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6/8/2022
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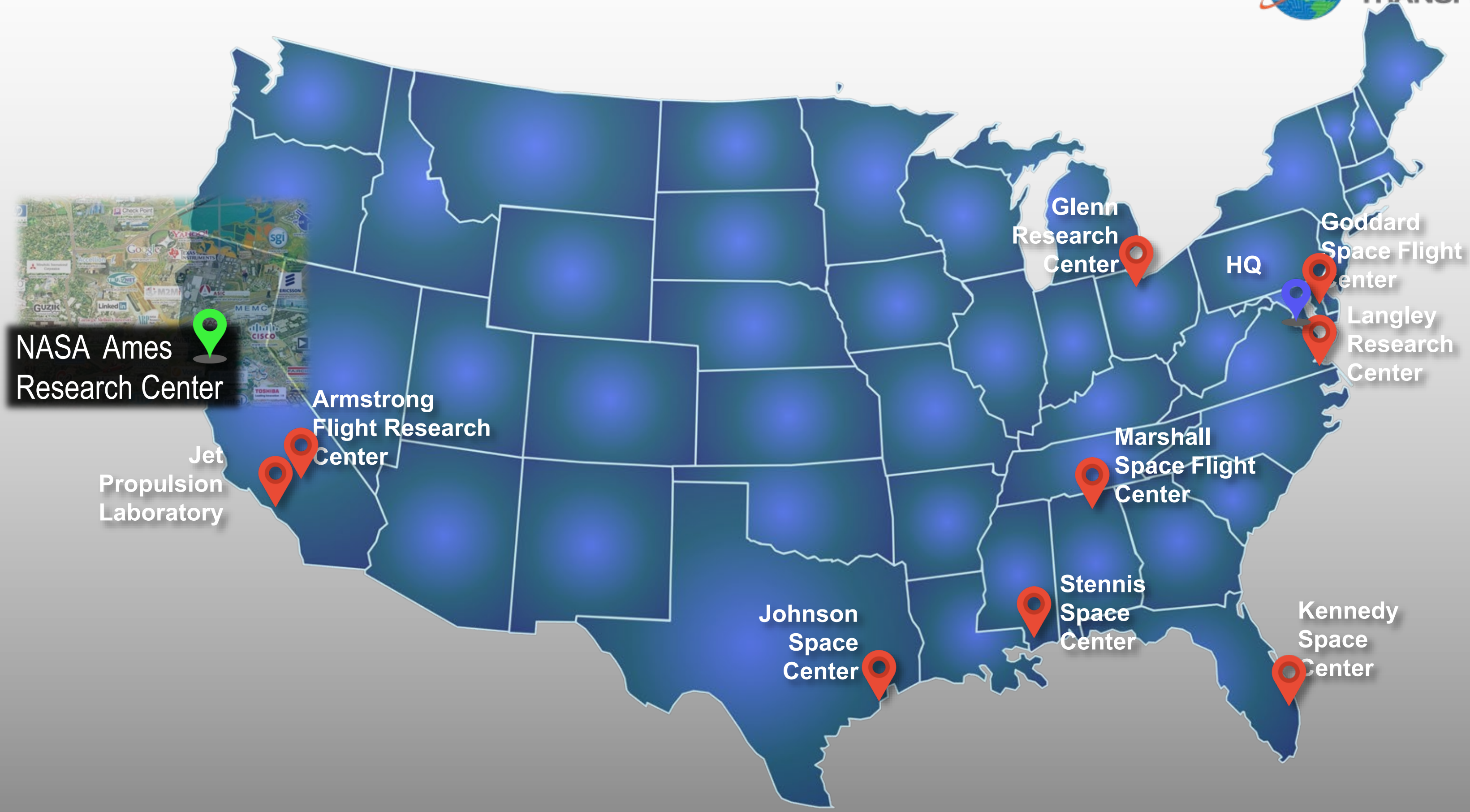
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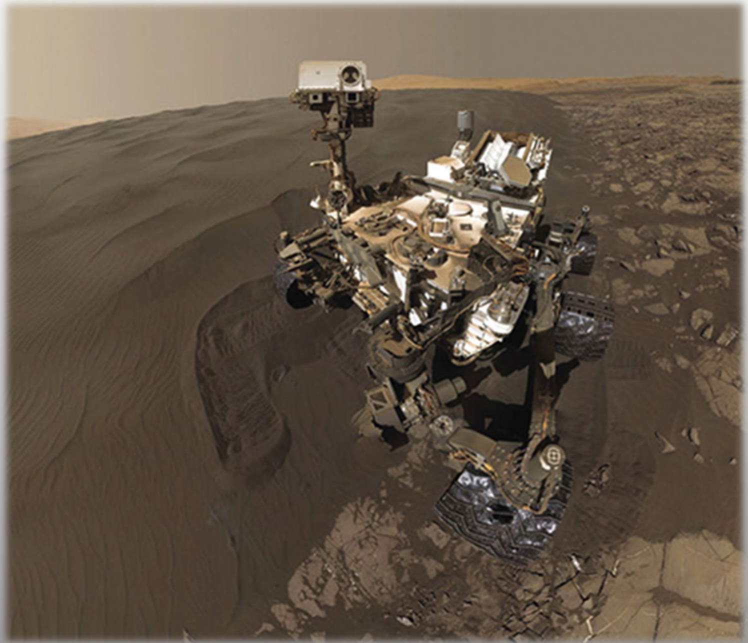

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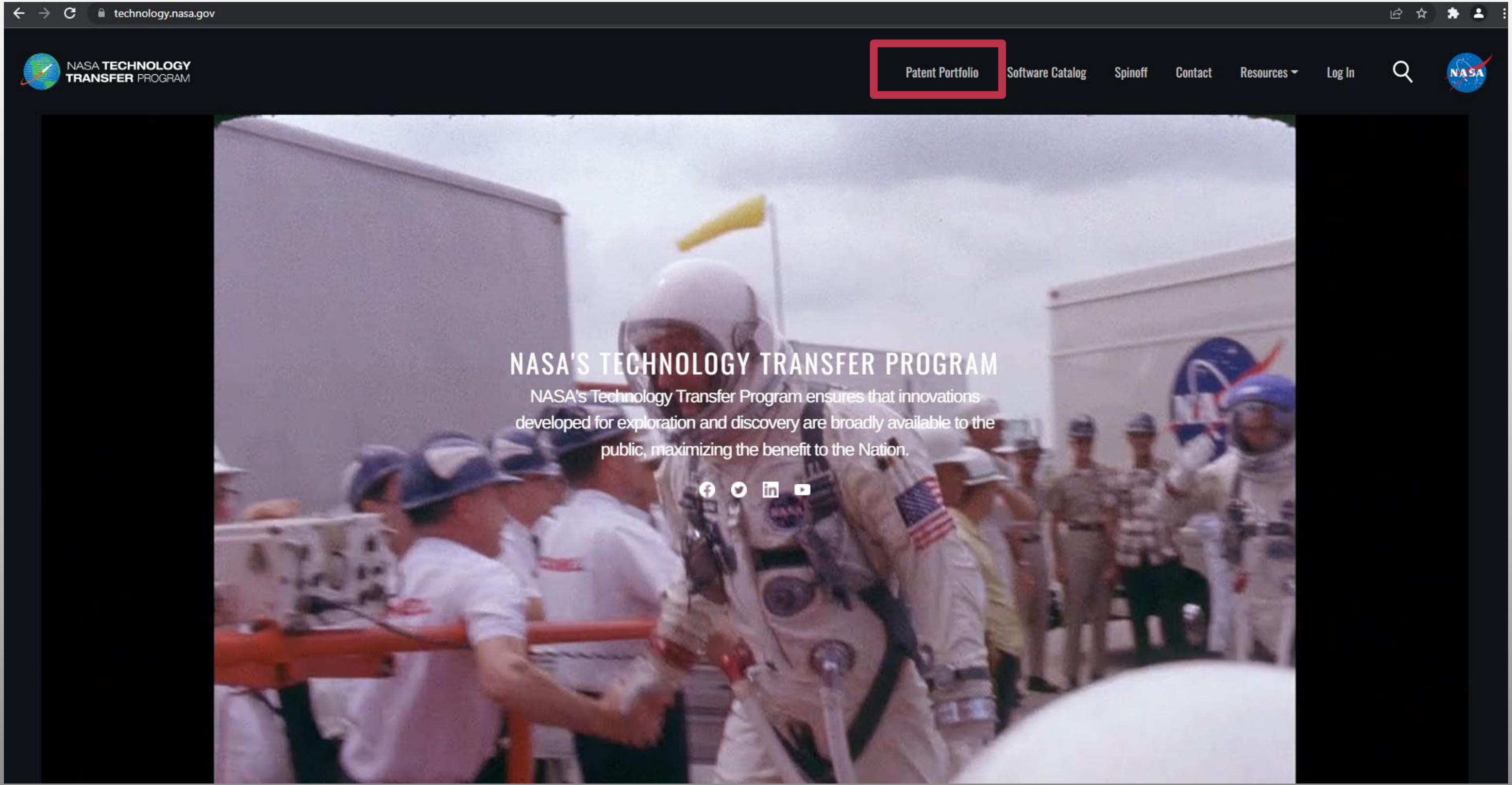

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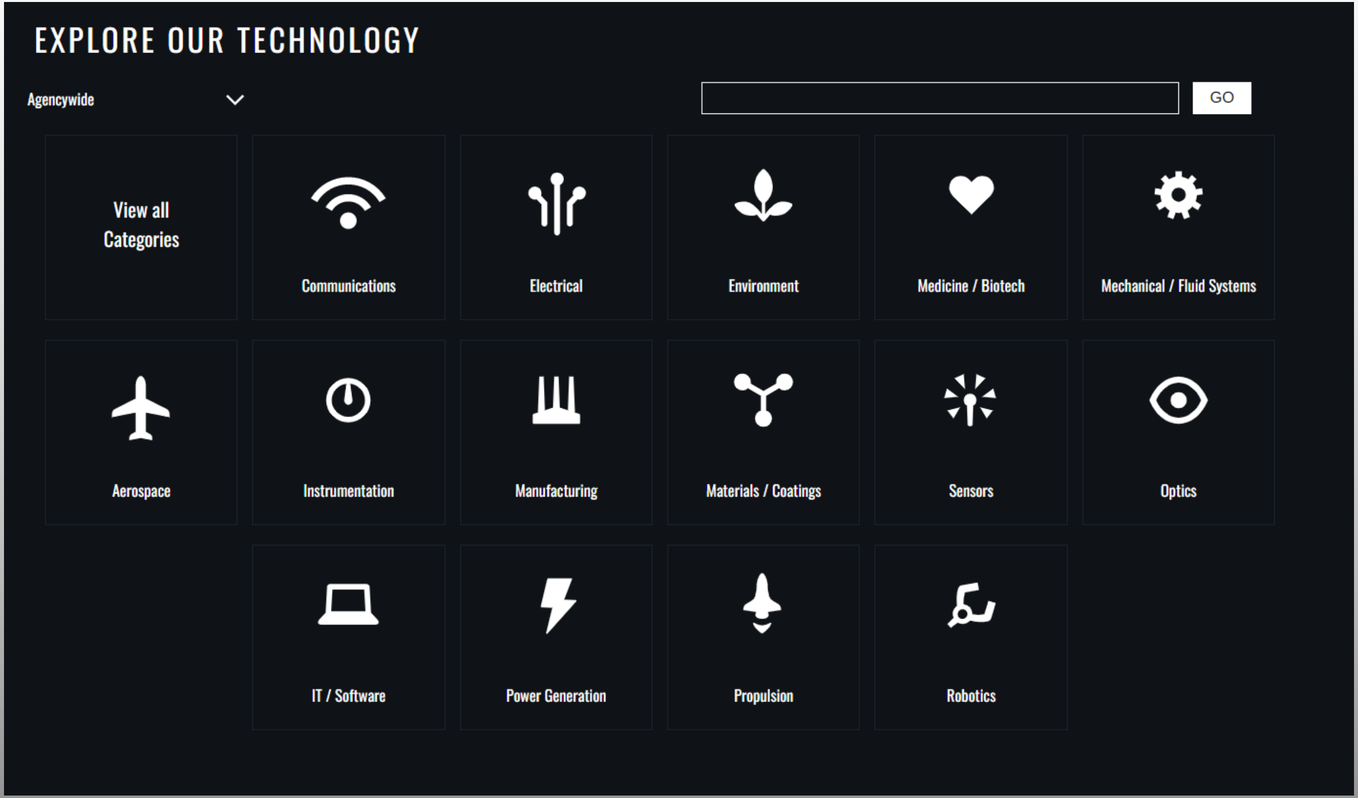

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NASA TECHNOLOGY TRANSFER PROGRAM

Instrumentation

Real Time Radiation Monitoring Using Nanotechnology (TOP2-236)

Questions?

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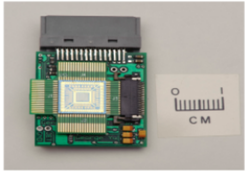
Carbon nanotube chemical sensors

Overview

NASA has patented a unique chemical sensor array leveraging nanostructures for monitoring the concentration of chemical species or gas molecules which is not damaged when exposed to protons and other high energy particles over time. The nanotechnology-enabled chemical sensor array uses single walled carbon nanotubes and metal catalyst-doped single walled carbon nanotubes (SWCNTs) and polymer-coated SWCNTs as the sensing media between a pair of interdigitated electrodes (IDE). By measuring the conductivity change of the SWCNT device, the concentration of the chemical species or gas molecules can be measured. These sensors have high sensitivity, low power requirements, and are robust and have a low manufacturing cost compared to other commercial chemical sensors for detection of trace amount of chemicals in gasses and liquids.

The Technology

Carbon nanotube chemical sensors are suitable for sensing different analytes. Such sensors can be configured in the form of an array to comprehensively and cost-effectively monitor multiple analytes. A 32-sensor array on a silicon chip was tested under the proton exposure at two energy levels, with three different fluences. The result of the proton irradiation experiment indicates that this SWCNT device is sensitive to the proton exposure at different levels and it recovers upon turning off the incident radiation. Carbon nanotube-based sensors are particularly suitable and promising for chemical and radiation detection, because the technology can be used to fabricate gas or liquid chemical sensors that have extremely low power requirements and are versatile and ultra-miniature in size, with added cost benefits. Low-power carbon nanotube sensors facilitate distributed or wireless gas sensing, leading to efficient multi-point measurements, and to greater convenience and flexibility in performing measurements in space as well as on Earth.



Benefits

- High sensitivity
- Capable of proton radiation detection.
- Tunable sensing properties through manipulation of nanostructured materials for selectivity
- Small size and lightweight
- Reliable sensor performance from chip to chip
- High yield and scalable sensors with a low cost for mass production
- Lower power consumption which is ideal for wireless monitoring
- Capability of built-in intelligence onto the sensor chip
- Simple electronic design for easy measurement and integration

Applications

- Petrochemical industry
- Nuclear industry
- Industrial and civil applications
- Defense applications
- Medical / Biomedical
- Spacecraft

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Technology Details

Category
instrumentation

Reference Number
TOP2-236

Case Number(s)
ARC-16001-1

Patent(s)
9,297,907

Tags: aerospace, chemical plants, composite materials, gas sensors, industrial manufacturing, materials, medical, military, natural gas, nuclear, security, sensors

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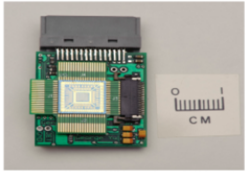

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Very Important! – Patent Claims

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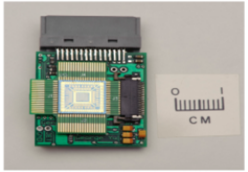

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Patent number hyperlinks to USPTO site.

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Patent Claims and Description

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(1 of 1)

United States Patent — **9,297,907**

Li , et al. — **March 29, 2016**

Real time radiation monitoring using nanotechnology

Abstract

System and method for monitoring receipt and estimating flux value, in real time, of incident radiation, using two or more nanostructures (NSs) and associated terminals to provide closed electrical paths and to measure one or more electrical property change values .DELTA.EPV, associated with irradiated NSs, during a sequence of irradiation time intervals. Effects of irradiation, without healing and with healing, of the NSs, are separately modeled for first order and second order healing. Change values .DELTA.EPV are related to flux, to cumulative dose received by NSs, and to radiation and healing effectivity parameters and/or .mu., associated with the NS material and to the flux. Flux and/or dose are estimated in real time, based on EPV change values, using measured .DELTA.EPV values. Threshold dose for specified changes of biological origin (usually undesired) can be estimated. Effects of time-dependent radiation flux are analyzed in pre-healing and healing regimes.

Inventors: **Li; Jing** (San Jose, CA), **Wilkins; Richard T.** (College Station, TX), **Hanratty; James J.** (San Francisco, CA), **Lu; Yijiang** (San Jose, CA)

Applicant:

Name	City	State	Country	Type
The United States of America as Represented by the Administrator of NASA	Washington	DC	US	

Assignee: **The United States of America as Represented by the Administrator of the National Aeronautics & Space Administration (NASA)** (Washington, DC)

Family ID: 55537429

Appl. No.: 14/205,003

Filed: March 11, 2014

It's important to review patent information and all claims to be sure the technology meet your needs.

Claims

What is claimed is:

1. A method for real time monitoring of radiation received, the method comprising: providing an array of at least two spaced apart nanostructures (NSs) that each extend between and electrically connect first and second terminals of an electrical property change value sensing mechanism, to form a closed electrical path, where the sensing mechanism senses a change value .DELTA.EPV in a selected electrical property value EPV associated with the at least two nanostructures; providing the at least two NSs with a selected coating or dopant to functionalize the at least two NSs to respond to exposure to incident radiation by a change value .DELTA.EPV in the electrical property value; providing or measuring at least one initial electrical parameter value EPV0 for the closed electrical path before exposure of the at least two NSs to incident radiation; exposing the at least two NSs to the incident radiation from a source of incident radiation particles having a representative particle flux .phi. and a representative particle energy E; measuring change values, .DELTA.EPV(t0;t1) and .DELTA.EPV(t0;t2), in the electrical property value EPV for measurement time intervals, t0.ltoreq.t.ltoreq.t1 and t0.ltoreq.t.ltoreq.t2, within a selected time interval t0.ltoreq.t.ltoreq.t3 with t0.ltoreq.t1<t2.ltoreq.t3, for the closed electrical path, as a result of exposure of the at least two NSs to the incident radiation; estimating a change value difference value .DELTA.EPV(t1;t2)=.DELTA.EPV(t0;t2)-.DELTA.EPV(t0;t1); providing a first correspondence or mapping that relates at least one of a dose .PHI.(t1;t2;cum) and the particle flux .phi. to a time rate of change df/dt in a first fractional value f(t;unaf) (0<f(t;unaf).ltoreq.1) of the at least two NSs that have received and reacted to receipt of the incident radiation in the measurement time interval, t1.ltoreq.t.ltoreq.t2, in a pre-heal time interval, where healing of the NS array has not yet begun, where t0 is an initial time and f0=f(t=t0;unaf); providing a second correspondence or mapping that relates the at least one EPV change value .DELTA.EPV(t1;t2) to a first fractional change value, .DELTA.f(t1,t2;unaf)=f(t2;unaf)-f(t1;unaf); and combining the first and second correspondences to relate dose or cumulative radiation received .PHI.(t1;t2;cum) by the at least two NS s in the time interval t1.ltoreq.t.ltoreq.t2, where healing has not yet begun, to the at least one change value .DELTA.EPV(t1;t2), whereby, when healing has not yet begun, an estimate of cumulative radiation dose received is provided at a time no more than about 10-30 seconds after the change values, .DELTA.EPV(t0;t1) and .DELTA.EPV(t0;t2) are completed.

2. The method of claim 1, further comprising choosing said second mapping to be of the form .DELTA.EPV(t1;t2)=.eta.1+.eta.2 .DELTA.f(t1,t2;unaf), where .eta.1 and .eta.2 are real coefficients that can be estimated from one or both of said measurements .DELTA.EPV(t0;t1) and .DELTA.EPV(t0;t2).

3. The method of claim 1, further comprising drawing said radiation particle source from a group of radiation sources consisting of a proton source, a neutron source, an ion source, a molecular beam source, an electron beam source, an ultraviolet source, and an X-ray source.

4. The method of claim 1, further comprising selecting said coating to comprise at least one of Au, ZnO, a sulfonated polymer, and hydroxypropyl cellulose.

Description

FIELD OF THE INVENTION

This invention relates to real time monitoring of receipt of ionizing radiation, using nanostructure devices.

BACKGROUND OF THE INVENTION

Monitoring of receipt of ionizing radiation (e.g., from high energy ions, X-rays, gamma rays, electrons, protons and/or neutrons) is normally done after the fact, using conventional dosimetry techniques and other processes that reflect the results of settled processes. One disadvantage of this approach is that, where receipt of incident radiation causes reactions or material changes that must be responded to promptly, intervention of long time intervals (hours to days) before the results are known may not be acceptable.

What is needed is a system that promptly and unambiguously responds to receipt of such radiation and that permits a prompt response to these results, either manually or in an automated manner. Preferably, the system should provide an estimate of the type of radiation received and/or of the energy range and/or of the flux or dose. Preferably, the system should permit recycling without physical change of the radiation test substances.

SUMMARY OF THE INVENTION

These needs are met by the invention, which provides a system and procedure for real time (i.e., prompt) monitoring of some effects on single wall or multi-wall carbon nanotubes ("SWCNTs" or "MWCNTs") immediately after irradiation of the SWCNTs with high flux, medium energy proton beams or other radiation beams. After irradiation ceases, some of these effects continue to develop.

A first embodiment of the invention relies upon real time measurements of some effects of exposure of one or more SWCNTs with a flux (e.g., 10.sup.x/cm.sup.2/sec with x=3-11) at one, two or more medium energy levels (e.g., 10 MeV and 40 MeV) of a proton (hydrogen ion) beam. The SWCNTs, unloaded, doped or coated with metal catalysts or with selected polymers, are part of a chemical sensor array that uses a pair of interdigitated electrodes ("IDEs"), connected by an array of two or more SWCNTs to form part of an electrochemical cell and a closed electrical circuit. A transfer of electrical charge from one electrode to the other electrode passes through one or more SWCNTs, whose charge transfer characteristics are changed in response to receipt of radiation. By measuring change of electrical conductivity or another electrical property value {".DELTA.EPV") of the SWCNT array, the flux can be estimated. For a particular ion beam, the cumulative dose can then be determined. This sensor array possesses high sensitivity, low power, robustness, and low cost compared with other commercial chemical sensors, which is suitable for detection of trace amounts of incident radiation.

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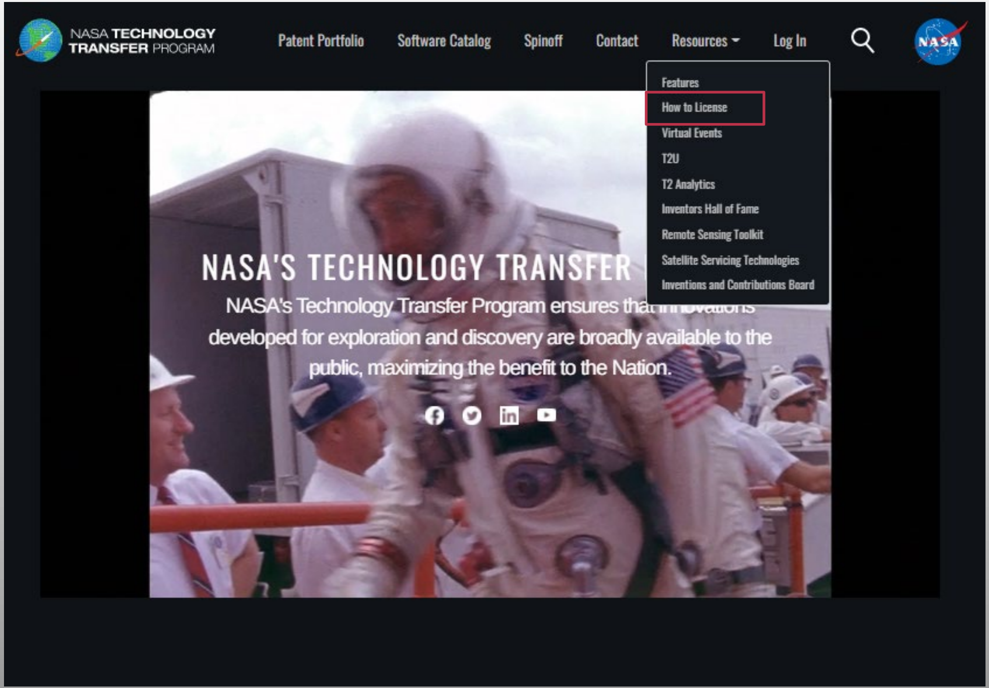

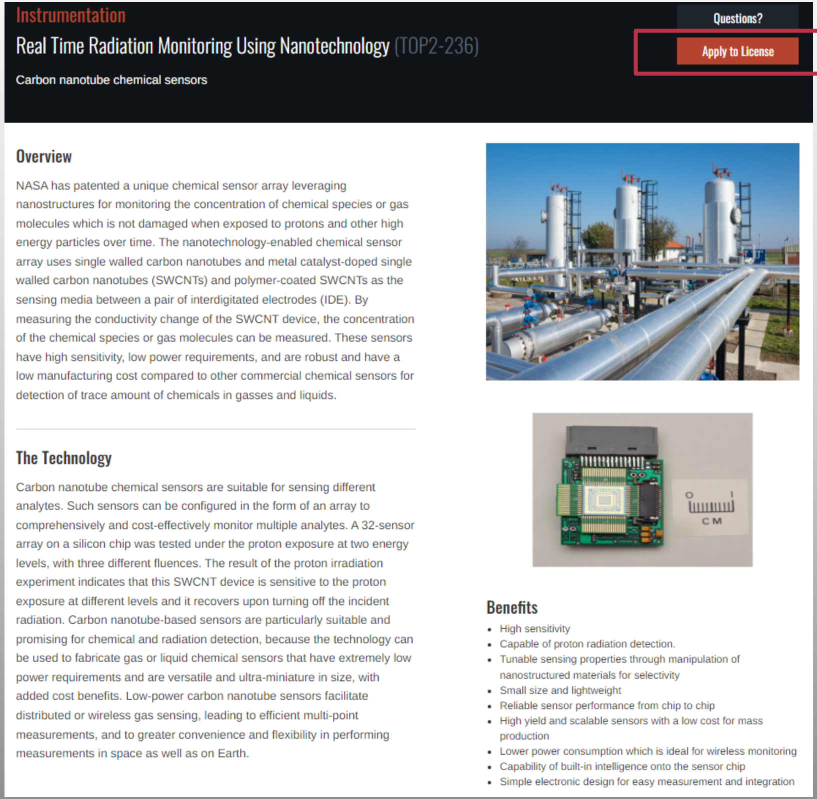

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Applying for a License…application process

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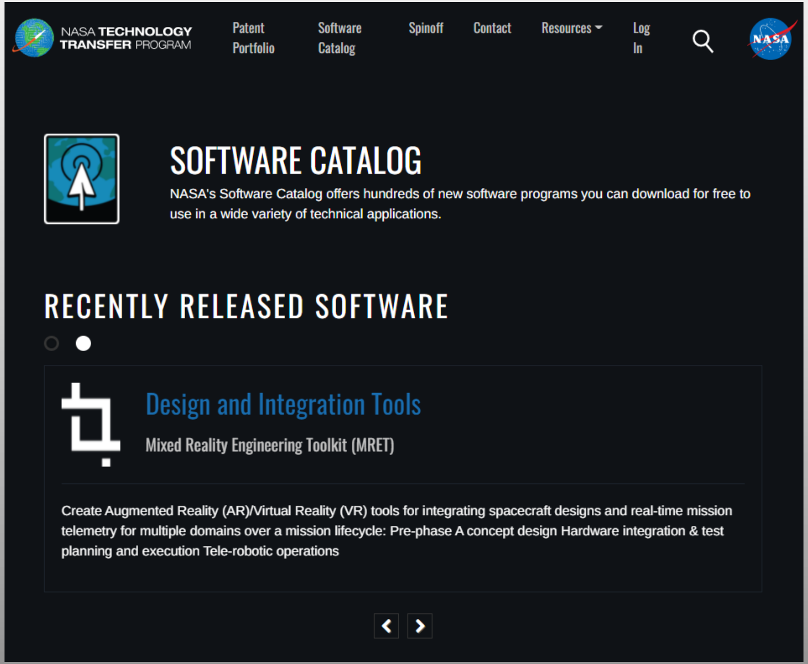

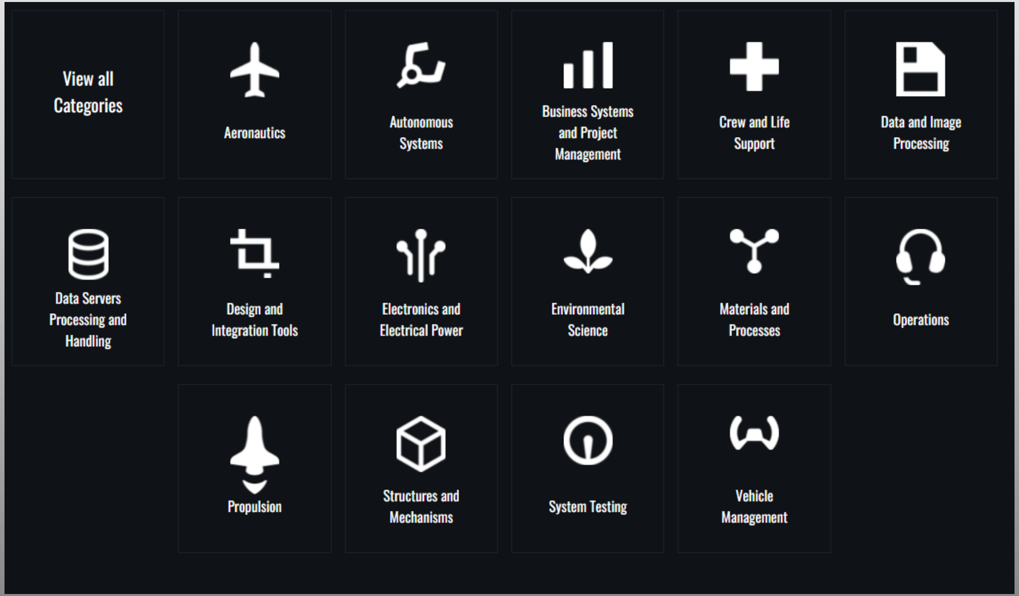

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What is left "undone" in your company/group that you might search NASA technology for a solution?