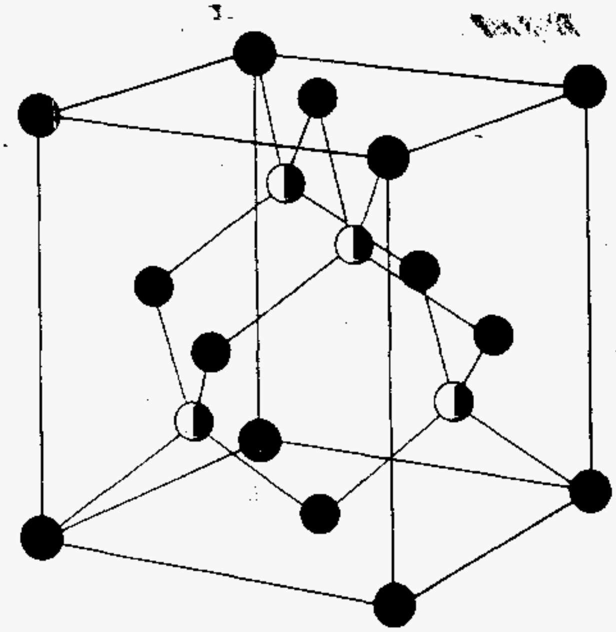
SAND--97-8615C

FINAL
CALL FOR PAPERS

The 1997 U.S. WORKSHOP on the PHYSICS and CHEMISTRY of II-VI MATERIALS

- HgCdTe and Other IR Materials
- X-Ray and γ-Ray Detector Materials
- Photonic Materials



Sponsored by

CECOM Night Vision & Electronics Sensors Directorate

U.S. Army SSDC

Office of Naval Technology

Air Force Wright Laboratory

American Physical Society

The Minerals, Metals, & Materials Society

October 21-23, 1997
Santa Barbara, California

1997 II-VI WORKSHOP

Purpose

The purpose of this Workshop is to bring together the universities and the industrial and governmental communities that work with II-VI materials which include HgCdTe and other IR materials, II-VI semiconductor alloys used for x-ray and γ-ray detectors, ZnSe-based II-VI photonic materials, and II-VI photorefractive materials. The Workshop aims at advancing the understanding of the physics and chemistry of these materials.

Areas of Interest

Areas covered include a broad range of disciplines: materials engineering, intrinsic and extrinsic defects including doping, surface sciences, manufacturing/processing, electrical, optical, and magneto-optical properties as well as interactions between them.

Workshop Format

To provide more discussion time, the Workshop program will consist of about 50 papers.

When appropriate, invited, encouraged, and contributed papers with a common theme will be grouped for presentation and then followed by an extensive discussion period. Scheduled morning and afternoon breaks as well as lunch, provided as part of the workshop fee, can also be used as additional discussion time. To further promote informal discussion and interaction, the first two days will conclude with a wine and cheese break accompanied by table-top displays from commercial vendors displaying products and services of interest to the community.

Authors of accepted papers will be invited to submit a full-length manuscript, subject to formal review, for publication in the *Journal of Electronic Materials.*

KEYNOTE SPEAKER

- **Dr. John H. Pollard**, Director, Science & Technology, CECOM Night Vision & Electronic Sensors Directorate, *Historical Perspective, Status, and Future Opportunities for the Device Applications of II-VI*

ISSUES

The scope of the Workshop includes all II-VI based materials because the basic physics and chemistry issues are common. Particular materials of interest include Hg-based IR detector materials, ZnSe and related wide-gap semiconductors for visible light emitters, II-VI based x-ray and γ-ray detectors, and photorefractive materials. Unresolved problems in the following critical areas will be emphasized.

- **Materials Growth and Device Engineering**
  - Control of composition
  - Novel material and device structures
  - *Modeling of growth, processing, and* performance
  - Equilibrium and nonequilibrium growth
- **Defects**
  - Effect on electrical properties
  - Effect on optical properties — linear and nonlinear
  - Thermodynamics
- **Doping**
  - Impurities and diffusion
  - Activation and segregation
- **Surfaces and Interfaces**
  - Dry processing
  - Etching, passivation, and metallization
- **Characterization of Materials**
  - Electrical and optical characterization
  - Defects and impurities
  - Contactless and other nondestructive methods
  - *Device-material correlation*

PARTIAL LIST OF INVITED SPEAKERS

- **Professor Robert L. Gunshor**, Purdue University, *The Growth of Wide-Bandgap II-VI Device Structures Incorporating Be*
- **Dr. Heyward G. Robinson**, Stanford University, *Process and Device Simulation for IR Detector Manufacturing*
- **Dr. Ralph B. James**, Sandia National Laboratories, *Material Properties of CdZnTe Crystals and Their Relationship to*

CALL FOR PAPERS

Papers describing significant advances in the state of the art in scientific results and understanding in the workshop issues are solicited. Experimental results or theoretical results addressing experiments are strongly encouraged. Emphasis should be on new fundamental physical or chemical properties and their relationship to the material characteristics where appropriate. Abstracts must contain results to be considered.

Papers will be selected on the basis of (1) originality, (2) significance of results, (3) quality and completeness of the research, and (4) breadth of interest.

The *submitted* abstract of all accepted papers will be published in the *Book of Abstracts.* Submitted full-length manuscripts, subject to formal review, will be published in the *Journal of Electronic Materials.*

ABSTRACTS/PAPERS

1. Abstracts, suitable for publication, should clearly indicate the following:
   a. original aspects of research
   b. objective and approach of work
   c. previous publications or presentations
   d. experimental data
   e. scientific implications of results
2. One-page abstracts should be double spaced on a single $8^1/_2 \times 11$ in. sheet. One (1) additional page of supporting figures will be accepted and is encouraged. The title, author(s), and affiliation should be included.
3. A complete mailing address (including telephone, fax, and e-mail) of the presenter should be typed on the back of the abstract.
4. Abstracts are to be submitted before May 1, 1997 to:

   Palisades Institute for
   Research Services, Inc.
   The 1997 II-VI Workshop
   Attn: Jay Morreale
   201 Varick Street, Suite 1006
   New York, NY 10014

Material Properties of Large-Volume Cadmium Zinc Telluride Crystals and Their Relationship to Nuclear Detector Performance

Abstract - (INVITED PRESENTATION)

R. B. James[*], J. Lund[*], H. Yoon[*,**], B. Brunett[*,+], P. Doty[***], E. Eissler[+++], J. Van Scyoc[*,**], H. Hermon[*], R. Olsen[*], E. Cross[*], N. Hilton[*,#], M. Schieber[*], L. Franks[*], J. Toney[+], T. E. Schlesinger[+], M. Goorsky[**], W. Yao[*,##], and A. Burger[++]

[*]Sandia National Laboratories, Livermore, CA; [**]UCLA, Los Angeles, CA; [***]Digirad, San Diego, CA; [+]Carnegie Mellon University, Pittsburgh, PA; [++]Fisk University, Nashville, TN; [+++]eV Products, Saxonburg, PA; [#]University of Arizona, Tuczon, AZ 85724; [##]University of Nebraska, Lincoln, NE 68588

The material showing the greatest promise today for production of large-volume gamma-ray spectrometers operable at room temperature is cadmium zinc telluride (CZT). Unfortunately, because of deficiencies in the quality of the present material, high-resolution CZT spectrometers have thus far been limited to relatively small dimensions, which makes them inefficient at detecting high photon energies and ineffective for weak radiation signals except in near proximity. To exploit CZT fully, it will be necessary to make substantial improvements in the material quality. Improving the material involves advances in the purity, crystallinity, and control of the electrical compensation mechanism. Sandia National Laboratories, California, in close collaboration with U.S. industry and academia, has initiated efforts to develop a detailed understanding of the underlying material problems limiting the performance of large volume gamma-ray spectrometers and to overcome them through appropriate corrections therein. A variety of analytical and numerical techniques are employed to quantify impurities, compositional and stoichiometric variations, crystallinity, strain, bulk and surface defect states, carrier mobilities and lifetimes, electric field distributions, and contact chemistry. Data from these measurements are correlated with spatial maps of the gamma-ray and alpha particle spectroscopic response to determine improvements in the material purification, crystal growth, detector fabrication, and surface passivation procedures. The results of several analytical techniques will be discussed. The intended accomplishment of this work is to develop a low-cost, high-efficiency CZT spectrometer with an active volume of 5 cm^3 and energy resolution of 1-2% (at 662 keV), which would give the U.S. a new field capability for screening radioactive substances.

Presenter: Ralph B. James, Distinguished Member of Technical Staff
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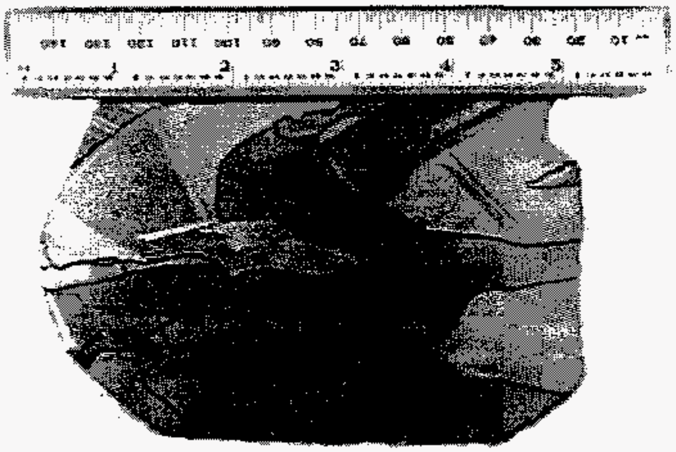
Phone, fax and email of presenter:
Phone: 510-294-2782, Fax: 510-294-3870, email: Rbjames@Sandia.Gov

(a)



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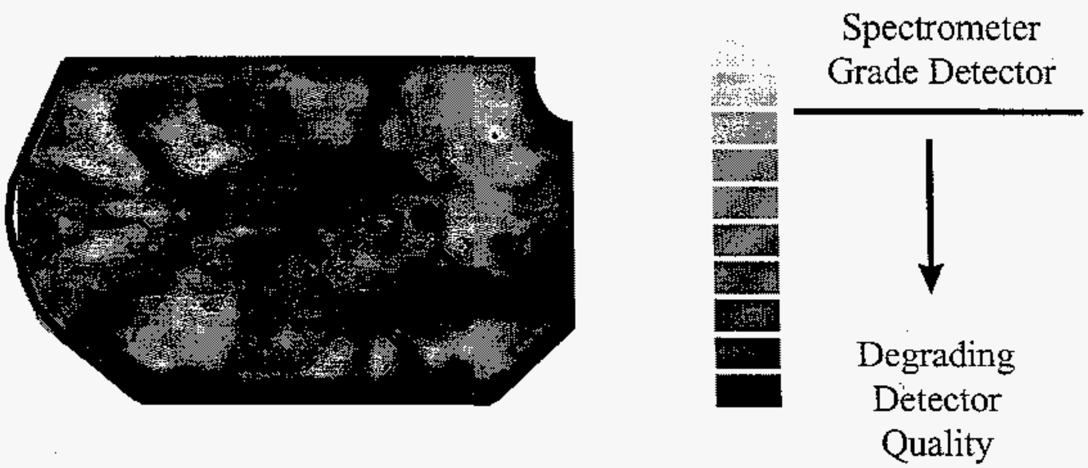

Figure 1. (a) Photograph of a typical large area CdZnTe sample and **(b)** spatial map of the material quality used for harvesting spectrometer grade detectors.

Material Properties of Large-Volume Cadmium Zinc Telluride Crystals and Their Relationship to Nuclear Detector Performance
(INVITED PRESENTATION)
Abstract for Book of Extended Abstracts

R. B. James*, J. Lund*, H. Yoon*,**, B. Brunett*,+, P. Doty***, E. Eissler+++, J. Van Scyoc*,**, H. Hermon*, R. Olsen*, E. Cross*, N. Hilton*,#, M. Schieber*, L. Franks*, J. Toney+, T. E. Schlesinger+, M. Goorsky**, W. Yao*,##, and A. Burger++
*Sandia National Laboratories, Livermore, CA 94550; **UCLA, Los Angeles, CA 90024; ***Digirad Corporation, San Diego, CA 92121; +Carnegie Mellon University, Pittsburgh, PA 15213; ++Fisk University, Nashville, TN 37208; +++eV Products, Saxonburg, PA 16056; #University of Arizona, Tuczon, AZ 85724; ##University of Nebraska, Lincoln, NE 68588

Fieldable gamma-ray spectrometers are required for many DOE and national security applications to monitor, locate, identify, or characterize nuclear materials. In order to perform many of these operations, particularly in a complex environment or changing radiological background, it is necessary to have a high-resolution detector that can resolve the energy of incident x- or gamma rays. For hand-held field instruments or systems requiring unattended operation, it is extremely desirable to have a semiconductor detector that operates at ambient temperature. The material showing the greatest promise today for production of large-volume gamma-ray spectrometers operable at room temperature is cadmium zinc telluride (CZT). Unfortunately, because of deficiencies in the quality of the present material, high-resolution CZT spectrometers have thus far been limited to relatively small dimensions, which makes them inefficient at detecting high photon energies and ineffective for weak radiation signals except in near proximity.

To exploit CZT fully, it will be necessary to make substantial improvements in the material quality. For example, high resolution spectrometers with active volumes greater than a few cm^3 cannot be produced because material problems limit charge collection and ultimately energy resolution. Studies on a large number of CZT crystals and detectors reveal four primary problems limiting the device response - inhomogeneity of the crystals, excessive trapping of charge, variations in the bulk resistivity, and mechanical cracking. Figure 1 shows a photo of a typical CZT specimen. This sample is taken from the center of a 12.5-cm long ingot. Grain boundaries, twinning, and cracking of the sample are apparent. Using alpha particle excitation and position-sensitive pulse height spectra, a map of the electron transport properties of the entire wafer can be visualized (also shown in Figure 1). The electron transport properties are seen to vary widely over the sample volume causing substantial variability in the performance of devices fabricated from different sections of the crystal. Furthermore the yield of small-area crystals for 1-cm thick devices is only about 10 per cent. The yield reduces to zero for active volumes of 3 cm^3 or larger.

The present need for room temperature radiation spectrometers that can resolve the unique radiological emissions of special nuclear materials and the clear potential of CZT to satisfy this need has led to a two pronged approach to develop the sensors. A near term effort has focused on optimizing the performance of currently available material by using pulse processing algorithms to mitigate the effects of hole trapping on detector energy resolution or using electron-only designs that negate most of the effects of hole transport. In parallel, a longer term effort has focused on improving the quality of the material by modifying the growth and processing technology.

Improving the material involves advances in the purity, crystallinity, and control of the electrical compensation mechanism. These are difficult issues; ordinarily ones not amenable to quick and simple fixes. However, the payoff for improving the quality of CZT is great. Not only do material improvements provide the key to larger active area devices and attendant efficiency enhancements, but they also benefit the near-term improvements based on pulse processing algorithms and electron-only charge registration. Sandia National Laboratories, California, in close collaboration with U.S. industry and academia, has initiated efforts to develop a detailed understanding of the underlying material problems limiting the performance of large volume gamma-ray spectrometers and to overcome them through appropriate corrections therein. A variety of analytical and numerical techniques are employed to quantify impurities, compositional and stoichiometric variations, crystallinity, strain, bulk and surface defect states, carrier mobilities and lifetimes, electric field distributions, and contact chemistry. Data from these measurements are correlated with spatial maps of the gamma-ray and alpha particle spectroscopic response to determine improvements in the material purification, crystal growth, detector fabrication, and surface passivation procedures. The results of several analytical techniques will be discussed. The intended accomplishment of this work is to develop a low-cost, high-efficiency CZT spectrometer with an active volume of 5 cm^3 and energy resolution of 1-2% (at 662 keV), which would give the U.S. a new field capability for screening radioactive substances.

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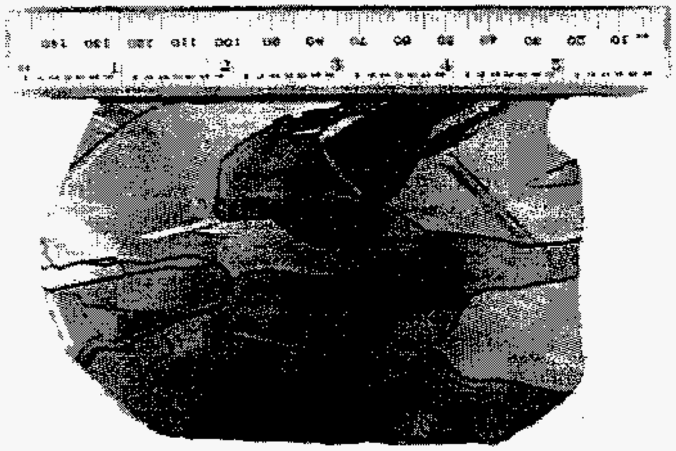

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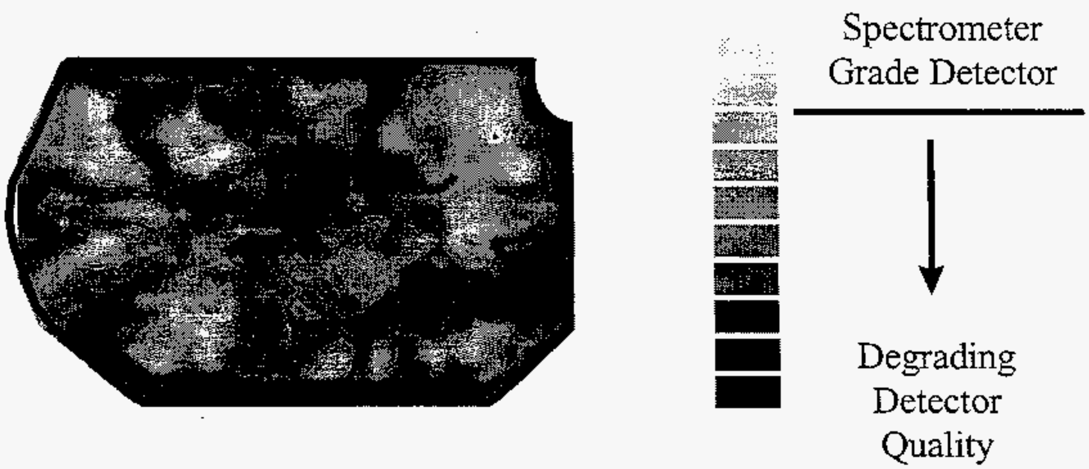

Figure 1. **(a)** Photograph of a typical large area CdZnTe sample and **(b)** spatial map of the material quality used for harvesting spectrometer grade detectors.

Figure 1. Photo of a typical large-area CZT sample and spatial map of the material quality used for harvesting spectrometer-grade detectors.

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