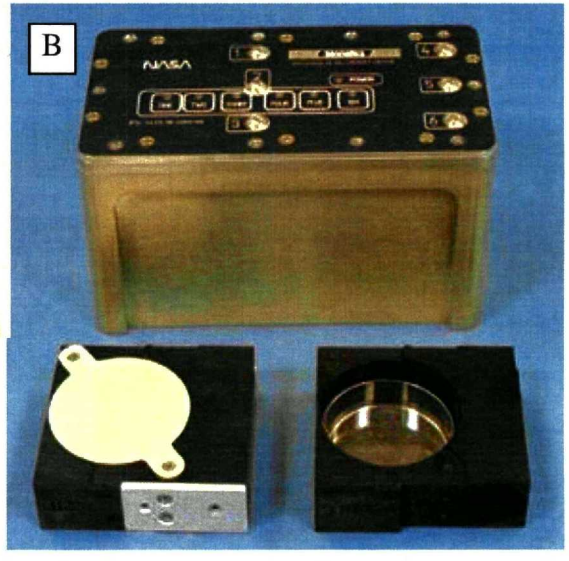
BIOLOGICAL ANALYSIS

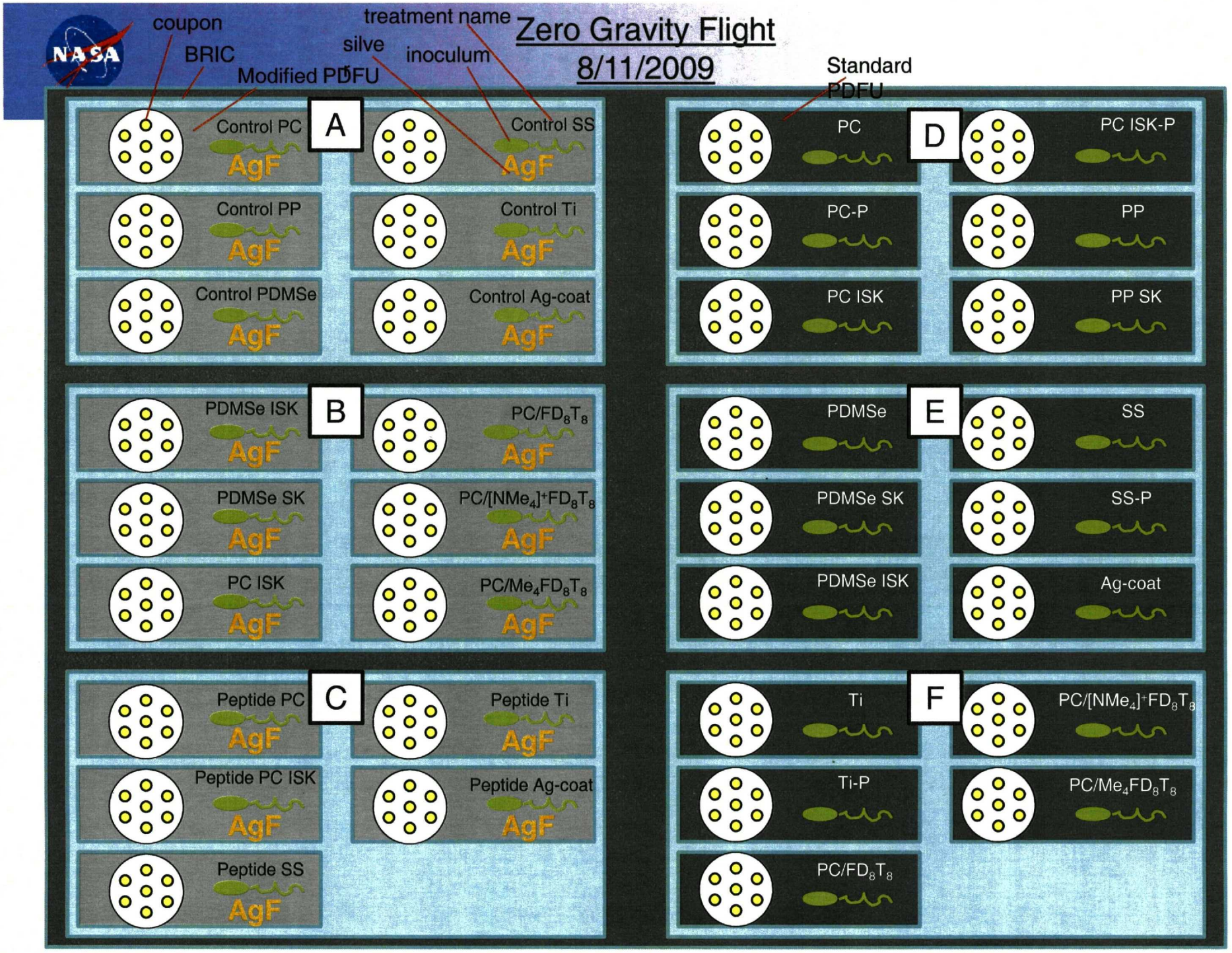
Confirm efficacy of *Pseudomonas fluorescens* bacteria species with Sharklet® topography coupons and different surface treatments

– *How well does it work in µG and lunar G compared to 1G?*








coupon
BRIC
Modified PDFU
treatment name
silve
inoculum
Zero Gravity Flight
8/11/2009
Standard PDFU
A
Control PC
Control SS
Control PP
Control Ti
Control PDMSe
Control Ag-coat
AgF
B
PDMSe ISK
PC/FD8T8
PDMSe SK
PC/[NMe4]+FD8T8
PC ISK
PC/Me4FD8T8
C
Peptide PC
Peptide Ti
Peptide PC ISK
Peptide Ag-coat
Peptide SS
D
PC
PC ISK-P
PC-P
PP
PC ISK
PP SK
E
PDMSe
SS
PDMSe SK
SS-P
PDMSe ISK
Ag-coat
F
Ti
PC/[NMe4]+FD8T8
Ti-P
PC/Me4FD8T8
PC/FD8T8

Wire System Materials

Insulation and Repair Materials

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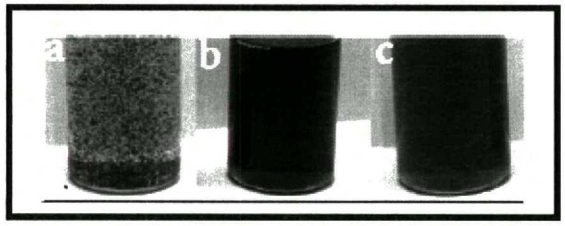
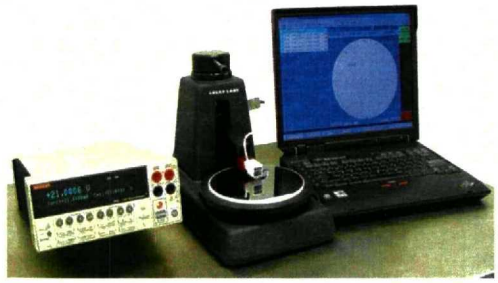
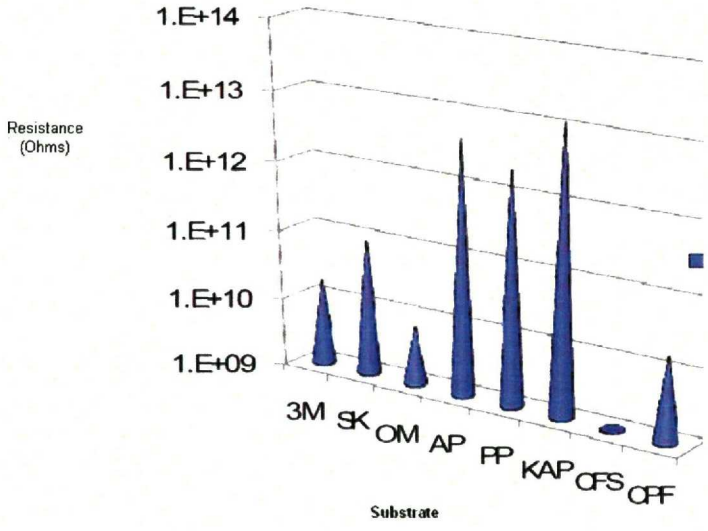
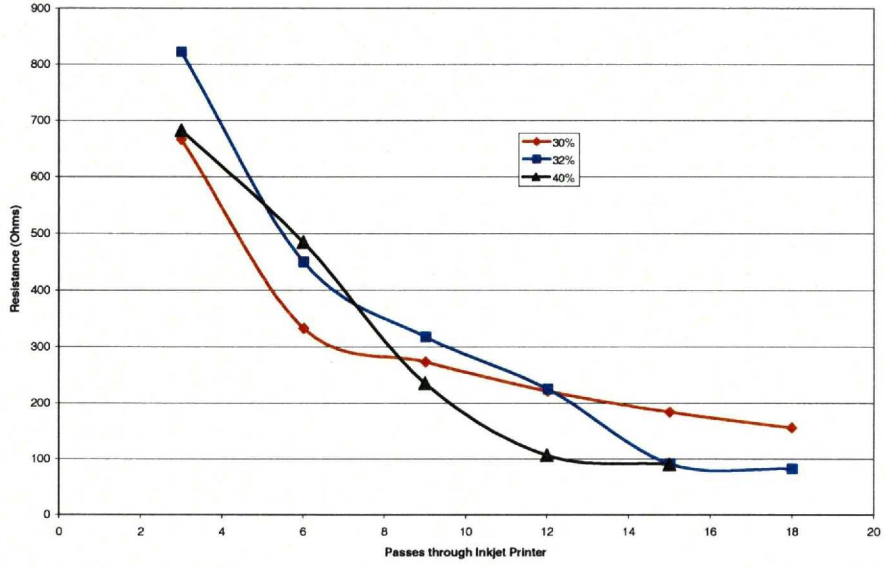
CNT Ink formulations



Journal of Nanoscience and Nanotechnology, 6, 2006







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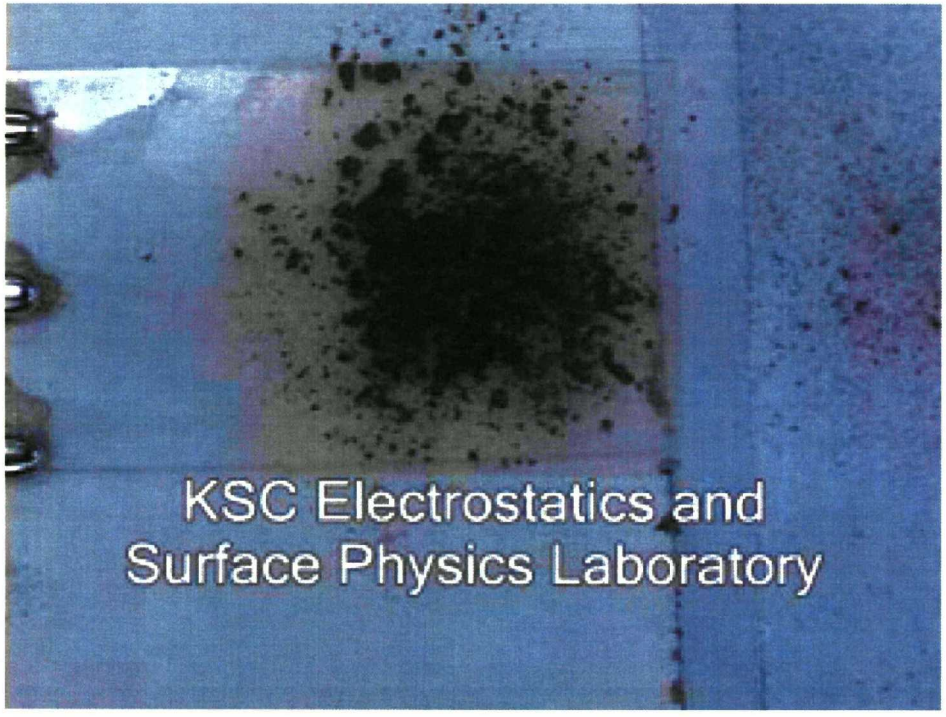
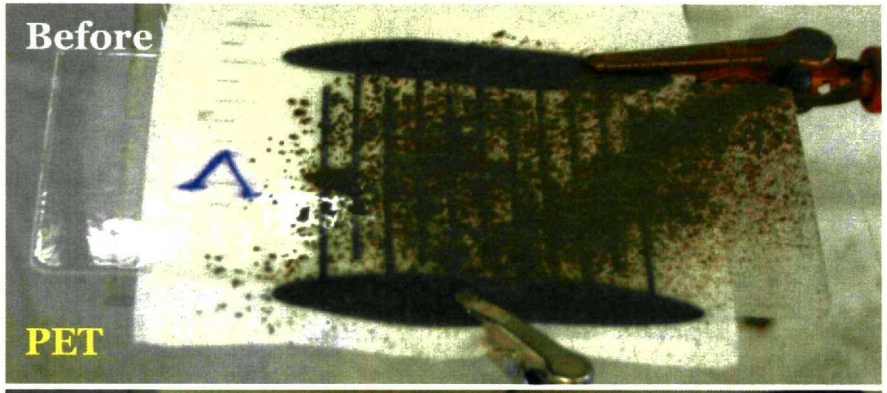
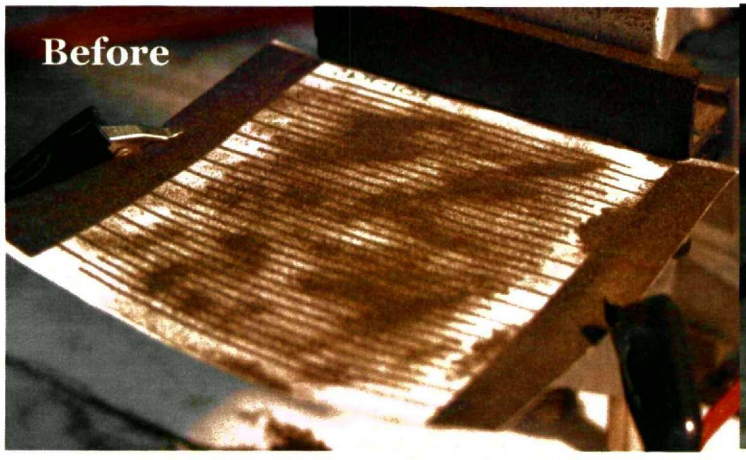
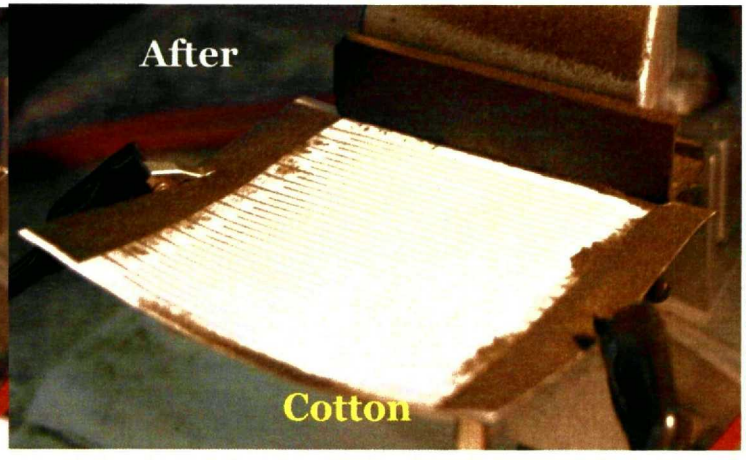
CNT Ink Dust Screens

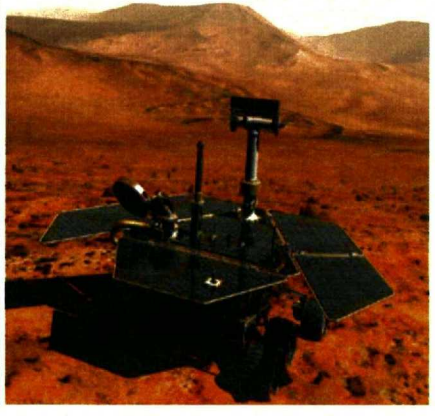
In collaboration with Electrostatics Laboratory











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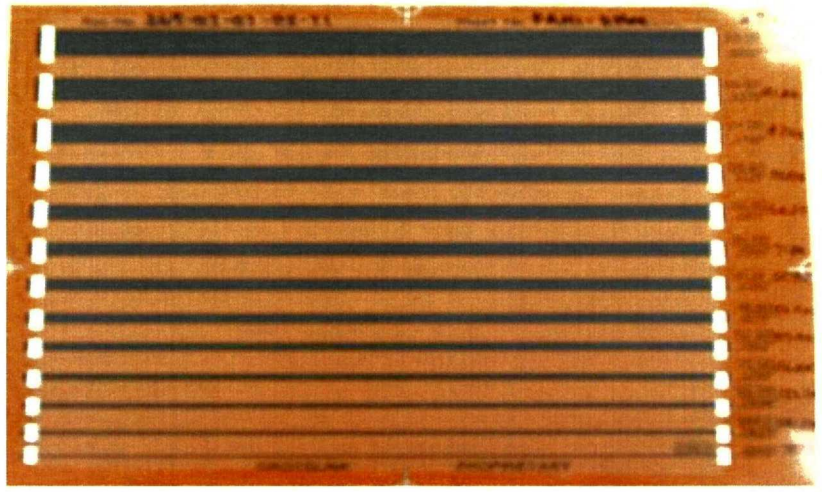
CNT Ink Printed Circuitry

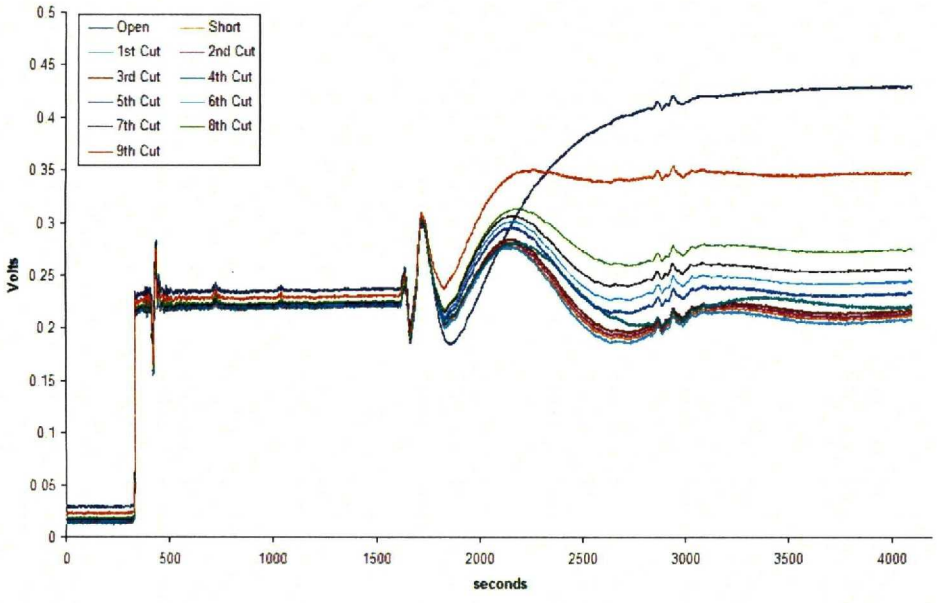
In collaboration with Crosslink

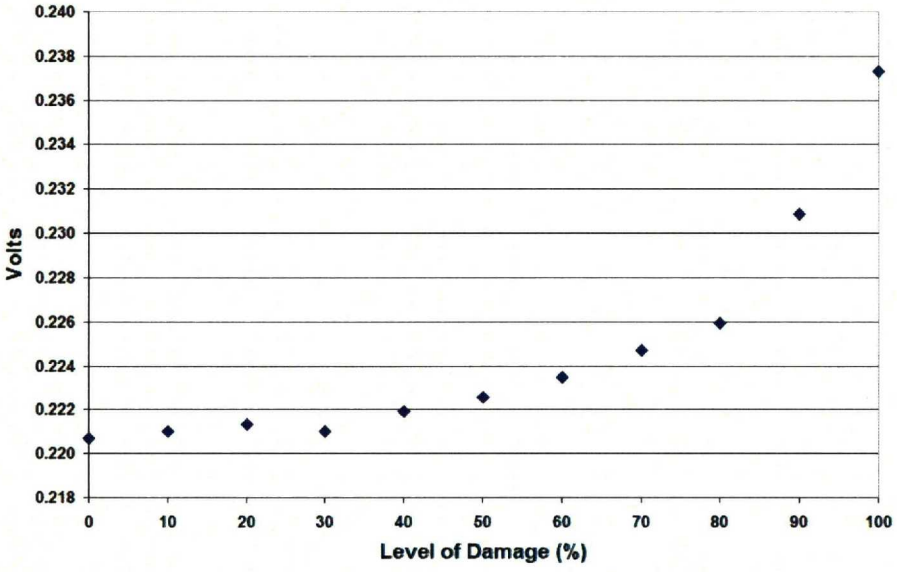
Screen printed polymer-composite material

Line thickness and width increases conductivity

50 Ohm resistance able to measure damage to circuits







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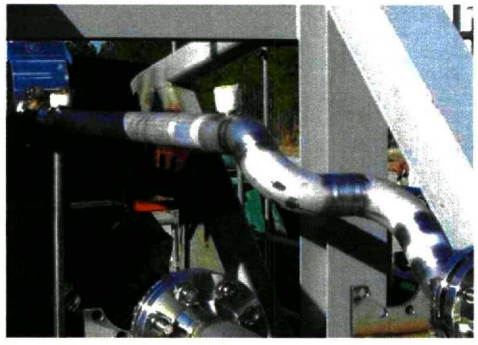
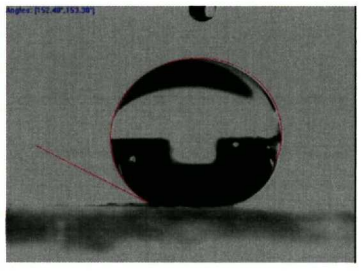
Cryogenic Materials Development

In collaboration with Electrostatics Laboratory

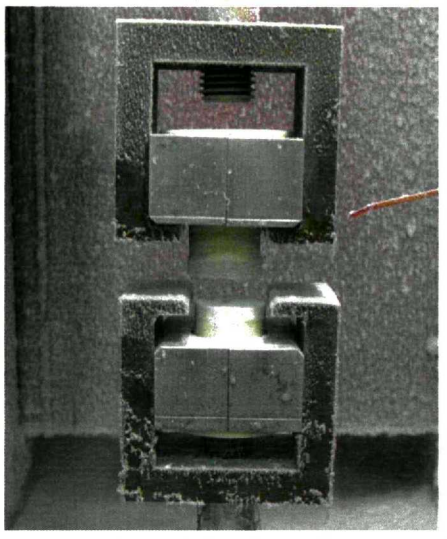
- Foam insulation materials
  - AeroFoam (patent pending)
  - Syntactic foams



- Ice release coatings
  - Shuttle Ice Liberation Coating (SILC)
  - Dow UCAR 439 and 627
  - Luna Innovations icephobic coating



- Structural aerogel composites
  - AeroPlastic (patent pending)
    - Polyamides
    - Polyetherimides
    - Polyolefins



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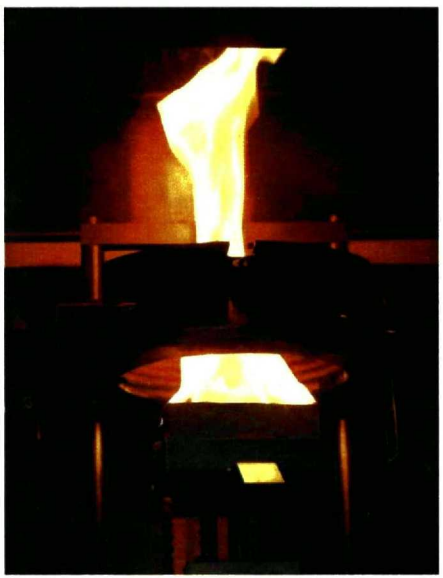
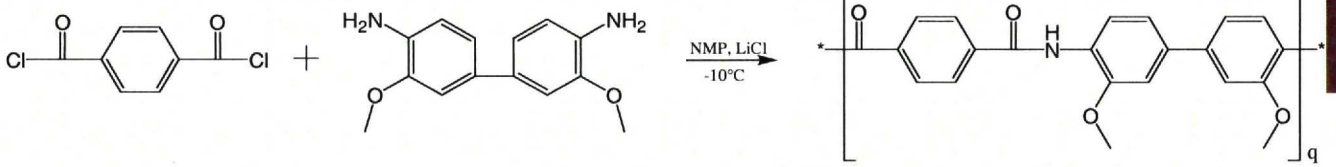
Fire and Polymers

- Flame retardant strategies
  - Polymethoxyamide derivatives for high temperature engineering polymers (patent issued)
  - Carbon nanotube synergistic FR properties
  - Polyhedral Oligomeric Silsesquioxanes (POSS) FR properties

- Fire risk consultation
  - Wire insulation
  - Thermal insulation
  - Ablator



- Fire standards and risk
  - Ares I
  - Ares V
  - Orion



The Importance of Lighting

Electric Lamp Options

Lamp Type	*Conversion* Efficiency*	*Lamp Life* (hrs)*	*Spectrum*
• Incandescent/Tungsten**	5-10%	2000	Intermd.
• Xenon	5-10%	2000	Broad
• Fluorescent***	20%	5,000-20,000	Broad
• LEDs (red and blue)****	25%	100,000 ?	Narrow
• Metal Halide	25%	20,000	Broad
• High Pressure Sodium	30%	25,000	Intermd.
• Low Pressure Sodium	35%	25,000	Narrow
• Microwave Sulfur	35-40%+	?	Broad

* *Approximate values.*

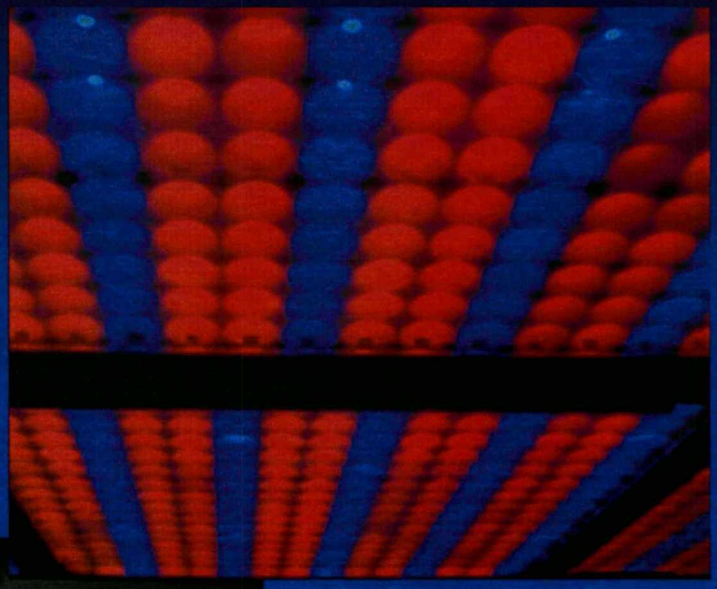
** *Tungsten halogen lamps have broader spectrum.*

*** *For VHO lamps; lower power lamps with electronic ballasts last up to ~20,000 hrs.*

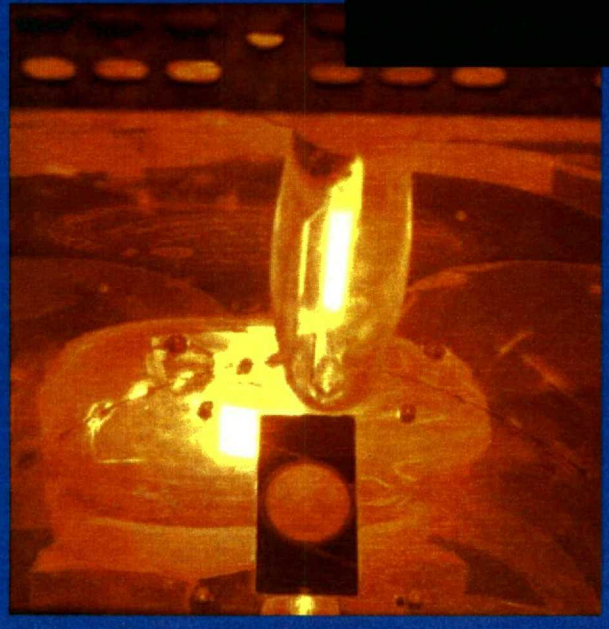
**** *Green LEDs ~10% efficient.*

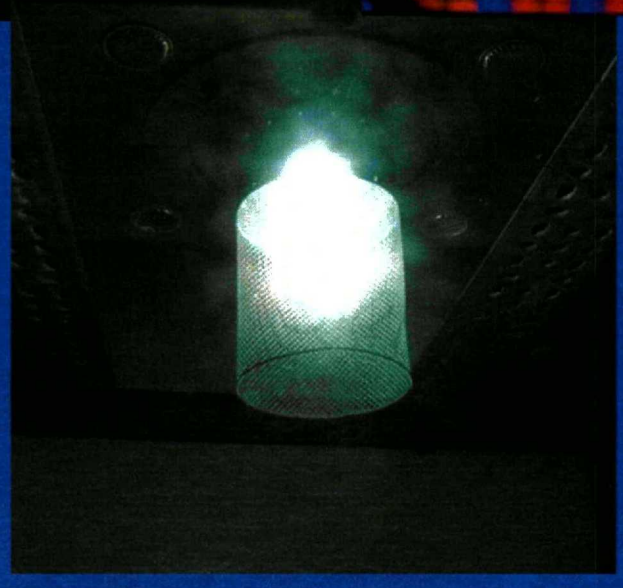
Electric Lighting Systems

Fluorescent



High-Pressure Sodium



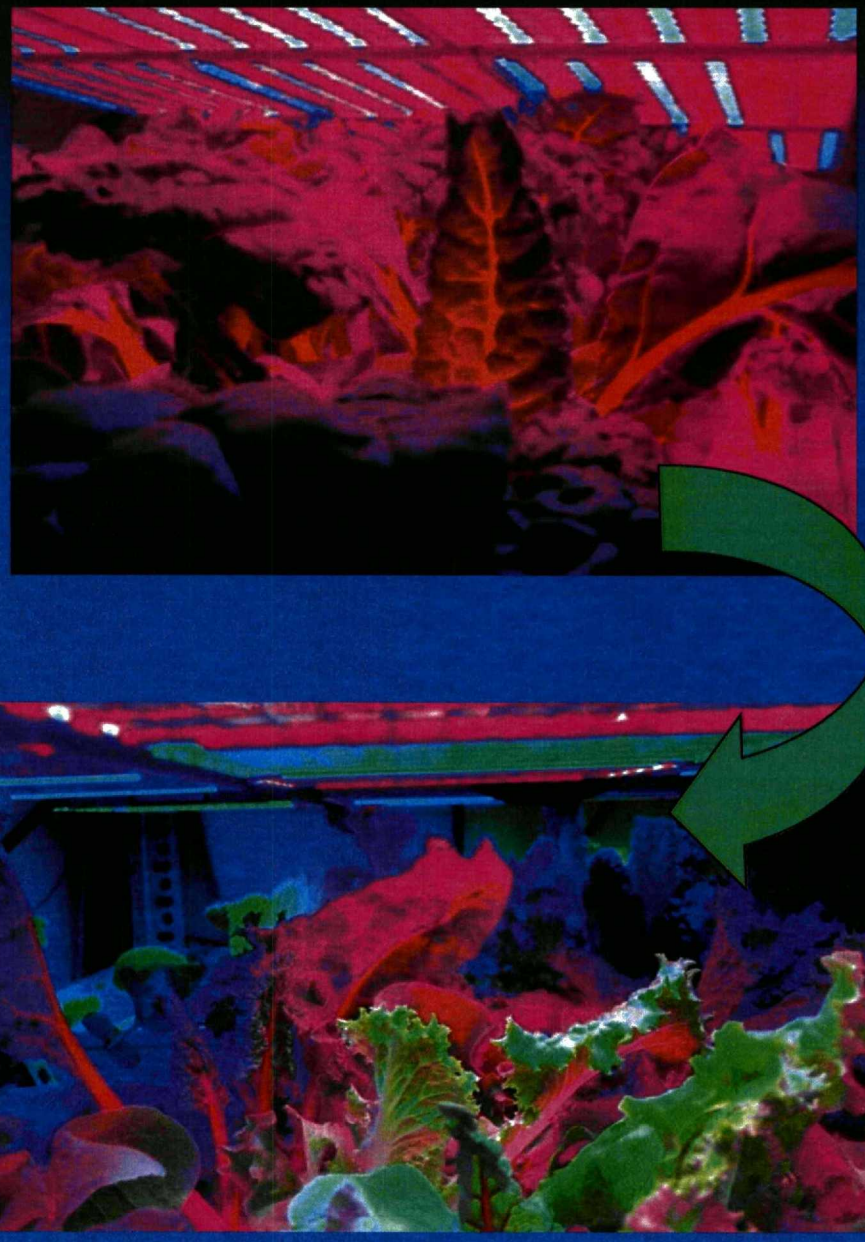


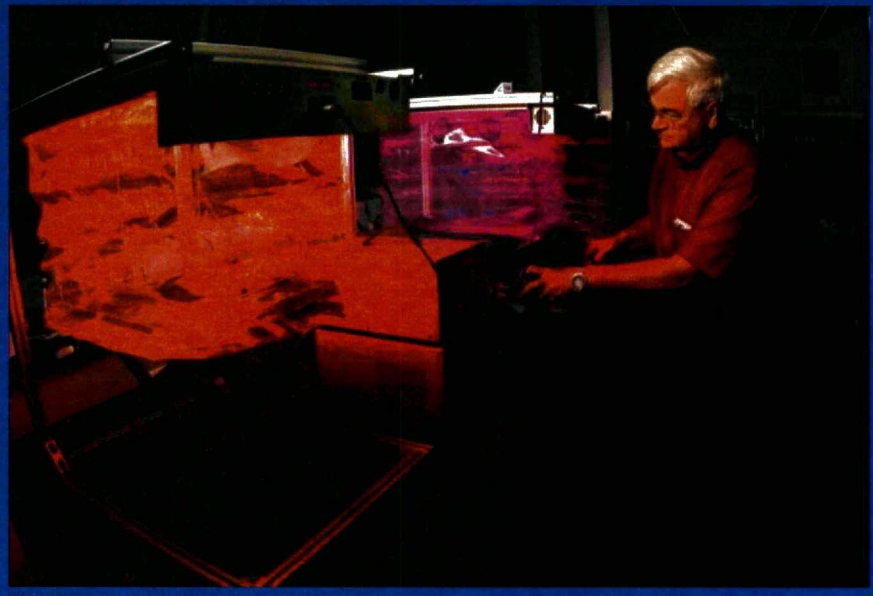
LEDs

Microwave Sulfur

LED for Plant Growth

Red...photosynthesis
Blue...photomorphogenesis
Green...human vision

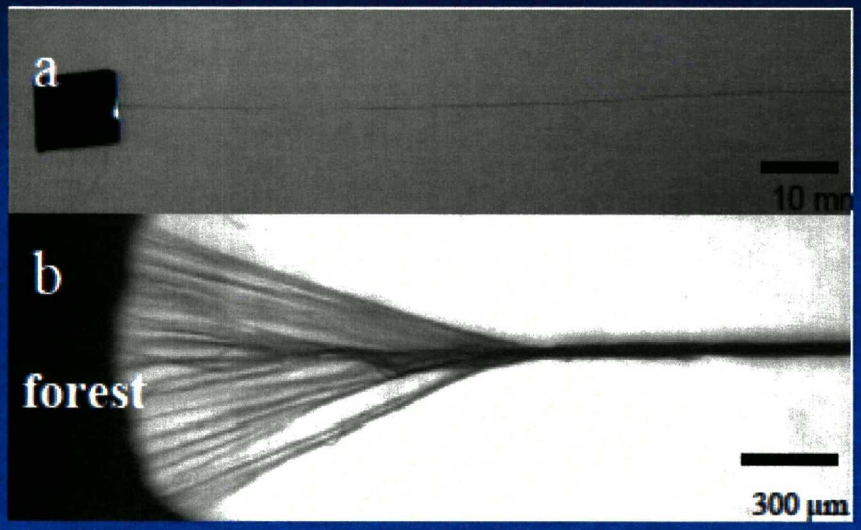




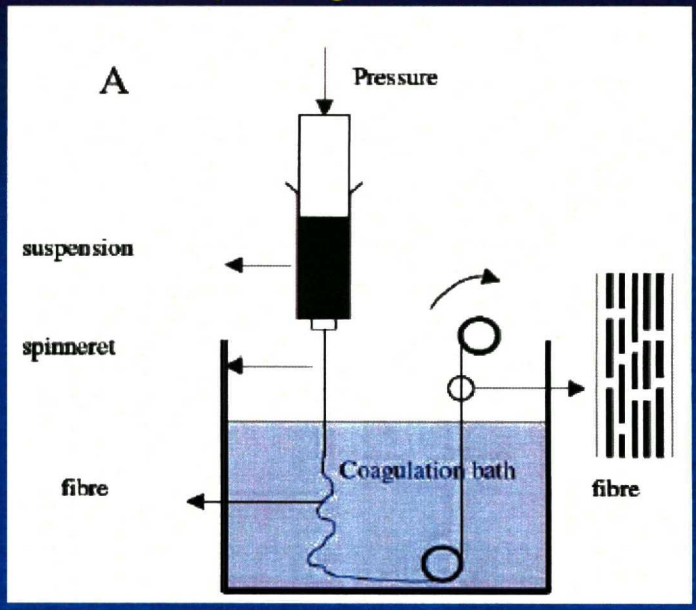
John Sager, KSC, Testing Prototype Flight Plant Chambers with LEDs

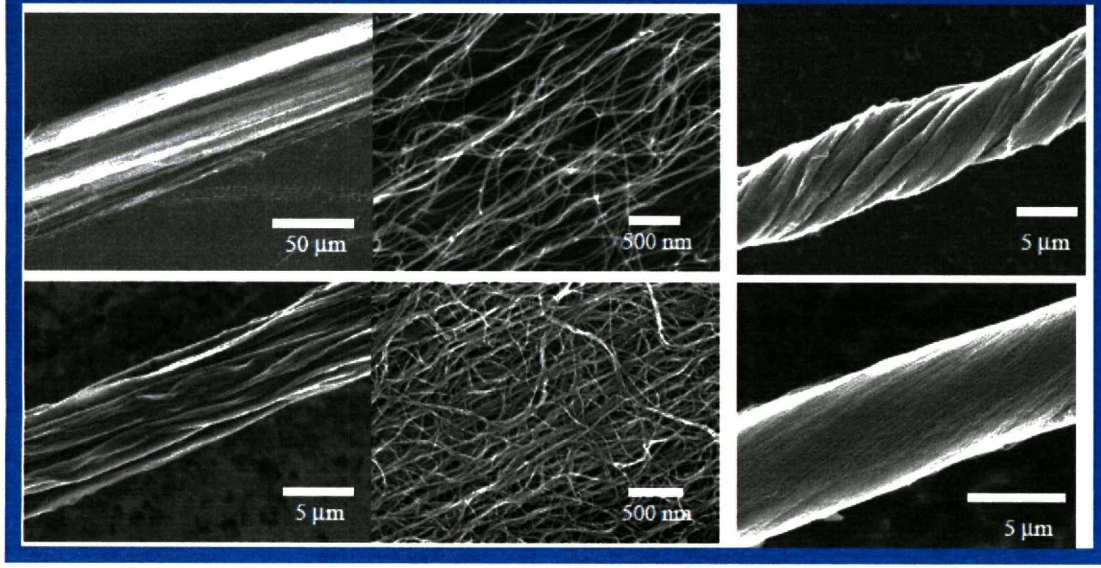
Carbon Nanotube Fiber Filaments

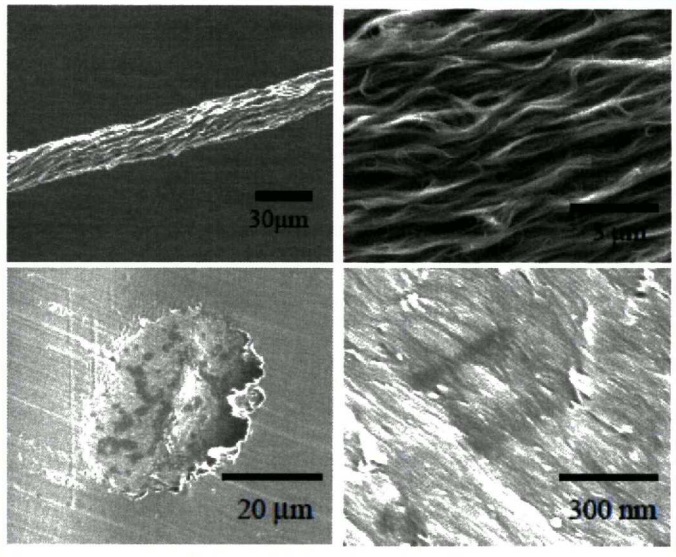
Dry Spinning of MWCNT Forests



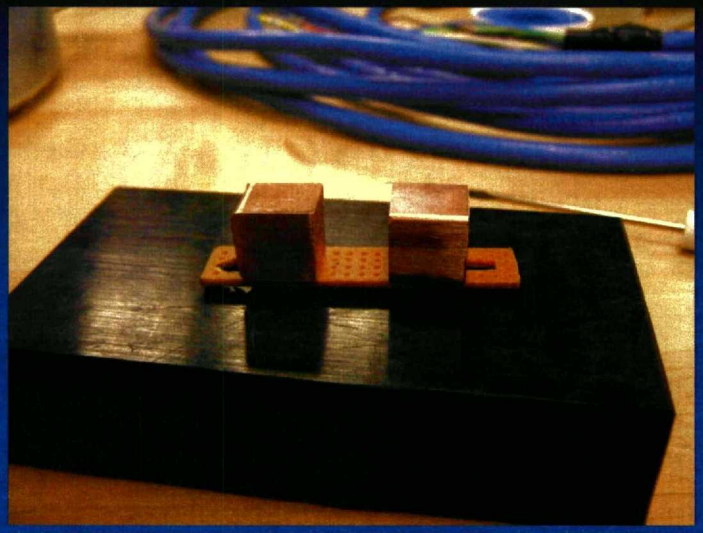
Wet Spinning of WMCNTs





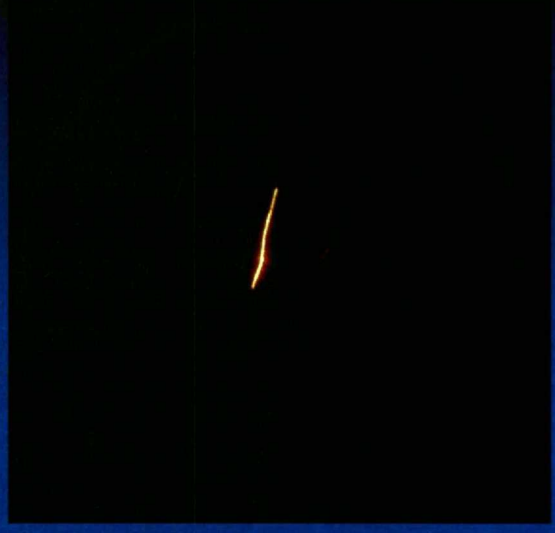


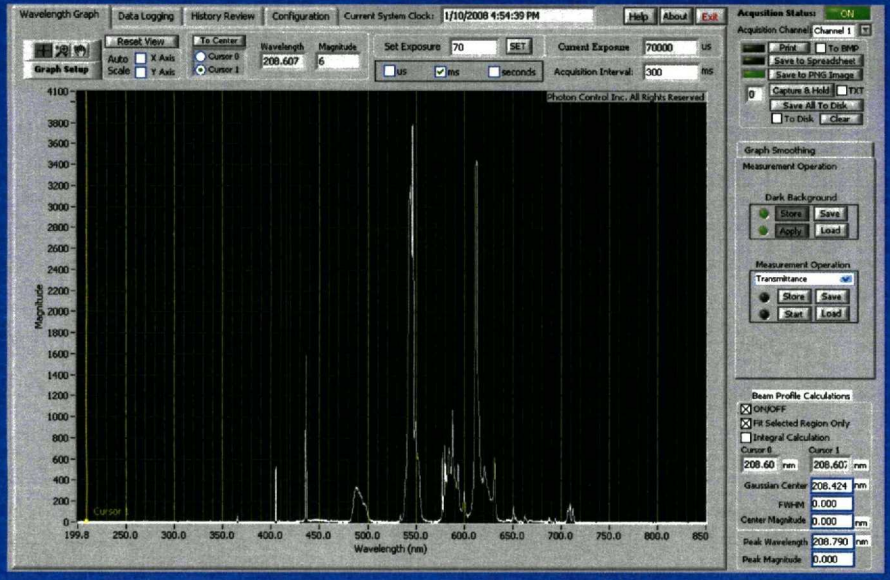
Carbon Nanotube Fiber Filaments



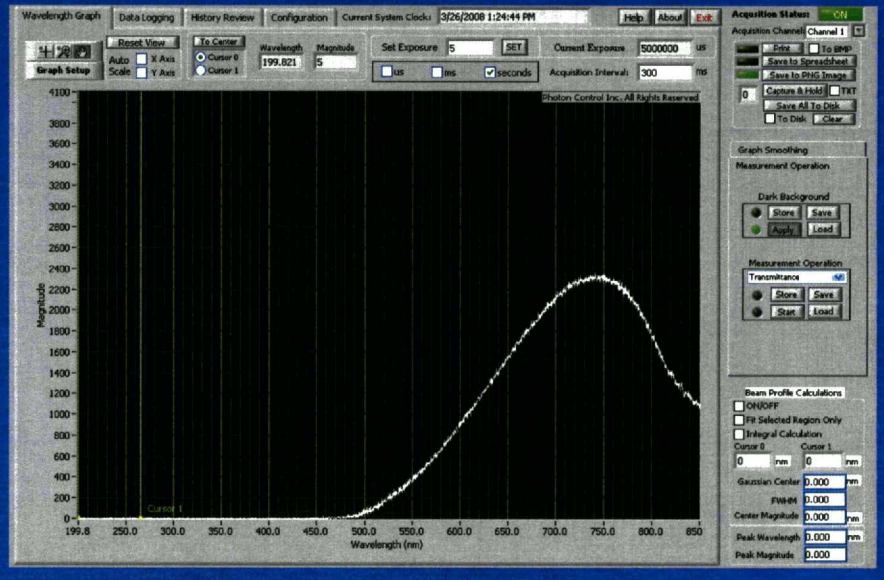
vac

35V
0.01A





Spectrum of CFL bulb



Spectrum of Wet CNT fiber

National Aeronautics and Space Administration

John F. Kennedy Space Center

Summary