RADIATION DETECTORS FOR SPACE APPLICATIONS: DETECTOR DESIGN, FABRICATION AND CHARACTERIZATION

Presentation at NASA HBCU/MSI Technology Infusion Road Tour University Capabilities
September 29, 2016
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Fisk-Vanderbilt Master’s-to-PhD Bridge Program:

Support: NSF, DOE/NNSA, DHS/DNDO, DOD/DTRA, NIH/NMBIB/R23, Vanderbilt/Discovery Grant, Cal Tech/JPL
Materials Science and Applications Group

Field requirements / needs

- Materials Discovery (semi-empirical)
- Understanding Improving Crystal Growth Limitations
- Design & Fabrication Of Gamma & Neutron Sensors
- SNM Detection

Improved understanding / new devices

Crystal growth is the critical enabling
Pandora: Unlocking the mysteries of the moons of Mars
Chemical composition of planetary surfaces provides clues about their origins and evolution

- Power < 3 W
- Potential for commercial-off-the-shelf components
SrI₂ scintillators for planetary gamma-ray spectroscopy

Figure 1. Cartoon of gamma-ray production processes in the surface of planetary bodies. Galactic cosmic rays

Figure 2. Comparison of the average lunar gamma-ray spectrum, as acquired during the Lunar Prospector (black) and Kaguya (red) missions.

Figure 3. Illustration showing how energy resolution affects the ability to extract chemical information from a lunar gamma-ray spectrum.

http://spie.org/x115974.xml

SrI₂ technology may find uses on future manned missions, and their robotic precursors, to nearby asteroids.
BASIC EQUIPMENT USED IN RADIATION DETECTION

Legend: 1-NIM Minibin, 2-High Voltage Power Supply, 3-Multichannel Analyzer, 4- Pulser, 5- Shaping amplifier, 6-Low Voltage Power Supply, 7-Digital oscilloscope, 8- Analog Oscilloscope, 9-Fast preamplifier C6438 (for scintillators), 10-Charge sensitive preamplifier (A250CF), 11-PMT(R6231-100), 12-Radiation source
Design

Vibration testing at Fisk
**Lithium Indium Disenlenide ($^6\text{LiInSe}_2$)**

Single crystal of LiInSe$_2$ semiconductor for neutron detector

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(Received 17 July 2012; accepted 8 October 2012; published online 12 November 2012)

Single crystals of semiconductor-grade lithium indium selenide (LiInSe$_2$) were grown using the vertical Bridgman method. The orthorhombic structure of the materials was verified using powder x-ray diffraction. The room temperature band gap of the crystal was found to be 2.85 eV using optical absorption measurements. Resistivity of LiInSe$_2$, obtained using current-voltage measurements, has semiconducting nature (decreases with increasing temperature) and is in order of $10^{10}$ $\Omega$·cm. Photoc conductivity measurement showed the photocurrent peak at 445 nm. Nuclear radiation devices were fabricated, and alpha particle detection was observed, suggesting that this material could be a candidate for neutron detection applications. © 2012 American Institute of Physics. [http://dx.doi.org/10.1063/1.4762002]

Z. Bell et al, 2015 SPIE Optics and Photonics, International Conference on Hard X-Ray, Gamma Ray and Neutron Detector Physics

LiInSe$_2$ Detection response

$^6\text{LiInSe}_2$, 12x7x1 mm$^3$ Au contacts 5 mm dia.
600V, Sh.T 2us

Lithium Distillation - Scale up
Gas vent/vacuum

The Bridgman-Stockbarger with Accelerated Crucible Rotation Technique
- Percy Williams Bridgman, 1923
- Donald C. Stockbarger, 1935
- Hans J. Scheel, ACRT, 1971-72
**LiInSe₂ prototype, CubeSat 2U**

- Collaboration funded by Vanderbilt – Discovery grant
- Space is sufficient to add a Raspberry Pi computer (Linux)
- LiInSe₂ operates in scintillator mode with a single APD readout. Plan to test it for neutron detection at LPL – University of Arizona
Cesium hafnium chloride: A high light yield, non-hygroscopic cubic crystal scintillator for gamma spectroscopy

Arnold Burger, Emmanuel Rowe, Michael Groza, Kristle Morales Figueroa, Nerine J. Cherepy, Patrick R. Beck, Steven Hunter, and Stephen A. Payne

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Published in APL Vol 107, on the web at http://dx.doi.org/10.1063/1.4932570

principal decay time is 4.37 µs

\( \lambda_{\text{max}} = 400 \text{ nm} \)

FWHM = 3.3% @ 662 keV
LY of 54,000 ph/MeV with silicon CCD photodetector

non-proportionality-limited resolution of 1.37% @ 662 keV
Detector Fabrication

**Equipment:**
diamond cutting wheel
diamond wire saws
8 in. Lapping Machine
e-beam evaporator
sputtering system
parylene coating system
Photolithography system
That's all Folks!