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A GUIDE TO THE LITERATURE ON MERCURY CADMIUM TELLURIDE PHOTODETECTORS (1 JANUARY 1959 - 30 JUNE 1969)

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DECEMBER 1969

GSFC
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CONTENTS

ABSTRACT

This document presents the results of a literature search on mercury cadmium telluride photodetectors through twenty-six scientific and technical journals, three conference proceedings, and the NASA Scientific and Technical Aerospace Reports (STAR) for the period 1 January 1959 through 30 June 1969. The results are presented in a chronological listing in which each item contains three sections: (1) a standard bibliographical listing, (2) an abstract of the paper or article, and (3) a comprehensive listing of keywords or phrases extracted from the publication. Over 59 references by 97 authors are included. This listing is followed by an alphabetical listing of the authors with their publications referenced to the chronological reference number assigned in the previous listing. The third listing, consisting of 125 items, gives, in alphabetical order, the extracted keywords and phrases referenced to the articles by the chronological reference numbers.

A GUIDE TO THE LITERATURE ON MERCURY CADMIUM TELLURIDE PHOTODETECTORS (1 January 1959 - 30 June 1969)

1. INTRODUCTION

The semiconductor, mercury cadmium telluride, is quietly revolutionizing the detection of infrared radiation in the 8- to 14-micrometer atmospheric window. Until the general availability of mercury cadmium telluride photodetectors, using both photoconductive and photovoltaic effects, the only sensitive detectors for this wavelength region required operating temperatures below 20° K. Mercury cadmium telluride photodetectors can be operated at temperatures in excess of 100° K. This capability eases operational requirements and makes possible a number of spaceborne infrared systems which would otherwise be impractical. Examples of such systems are the high resolution radiometer and laser communication experiment to be flown on the Applications Technology Satellite, ATS-F.

The following document is intended to simplify the task of the researcher or engineer who needs a comprehensive survey of the literature which has been published on mercury cadmium telluride photodetectors. This report should speed efforts to locate various parameters or measurements and should reduce the time that the average researcher must devote to literature searching by a considerable factor.

This document is divided into three sections: (1) An annotated chronological listing of the publications on mercury cadmium telluride which have appeared in twenty-six scientific and technical journals, three conference proceedings, and the NASA Scientific and Technical Aerospace Reports (STAR) during the period 1 January 1959 through 30 June 1969. This listing includes the standard bibliographic item, an abstract of the article (usually the author's abstract, when it is available), and a number of keywords or phrases extracted from the article which describe its contents. Each of the articles is numbered chronologically and the assigned number is used in the remainder of this document to identify the article in question. (2) An alphabetical listing of all authors with the chronological reference numbers of their publications. (3) An alphabetical listing of the keywords and phrases which characterize the various publications and which were extracted in the second section.

The following journals were searched in the preparation of this document:

1. J. Phys. Chem. Solids
2. Physical Review
3. Physical Review Letters
4. J. Appl. Physics
5. Appl. Phys. Letters
6. Infrared Physics
7. Proc. IEEE (and Proc. IRE)
8. IEEE Trans. Elec. Devices
9. IEEE J. Quantum Electronics
10. Soviet Physics - Solid State
11. Soviet Physics - Technical Physics
12. Soviet Physics - JETP (omitting June 1969 issue)
13. Soviet Physics - Semiconductors
14. Acta Physica Polonica
15. Solid State Communications
16. Applied Optics
17. Comptes Rendus (Paris)
18. Physica Status Solidi
19. J. Electrochemical Society
20. Physics Letters
21. Physica
22. Proc. Royal Soc. (continued in J. Physics C - Solid State Physics)
23. J. Optical Society of America
24. Philips Research Reports (omitting June 1969 issue)
25. Philips Technical Journal (omitting June 1969 issue)
26. Philips Research Reports Supplements (omitting Apr. - June 1969 issues)

The following conference proceedings were included in the search:

1. Report of the International Conference on the Physics of Semiconductors, Institute of Physics and the Physical Society, London, 1962.

2. Proceedings of the 7th International Conference on the Physics of Semiconductors, Dunod, Paris, 1964.

3. International Conference on II-VI Semiconducting Compounds, Brown University 1967, ed. D. G. Thomas, W. A. Benjamin Inc., New York, 1967.

It is almost inevitable that omissions or errors have crept into this work. The compilers regret all mistakes and seek corrections and additions so that this listing may be as accurate as possible. Suggestions and comments can be

sent to them through the Optical Systems Branch, Mail Code 524, Goddard Space Flight Center, Greenbelt, Maryland, 20771.

2. ANNOTATED CHRONOLOGICAL BIBLIOGRAPHY

The following bibliography lists the papers pertaining to mercury cadmium telluride in chronological order. Each paper has been assigned a reference number in accordance with its chronological position. These numbers are employed in the index to identify the papers.

1. Lawson, W. D., Nielsen, S., Putley, E. H., and Young, A. S.: Preparation and Properties of HgTe and Mixed Chrystals of HgTe-CdTe. J. Phys. Chem. Solids, Vol. 9, 1959, pp. 325-329.

   Abstract: The elements mercury, cadmium, and tellurium have been purified, and crystals of the compounds CdTe and HgTe, and of the mixed compounds CdTe-HgTe have been prepared. X-ray and cooling curve data have established that CdTe and HgTe mix in all proportions to give single-phase crystals. Hall-coefficient and conductivity measurements show that HgTe is a semi-conductor with a very low activation energy ($\sim$0.01 eV) and a high mobility ratio ($\sim$ 100). HgTe is opaque to infrared radiation out to a wavelength of 38 micrometers, but the mixed crystals show absorption edges which vary in position with composition from 0.8 micrometers in pure CdTe to 13 micrometers in crystals containing 90 percent HgTe. Photoconductivity has been observed in filamentary detectors made from the mixed crystals.

   Keywords: Conductivity, Absorption Edge, Photoconductivity, X-ray Data, Cooling-curve Data, Preparation, Absorption, Resistivity, Hall Coefficient

2. Woodley, J. C. and Ray, B.: Solid Solution in A^{II} B^{VI} Tellurides. J. Phys. Chem. Solids, Vol. 133, 1960, pp. 151-153.

   Abstract: Alloys have been produced for the three systems CdTe-HgTe, CdTe-ZnTe, and HgTe-ZnTe and annealed to obtain equilibrium conditions. It has been confirmed that solid solution occurs at all compositions in each system and the variation of lattice parameters with composition has been determined in each case. The form of the solidus curve has been obtained by X-ray methods in the HgTe-ZnTe system.

Keywords: Lattice Parameters, X-ray Data, Preparation, Miscibility Gaps, Mole Fraction (effects of), II-VI Compounds, Solid Solutions

3. Shneider, A. D. and Gavrishchak, I. V. : Structure and Properties of the HgTe-CdTe System. Soviet Physics - Solid State, Vol. 2, No. 9, Sept. 1960, pp. 1865-1867.

Abstract: The formation of solid solutions in systems consisting of two III-V-type compounds has been subjected to intensive study, while systems of II-VI compounds have not. To correct that situation, the authors undertook a detailed analysis of the structure and structural properties of a HgTe-CdTe system.

Keywords: II-VI Compounds, Solid Solutions, Forbidden Gap, Electron Mobility, Conductivity, X-ray Data, Mole Fraction (effects of)

4. Harman, T. C., Strauss, A. J., Dickey, D. H., Dresselhaus, M. S., Wright, G. B., and Mavroides, J. G.: Low Electron Effective Masses and Energy Gap in $Cd_xHg_{1-x}Te$. Physical Review Letters, Vol. 7, No. 11, Dec. 1, 1961, pp. 403-405.

Abstract: Various parameters, such as electron effective mass and Hall mobility, were measured for different values of x in $Cd_xHg_{1-x}Te$. The authors also took data on optical characteristics of the samples and the dependence of these upon the value of x.

Keywords: Preparation, Electron Effective Mass, Hall Mobility, Optical Transmission, Magnetic Field (effects of), Plasma Edge, Absorption, Temperature (effects of), Dielectric Constant, Energy Gap, Mole Fraction (effects of)

5. Strauss, A. J., Harman, T. C., Mavroides, J. G., Dickey, D. H., and Dresselhaus, M. S.: Optical and Electrical Properties of $Cd_xHg_{1-x}Te$ Alloys, Report of the International Conference on the Physics of Semiconductors, The Institute of Physics and the Physical Society, London, 1962.

Abstract: On the basis of Hall coefficient and resistivity data, the intrinsic carrier concentration for HgTe is estimated to be 2×10^{16} cm^{-3} at 4.2° K. Since this value is too high to be consistent with an energy gap between the valence and conduction band, it is concluded that HgTe is a semi-metal. For the $Cd_xHg_{1-x}Te$ alloys a transition to semiconductor behavior occurs with increasing cadmium content, probably at about 20 mole % CdTe. Both cyclotron resonance and interband transitions have been observed in infra-red magneto-reflection experiments on $Cd_{0.17}Hg_{0.83}Te$. The data for this sample and earlier data for $Cd_{0.14}Hg_{0.86}Te$ have been interpreted in terms of the nonparabolic conduction band model proposed by Kane for InSb. Reasonable agreement with experiment is obtained by adopting an energy gap of 0.006 eV and matrix element $P = 8 \times 10^{-8}$ eV-cm.

Keywords: Hall Mobility, Electron Effective Mass, Matrix Element, Energy Gap, Magnetoreflection, Magnetoresistance, Fermi Level, Direct Transitions

6. Kruse, P. W., Blue, M. D., Garfunkel, J. H., and Saur, W. D.: Long Wavelength Photoeffects in Mercury Selenide, Mercury Telluride, and Mercury Telluride-Cadmium Telluride. Infrared Physics, Vol. 2, 1962, pp. 53-60.

Abstract: Mercury selenide, mercury telluride, and mercury telluride-cadmium telluride are semiconductors which have been investigated as intrinsic infrared detecting materials. Mercury selenide and mercury telluride in the photoelectromagnetic-Nernst configuration exhibit spectral and frequency responses indicative of thermal rather than photon behavior. The signal is believed due to the Nernst thermal effect rather than the PEM photon effect. Mercury telluride-cadmium telluride exhibits photoconductivity at 77° K and 4.2° K with a spectral response extending past 15 micrometers.

Keywords: II-VI Compounds, Energy Gap, Preparation, Temperature (effects of), Photoconduction, Response, Signal Voltage, Noise Voltage, Signal-to-Noise Ratio

7. Kot, M. V., Tyrziu, V. G., Simashkevich, A. V., Maronchuk, Yu. E., and Mshenskii, V. A.: Dependence of Activation Energy on Molar Composition for Certain A^{II} B^{VI} -A^{II} B^{VI} Systems in Thin Layers, Soviet Physics - Solid State, Vol. 4, No. 6, Dec. 1962, pp. 1128-1132.

Abstract: The Vekshinskii method was used to prepare thin layers of ZnSe-CdSe, ZnTe-CdTe, ZnSe-HgSe, CdSe-HgSe, CdTe-HgTe systems. The initial components were binary compounds. It was shown that under certain thermal conditions this method gives layers of systems having variable composition which apparently are continuous series of solid solutions.

Keywords: II-VI Compounds, Preparation, Temperature (effects of), Activation Energy, Conductivity, Transmission, Reflection, Photoconductivity, Mole Fraction (effects of), Vekshinskii, Method

8. Giriat, W.: Optical Properties of $Cd_x Hg_{1-x}$ Te Semiconductors x = 1.0; 0.9; 0.8. Acta Physica Polonica, Vol. 24, No. 2, 1963, pp. 191-197.

Abstract: The value of the forbidden energy gap and its variation with temperature were derived from measurements of the optical absorption near the fundamental absorption edge. The transitions were found to be indirect. The energy of the phonons involved were determined.

Keywords: II-VI Compounds, Forbidden Band, Absorption Edge, Preparation, Refractive Index, Absorption Coefficient, Temperature (effects of), Mole Fraction (effects of), Phonon Energy

9. Kamieniecki, E. : On Some Optical Properties of Thin $Cd_{0.9}Hg_{0.1}Te$ Layers. Acta Physica Polonica, Vol. 14, No. 2, 1963, pp. 199-207.

Abstract: A method of depositing thin $Cd_{0.9}Hg_{0.1}Te$ layers by evaporation is considered. The dependence of the light absorption coefficient on the wavelength in the range of 0.8 micrometer to 2.4 micrometers is given. From the shape of the transmittivity curve and from the analysis of interference fringes in the 1.2-micrometer-2.4-micrometer range, the layers investigated

are concluded to present two refractive indices: a "surface" index of $n_p = 1.9$ at the air-contacting surface, inside the layer and at the surface contacting glass "volume" refractive index of $n_0 = 3.1$.

Keywords: Preparation (bonding), Forbidden Band, Refractive Index, Absorption Coefficients, Optical Properties, Transmissivity

10. Galazka, R. R.: Preparation, Doping, and Electrical Properties of $Cd_{0.1}Hg_{0.9}Te$. Acta Physica Polonica, Vol. 24, No.6, 1963, pp. 791-800.

Abstract: The process of preparation and crystallization of $Cd_{0.1}Hg_{0.9}Te$ is discussed. The effect of various technological processes, deviations from stoichiometry (excess Cd, Te and Hg were introduced) and doping with the foreign elements Cu, In, Al, and Ni on the shape of the temperature dependence of the Hall coefficient and electric conductivity between 77° K and 300° K was investigated. In the material under investigation the excess Te atoms probably occupy the sites of Hg atoms yielding donor levels. Hg dopes the semiconductor to p-type. Excess Cd produces no noticeable change. In the group of foreign atoms, Cu yields acceptor levels. Al would seem to introduce neutral centers. A method of determining the composition (the value of x) in $Cd_xHg_{1-x}Te$ crystals by measuring their density is described. The density varies linearly with the composition. Hole mobility was evaluated at $\mu_p = 420$ cm^2/Vsec. Material was obtained wherein the value of the product $R_H \times \sigma$ at 200°K amounted to 4×10^5 cm^2/Vsec. The σ(T) curves were found to reveal characteristic maxima at about 300° C.

Keywords: Preparation (doping, crystallization), Mole Fraction (effects of), Temperature (effects of), Electric Conductivity, X-ray Data, p-type, Crystal Structure, Hall Coefficient

11. Shneider, A. D. and Gavrishchak, I. V.: The Electrical Properties of p-Type Semiconductors of the HgTe-CdTe System. Soviet Physics - Solid State, Vol. 5, No. 4, Oct. 1963, pp. 881-884.

Abstract: The authors have experimentally investigated the electrical conductivity, Hall effect, thermal emf, and transverse and longitudinal Nernst-Ettinghausen effects in p-type specimens with the following compositions: 95% HgTe-5% CdTe, 90% HgTe-10% CdTe, 85% HgTe-15% CdTe, and 75% HgTe-25% CdTe; and hole impurity concentrations of 8×10^{16} to 3×10^{17} cm^{-3} over the temperature range 77 to 420° K. It is shown that the continuous series of solid solutions of the HgTe-CdTe system with compositions close to 90% HgTe-10% CdTe displays peculiarities in the behavior of the electrical properties.

Keywords: II-VI Compounds, Hall Coefficient, Conductivity, Temperature (effect of), Electron Mobility, Fermi Level, Effective Electron Mass, Nernst-Ettinghausen Effect, Thermal EMF, p-Type

12. Chapman, C. M., Moody, J. W., Himes, R. C., and Shilliday, T. S.: Research, Studies, and Investigations of Materials Sensitive to Radiation in the 8 to 14 Micron Region of the Infrared Spectrum. Final Report, 1 Oct. 1962 - 30 Nov. 1963, Battelle Memorial Institute, Contract DA-44-009-ENG-4461, AD-429 997, N64-18 655, 1964.

Abstract: Periodic Group IIB-VIA compounds and alloys were investigated as possible materials for an infrared detector sensitive to radiation in the 8- to 14-micron region of the spectrum. Results indicate that: (1) The HgTe, HgSe, and CdTe are not suitable materials for the detector. (2) The most suitable cells have photoconductive response maxima at 9.9 and at 10.8 microns when cooled to 77° K. Their compositions are approximately 78% HgTe-22% CdTe (mole percent). An estimate of the spectral density of each cell is D^*_λ (9.9, 900, 1) = 10^9 $cm(cps)^{1/2}/watt$ and D^*_λ (10.8, 900, 1) = 10^9 $cm(cps)^{1/2}/watt$. The effective time constants are about 50 microseconds. Also, properties of the HgTe-CdTe alloy applicable to a detector of infrared radiation in the 8- to 14-micron wavelength region, suggestions for the improvement of existing detectors, and recommendations for further work on the alloy system leading to the preparation of optimum HgTe-CdTe detectors are summarized.

Keywords: II-VI Compounds, Spectral Density, Time Constant, Photovoltaic, Photoconduction, Detectivity (D*), n-type, Resistivity, Electron Mobility

13. Kolomiets, B. T. and Mal'kova, A. A.: Spectral Distribution of Absorption and the Photomagnetic Effect in $Cd_xHg_{1-x}Te$ Solid Solutions. Soviet Physics - Solid State, Vol. 5, No. 4, Dec. 1963, pp. 1212-1220.

Abstract: The photomagnetic effect in semiconductors is attracting the attention of many investigators. Of special interest is the study of this effect in materials with a small energy gap and a high carrier mobility. The present paper reports the first results of a study of the composition dependence of the absorption and photomagnetic effect spectra of $Cd_xHg_{1-x}Te$ solid solutions.

Keywords: Photomagnetic, Transmission, Solid Solutions, Photoconduction, Absorption Spectra, Photoelectromagnetic, Mole Fraction (effects of)

14. Blue, M. D.: Optical Absorption in Small Gap Semiconductors: HgTe and HgTe-CdTe. Proceedings of the 7th International Conference on Physics of Semiconductors, Dunod, Paris, 1964.

Abstract: The compound HgTe, and its alloys with CdTe, occupy a unique position among the known semiconducting materials because of their high carrier mobilities and small energy gaps. This work is concerned with measurements of optical absorption in HgTe-rich alloys and comparison of the results with absorption spectra calculated for some possible band structures. Finally we discuss the implications of the absorption spectra in relation to the electrical properties of these compounds.

Keywords: Preparation, Absorption, Absorption Coefficient, Absorption Spectra, Fermi Level, Temperature (effects of), Energy Gap

15. Giriat, W., Dziuba, E. Z., Galazka, R. R., Sosnowski, L., and Zakrzewski, T.: Electrical Properties of the Semiconducting System $Cd_xHg_{1-x}Te$. Proceedings of the 7th International Conference on Physics of Semiconductors, Dunod, Paris, 1964.

Abstract: CdTe and HgTe form a system of mixed crystals $Cd_xHg_{1-x}Te$ presenting semiconducting properties which vary continuously with x. Thus, by appropriately choosing the value of x, a semiconductor with any value of the forbidden energy gap between about zero eV and 1.45 eV can be obtained. A number of papers deals with properties of $Cd_xHg_{1-x}Te$ system. It was reported that for x = 0.00 overlapping of valence and conduction bands occurs. This overlapping for $x < 0.2$ was also reported by Strauss, Harman, Mavroides, Dickey, and Dresselhaus, where it was stated that a transition to semiconducting behavior occurs with increasing cadmium content, probably in the vicinity of x = 0.20. The $Cd_xHg_{1-x}Te$ system present very interesting properties. Harman, Strauss, Dickey, Dresselhaus, Wright, and Mavroides found a mobility of 1.1×10^6 $cm^2/Vsec$ and an effective mass of 0.003 m_0 for x in the range 0.1-0.2. The behavior of this system is strongly dependent on the presence of impurities, which is seen even in the case of x = 1.00 and x = 0.00. In the present paper investigations on the electrical properties of $Cd_xHg_{1-x}Te$ for $x < 0.20$ are given.

Keywords: Conductivity, Temperature (effects of), Magnetic Field (effect of), Energy Gap, Hall Coefficient, Mole Fraction (effects of)

16. Rodot, M., Rodot, H., and Verie, C.: Proprietes Intrinsiques et Defauts de Reseau des Alliages HgTe-CdTe. Proceedings of the 7th International Conference on the Physics of Semiconductors, Dunod, Paris, 1964.

Abstract: Electrical properties of $Hg_{1-x}Cd_xTe$ alloys have been measured. In the intrinsic range, the resistivity is proportional to the temperature. A model including band non-parabolicity and acoustic phonon scattering is in quantitative agreement with the observed temperature variation of electron concentration and mobility. The extrinsic carrier concentration can be varied by controlled annealing of the samples. The analysis of the PTX diagram leads to the conclusion that, besides Frenkel disorder, there exist "complex vacancies" (with displacement of neighboring atoms),

whose ionization energy is much higher than for normal vacancies. An explanation is proposed for the occurrence of high mobilities.

Keywords: Electron Mobility, Temperature (effects of), Hall Mobility, Electron Concentration, Frenkel Disorder, Complex Vacancies, Band Non-Parabolicity, Acoustic Phonon Scattering

17. Ivanov-Omskii, V. I., Kolomiets, B. T., Mal'kova, A. A., Ogorodnikov, V. K., and Smekalova, K. P.: Electron Properties of Single Crystals of p-Type HgTe and Its Solutions with CdTe. Academy of Science USSR, Bulletin, Physics Series, Vol. 28, No. 6, June 1964, pp. 958-964.

Abstract: The electric properties of HgTe and mixed crystals of this compound with CdTe have been investigated by a number of authors, most of whom concluded that HgTe is a semiconductor with a very narrow energy gap (0.02 eV), as evaluated from the temperature dependence of the Hall constant in the range of high temperatures. Recently, however, Strauss, Harman, Mavroides, Dickey, and Dresselhaus reported that HgTe is a semimetal. Analysis of the experimental results obtained in the present work substantiates the semimetallic nature of the conductivity of the HgTe-dominated mixtures with gradual transition to semiconductor conductivity with increase of the CdTe content.

Keywords: Preparation, Temperature (effects of), Conductivity, Hall Coefficient, Electron Mobility, Hole Mobility, Carrier Mobility, Magnetoresistance, Energy Gap, Absorption, Absorption Coefficient

18. Harman, T. C., Kleiner, W. H., Strauss, A. J., Wright, G. B., Mavroides, J. G., Honig, J. M., and Dickey, D. H.: Band Structure of the HgTe and HgTe-CdTe Alloys. Solid State Communications, Vol. 2, No. 10, Sept. 1964, pp. 305-308.

Abstract: The gray tin band model of Groves and Paul, which is extended to include overlap of the valence and conduction bands, is applied to HgTe and $Hg_{1-x}Cd_xTe$ alloys. Theoretical and experimental evidence for the model is presented, and band parameters deduced from experimental data are given.

Keywords: Energy Gap, Block Function, Mole Fraction (effect of), Lattice Parameters, Electron Effective Mass, Carrier Concentration

19. Blue, M. D.: Optical Absorption in HgTe and HgCdTe. Physical Review, Vol. 134, No. 1A, April 6, 1964, pp. A226-A234.

Abstract: Absorption and reflectivity near the fundamental absorption edge have been measured in the HgTe-CdTe alloy series for CdTe concentrations of up to 28%. In the HgTe rich region, the edge shifts to longer wavelengths with decreasing temperature. For HgTe, the absorption rises to 2×10^4 cm^{-1} at a photon energy of 0.6 eV. Absorption did not decrease below 1.4×10^3 cm^{-1} at room temperature. The theory of optical absorption in zinc-blende compounds is reviewed. Absorption in this alloy series agrees with theory for direct transitions with an energy-dependent matrix element evaluated by Kane for InSb. Analysis of reflectivity in HgTe indicates an electron effective mass of 0.02 m_0 at 100° C.

Keywords: Energy Gap, Absorption, Direct Transitions, Indirect Transitions, Absorption Coefficient, Reflection, Matrix Element

20. Ivanov-Omskii, V. I., Kolomiets, B. T., and Mal'kova, A. A.: Optical and Photoelectric Properties of HgTe and Its Alloys with CdTe. Soviet Physics - Solid State, Vol. 6, No. 5, Nov. 1964, pp. 1140-1143.

Abstract: The authors have measured the transmission and reflection of 1- to 25-micrometer waves in $Cd_xHg_{1-x}Te$ at 300 and 150°K. They investigated the photosensitivity of these alloys at different temperatures under conditions of photoconductivity and the photomagnetic effect. They also conclude that in alloys with a high concentration of HgTe the photosensitivity is due to the Nernst photomagnetic effect.

Keywords: Preparation, Absorption Coefficient, Transmission, Absorption, Photoconductivity, Photomagnetic, Mole Fraction (effects of), Thickness (effects of), Frequency Response, Photoelectromagnetic, Nernst-Ettinghausen Effect

21. Lallemand, M., Weill, G., Lacam, A., and Rodot, M.: Mesure des proprietes electroniques jusqu'a 4500 bars d'alliages HgTe-CdTe. Academie des Science Comptes Rendus (Paris), Vol. 260, No. 17, April 26, 1965, pp. 4469-4472.

Abstract: Results are reported of an experimental study of the pressure dependence of the electrical properties of HgTe-CdTe alloys for various values of x.

Keywords: Mobility, Carrier Concentration, Pressure (effects of), Mole Fraction (effects of), Solid Solutions, Hall Coefficient

22. Kruse, P. W.: Photon Effects in $Hg_{1-x}Cd_xTe$. Applied Optics, Vol. 4, No. 6, June 1965, pp. 687-691.

Abstract: Infrared detectors prepared from the alloy semiconductor $Hg_{1-x}Cd_xTe$ exhibit a family of relative response characteristics throughout the 1-micrometer to 14-micrometer spectral interval. Both photoconductive and photovoltaic effects are observed. The relative spectral responses shift to longer wavelengths with decreasing temperature. Photoconductive response time measurements at 77°K reveal values no greater than 10^{-7} sec. Detectors are limited by either thermal noise or current (1/f) noise, depending upon measurement frequency and magnitude of bias current.

Keywords: Preparation, Photoconduction, Photovoltaic, Spectral Response, Frequency Response, Noise Spectrum, Refractive Index.

23. Verie, C. and Granger, R.: Proprietes de Jonctions p-n d'alliages $Cd_xHg_{1-x}Te$. Academie des Science Comptes Rendus (Paris), Vol. 261, No. 6, Oct, 27, 1965, pp. 3349-3352.

Abstract: Experimental results are reported on the preparation of p-n junctions in $Cd_{0.35}Hg_{0.65}Te$. Such junctions are important for photovoltaic detectors and infrared injection lasers.

Keywords: Current-Voltage Characteristics, Recombination Parameters, Preparation, Response, Photovoltaic, Photoconduction, p-n Junction, Absorption, Photoluminescence, Recombination Radiation

24. Mali, M.: Electron Effective Masses in Heavily Doped n-Type $Cd_xHg_{1-x}Te$, Physica Status Solidi, Vol. 13, No. 1, Jan. 1966, pp. 215-217.

Abstract: Electron effective masses (m*) for n-type $Cd_xHg_{1-x}Te$ with $x < 0.2$ and a free electron concentration N in the range 1.25 to 1.4×10^{18} cm^{-3} are obtained from measurements of thermoelectric power as a function of magnetic field. The values of m* can be explained on the basis of the energy band model of Groves and Paul with parameters $P = 8 \times 10^{-8}$ eV-cm and $|E_0| \leq 0.19$ eV.

Keywords: Energy Gap, Fermi Level, Conductivity, Thermo-Electric Power, Electron Effective Mass, n-Type, Electron Concentration, Hall Coefficient, Magnetic Field (effects of), Matrix Element.

25. Melngailis, I. and Strauss, A. J.: Spontaneous and Coherent Photoluminescence in $Cd_xHg_{1-x}Te$. Applied Physics Letters, Vol. 8, No. 7, April 1, 1966, pp. 179-180.

Abstract: In this letter the authors report the observation of spontaneous emission at wavelengths from 3 to 15 micrometers and laser emission at 3.8 and 4.1 micrometers from $Cd_xHg_{1-x}Te$ crystals excited optically by the radiation from a GaAs diode laser. Spontaneous injection luminescence from p-n junctions has recently been observed for $Cd_{0.35}Hg_{0.65}Te$ at 3.7 micrometers and for CdTe at about 0.85 micrometer, and laser action has been reported at 0.78 micrometer in CdTe excited by fast electrons. Their results strongly suggest that it will be possible to make $Cd_xHg_{1-x}Te$ for the efficient generation of infrared radiation at wavelengths appreciably beyond 8.5 micrometers, the maximum so far obtained from unstressed semiconductor lasers. In addition, the photoluminescence studies are of interest because they should assist in elucidating the band structure

of the $Cd_xHg_{1-x}Te$ alloys, particularly in the vicinity of the semimetal-to-semiconductor transition which occurs near x = 0.2.

Keywords: Spontaneous Emission, Laser Emission, Band Structure, Photoluminescence, Recombination Radiation

26. Ludeke, R. and Paul, W.: Optical Properties of Epitaxial Films of $Cd_xHg_{1-x}Te$. Journal of Applied Physics, Vol. 37, No. 9, Aug. 1966, pp. 3499-3501.

Abstract: Epitaxial crystal films of alloys of CdTe and HgTe and BaF_2 substrates have been produced by a flash-evaporation technique. The energies of several interband electronic transitions have been measured and found to vary linearly with composition. Arguments are presented that this method produces single-crystal alloy films of accurately predetermined composition.

Keywords: Preparation, Epitaxial, Absorption, Mole Fraction (effects of), Transmission, Reflection, Lattice Parameters

27. Weill, G. and Verie, C.: Deformation sous l'effet de la pression, de la structure de band des alliages HgTe-CdTe. Academie des Science Comptes Rendus (Paris), Vol. 263, No. 6, Aug. 8, 1966, pp. 463-465.

Abstract: Experimental results are presented of a study of the deformation of the band structure in $Hg_{1-x}Cd_xTe$ as a function of pressure. The coefficient of pressure for the energy gap is found to be $12 \pm 2 \times 10^{-6}$ eV/bar.

Keywords: Carrier Concentration, Mobility, Pressure (effects of), Hall Coefficient, Band Structure

28. Verie, C.: Sur la Structure de Bandes de Alliages HgTe-CdTe. Physica Status Solidi, Vol. 17, No. 2, Oct. 1966, pp. 889-901.

Abstract: Electrical measurements are made on the intrinsic alloys $Cd_xHg_{1-x}Te$ for x = 0 to 0.30. A simple statistical treatment of carrier distribution functions is developed which describes the temperature dependence of the electrical properties of a solid

with zincblende structure as it changes from an intrinsic semimetal to a small gap semiconductor. The results of the calculations, which also yield a simple criterion for distinguishing semimetals with slightly overlapping bands from semiconductors with very small gaps, account for the observations on the three sequences of the alloys $Cd_xHg_{1-x}Te$ with composition ranges from x = 0 to 0.10, x = 0.10 to 0.20, and $x \geq 0.20$.

Keywords: Mole Fraction (effects of), Energy Gap, Carrier Concentration, Hall Coefficient, Band Structure

29. Flynn, J. B. and Schlickman, J. J.: Room Temperature Lorentz Field Induced Recombination in InSb and $Cd_xHg_{1-x}Te$. Proc. IEEE, Vol. 54, No. 11, Nov. 1966, pp. 1597-1598.

Abstract: Recombination radiation, induced in a semiconductor by means of a self-generated magnetic field in association with an orthogonal electric field has been reported by several authors. The authors wish to report observation of room temperature recombination radiation induced by a Lorentz field in indium antimonide and a ternary alloy of mercury, cadmium, and tellurium under crossed-field conditions.

Keywords: Response, Spectral Response, Lorentz Field, Recombination Radiation

30. Almasi, G. S.: Photovoltaic Effects in Cadmium Telluride - Mercury Telluride Heterostructures. Massachusetts Institute of Technology (Grant NsG-496), NASA CR-81144; SR-2, N67-15278, Nov. 1, 1966.

Abstract: Measurements made on photovoltaic devices by the interdiffusion of CdTe and HgTe are reported. It is found that the devices display rectification and possess a spectral response which decreases exponentially with decreasing energy from a maximum at the energy corresponding to the CdTe bandgap. The theoretical model developed to account for this behavior involves a sandwich of constant energy gap material and graded gap material, with a p-n junction in the constant-gap material immediately adjacent to the graded region. The exponent of the spectral

response is then found to reflect the band-edge variation of the carrier species being collected by the junction. Because the spectral bandwith is so narrow, these devices offer no improvement over present photovoltaic energy converters. To improve their performance as photodetectors, a more precise control of the equilibrium carrier concentrations must be developed.

Keywords: Photovoltaic, Spectral Response, Energy Gap, Graded Gap, p-n Junction, Carrier Concentration, Current-Voltage Characteristics, Frequency Response

31. Galazka, R. R. and Sosnowski, L.: Conduction Band Structure of $Cd_{0.1}Hg_{0.9}Te$. Physica Status Solidi, Vol. 20, No. 1, March 1967, pp. 113-120.

Abstract: The Hall coefficient R_H and the conductivity σ are measured in the temperature range 4.2 to 300°K. The thermoelectric power α as a function of the magnetic field and temperature are measured in the range 100 to 300°K. The value of the effective mass m* is calculated from these measurements for electron concentrations from 6.25×10^{16} to 2.71×10^{18} cm^{-3}. The dependence of the effective mass m* on k is interpreted according to Kane's model of the conduction band structure. The best agreement is obtained for values of the parameters $E_0 = -0.00$ eV and the coupling constant Q = 12 eV, that is for a linear E vs k dependence. The mobility of the electrons as a function of concentration and temperature is also analyzed. For temperatures below 77°K impurity scattering is dominant. Within the temperature range 77 to 300°K the best agreement between theory and experiment is obtained for mixed ionic and optical phonon scattering.

Keywords: Conductivity, Preparation, Thermoelectric Power, Electron Effective Mass, Mobility, Hall Coefficient, Ionized Impurity Scattering, Optical Phonon Scattering

32. Verie, C. and Ayas, J.: $Cd_xHg_{1-x}Te$ Infrared Photovoltaic Detectors. Applied Physics Letters, Vol. 10, No. 9, May 1, 1967, pp. 241-243.

Abstract: Using departure from stoichiometry for doping, p-n junctions were prepared from $Cd_xHg_{1-x}Te$ alloys with $0.15 < x \leq 0.28$, and their current-voltage characteristics were measured at 77°K. The spectral study of these photovoltaic detectors operating at 77°K showed responses from 3 micrometers up to 17.5 micrometers. Detectivity measurements at the wavelengths of maximum response of these detectors yielded values at 77°K between 1 and 5×10^9 cm-W^{-1}-$Hz^{1/2}$ in the range 3 to 14-micrometers. The speed of these detectors was measured to be < 50 nsec, which was also confirmed by the observation of mode beats on the continuous output of a low-power CO_2 laser at several frequencies up to 25 MHz.

Keywords: Current-Voltage Characteristics, Photovoltaic, Energy Gap, Temperature (effects of), p-n Junctions, Frequency Response, Spectral Response

33. Kraus, H., Parker, S. G., and Smith, J. P.: $Cd_xHg_{1-x}Te$ Films. Journal of the Electrochemical Society, Vol. 114, No. 6, June 1967, pp. 616-619.

Abstract: Films of $Cd_xHg_{1-x}Te$ ranging from x = 0.05 to x = 0.15 were deposited by cathodic sputtering on single crystal substrates of NaCl, Ge, and sapphire. The resulting films were amorphous, but became crystalline on annealing. Optical transmission and electron probe analysis showed a slightly lower Hg concentration in the film than was present in the source material. Although CdTe can be sputtered to give a polycrystalline film, it was not possible to obtain a film by sputtering HgTe.

Keywords: Preparation, Absorption Edge, Response, Optical Properties, Mole Fraction (effects of), Crystal Structure, Polycrystalline Film, Transmission, Electron Probe Analysis

34. Ray, B. and Spencer, P. M.: Phase Diagram of the Alloy System HgTe-CdTe. Physica Status Solidi, Vol. 22, No. 2, Aug. 1967, pp. 371-372.

Abstract: The solidus and liquidus for the pseudo-binary alloy system HgTe-CdTe has been determined with differential thermal analysis and X-ray techniques. Solid solution exists throughout the system. The liquidus deviates slightly from the linear but the solidus rises very slowly with increasing CdTe concentration to approximately 40 mol%. At higher concentrations the increase is more rapid.

Keywords: Preparation, Temperature-Composition Equilibrium, Pressure (effects of), X-ray Data, Solid Solutions, Phase Diagram

35. Ayache, J. and Marfaing, Y.: Rendement quantique de l'effet photoelectrique interne de l'alliage $Cd_{0.23}Hg_{0.77}Te$. Academie des Science Comptes Rendus (Paris), Vol. 265, Aug. 7, 1967, pp. 363-366.

Abstract: This paper presents an analysis of the variation of the quantum efficiency of the internal photoelectric effect as a function of the energy of absorbed photons. It presents experimental results and provides an interpretation of those results with an extension of the theory for InSb.

Keywords: Internal Photoelectric Effect, Photoconduction, Photomagnetic, Photoelectromagnetic, Spectral Response, Energy Gap, Reflection, Absorption, Quantum Efficiency

36. Ayache, J. and Marfaing, Y.: Determination de la Durie de Vie et du Mecanisme de Recombinaison dans l'Alliage $Cd_{0.23}Hg_{0.77}Te$ de Type N. Academie des Science Comptes Rendus (Paris), Vol. 256, No. 9, Aug. 28, 1967, pp. 568-571.

Abstract: This paper presents an analysis and experimental results of a study of recombination mechanisms in n-type mercury cadmium telluride.

Keywords: n-Type, Recombination, Mobility, Electron Mobility, Absorption Coefficient, Diffusion Length, Solid Solutions, Ambipolar Diffusion

37. Long, D.: Generation-Recombination Noise Limited Detectivities of Impurity and Intrinsic Photoconductive 8-14μ Infrared Detectors. Infrared Physics, Vol. 7, No. 3, Sept. 1967, pp. 121-128.

Abstract: An analysis has been made of the dependences of the detectivities (D*) of impurity and intrinsic photoconductive 8-14 micrometer infrared detectors on temperature for the situation in which only the bulk generation-recombination noise is important; this case determines the upper limit to the detectivity of a background noise limited detector attainable by narrowing the field of view from the usual 180° to approach 0°. Hg-doped Ge and $Hg_{0.8}Cd_{0.2}Te$ are considered as examples of impurity and intrinsic photoconductors, respectively, and it is found that for realistic optimum values of material parameters one can achieve a given D* at a higher operating temperature with the intrinsic photoconductor than with the impurity photoconductor, up to a certain D* level.

Keywords: Photoconductivity, Noise Voltage, Hole Concentration, Carrier Concentration, Temperature (effects of), Detectivity (D*), Generation-Recombination Noise

38. Long, D.: On Generation-Recombination Noise in Infrared Detector Materials. Infrared Physics, Vol. 7, No. 3, Sept. 1967, pp. 169-170.

Abstract: In attempting to improve the properties of a photoconductive infrared detector material toward the achievement of photon noise limited performance, one must take into account, among other factors, the generation-recombination (gr) noise in the semiconductor material and how it depends upon materials parameters. It is shown that the expression for gr noise in extrinsic photoconductors must be modified before it can be applied to intrinsic photoconductors.

Keywords: Noise Voltage, Generation-Recombination Noise, Intrinsic Photoconduction, Extrinsic Semiconductor

39. Galzaka, R. R. and Zakrzewski, T.: Heavy Hole Effective Mass of $Cd_{0.1}Hg_{0.9}Te$. Physica Status Solidi, Vol. 23, No. 1, Sept. 1967, pp. K39-K43.

Abstract: In the present work p-type $Cd_{0.1}Hg_{0.9}Te$ samples were investigated. The sample had been prepared by doping with Cu. R_H and σ were measured within the temperature range 4.2 to 300°K while the thermoelectric power was measured within the temperature interval 100 to 300°K.

Keywords: Conductivity, Thermoelectric Power, Temperature (effects of), p-Type, Hall Coefficient

40. Verie, C.: Electronic Properties of $Cd_xHg_{1-x}Te$ Alloys in the Vicinity of the Semi-metal - Semiconductor Transition. International Conference on II-VI Semiconducting Compounds, Brown University 1967, ed. D. G. Thomas; W. A. Benjamin Inc., New York, 1967.

Abstract: We present a summary of the results that we obtained on $Cd_xHg_{1-x}Te$ alloys ($0 < x < 0.30$), using systematic measurements, as a function of x, of temperature dependence of intrinsic carrier concentrations and mobilities, intraband reflectivity, optical absorption, opto-electronic effects in p-n junctions and electrical measurements under hydrostatic pressure. The investigations of the electronic properties led to a quantitative characterization of the semimetal - semiconductor transition (SM - SC). As an illustration, photovoltaic studies on p-n junctions show an extension of the intrinsic infrared detection in semiconductors to 25 micrometers. All these data establish the validity of a band model which is a combination of the models of InSb (Kane) and α-Sn (Groves and Paul), with a particular temperature dependence of the band parameters.

Keywords: Recombination Parameters, Carrier Concentration, Electron Effective Mass, Hall Coefficient, Semimetal - Semiconductor Transition, p-n Junctions, Optical Properties, Photovoltaic, Mobility

41. Cohen-Solal, G., Marfaing, Y., and Kamadjiev, P.: Photoelectric Properties of $Cd_xHg_{1-x}Te$ Graded Gap Structures. International Conference on II-VI Semiconducting Compounds, Brown University 1967, ed. D. G. Thomas; W. A. Benjamin Inc., New York, 1967.

Abstract: Photoconductive and photoelectromagnetic effects have been observed at 77°K and 300°K in p-type $Cd_xHg_{1-x}Te$ graded-gap structures prepared by the EDRI method. A theoretical model has been developed, taking into account the internal electric fields due to the gradients of gap, effective mass, lifetime, and doping level. Experimental results show that the structures behave like pseudo-homogeneous materials in which the motion of excess carriers is due to a diffusion process, the effect of the graded gap being cancelled out by the other gradients.

Keywords: Graded Gap, Band Gap, Spectral Response, Photoconduction, Photoelectromagnetic, Mobility, Electron Lifetime, Absorption, Photomagnetic, p-Type

42. Giriat, W.: Quantum Oscillation in $Cd_xHg_{1-x}Te$. International Conference on II-VI Semiconducting Compounds, Brown University 1967, ed. D. G. Thomas; W. A. Benjamin Inc., New York, 1967.

Abstract: This paper reports the results of a study of the Shubnikov-de Haas effect in $Cd_xHg_{1-x}Te$ ($x = 0.15$). The measurements were performed at 4.2° and 1.2°K in magnetic fields up to 80 kG. Very clearly pronounced oscillations were observed, which were periodic in 1/H, and the period of oscillation was in good agreement with the Hall effect data.

Keywords: Magnetoresistance, Oscillations, Electron Effective Mass, Magnetic Fields (effects of), Matrix Element, Temperature (effects of), Fermi Level, Shubnikov-de Haas Effect

43. Sosnowski, L. and Galazka, R. R.: Band Structure of $Cd_xHg_{1-x}Te$ Mixed Crystals. International Conference on II-VI Semiconducting Compounds, Brown University 1967, ed. D. G. Thomas; W. A. Benjamin Inc., New York, 1967.

Abstract: In the last few years considerable evidence has accumulated on the band structure of HgTe. On the other hand CdTe has a standard band structure with $E_0 = 1.5$ eV at 300°K. In order to find out these structures experimentally, investigations of effective

mass for n-type materials of composition range x = 0 to 30% CdTe in HgCdTe have been carried out.

Keywords: Energy Gap, Band Structure, Mole Fraction (effects of), Electron Effective Mass, Carrier Concentration, Thermoelectric Power, Magnetic Field (effects of), n-Type

44. McElroy, J. H.: DC-Biased Photoconductive Detection of Wideband Carbon Dioxide Laser Signals. NASA TM X-524-68-54, Goddard Space Flight Center, Greenbelt, Maryland, Feb. 1968.

Abstract: The application of dc-biased photoconductive detectors to the reception of wideband CO_2 signals is described. Signal-to-noise power ratios in the detection of AM, PM, and FM by photomixing are derived and the frequency dependence of both signal and noise is examined. Expressions are given for the maximum tolerable mechanical vibration amplitude in a photomixing system and for the beam alignment requirements. Local oscillator power requirements are also investigated. Recommendations are made for mixer elements, HgCdTe being one.

Keywords: Bandwidth, CO_2 Laser, Signal to Noise Ratio, Generation-Recombination Noise, Johnson Noise, Low-Frequency Noise, Thermal Noise, Bias, Carrier Mobility, Quantum Efficiency, Carrier Lifetime, Heterodyne Detection, Photoconductivity, DC-Biased Photoconductor

45. Smollett, M.: The Properties and Performance of Some Modern Infrared Radiation Detectors. Infrared Physics, Vol. 8, No. 1, March 1968, pp. 3-7.

Abstract: Many new types of solid state infrared detectors have become available in the last few years. The properties and performance of some of the most important and widely used detectors are described.

Keywords: Detectivity (D*), Time Constant, Resistivity, Mobility, Carrier Concentration

46. Verie, C. and Martinez, G.: Transition semi-metal - semiconducteur induite par une pression hydrostatique dans $Cd_{0.11}Hg_{0.89}Te$. Academie des Science Comptes Rendus, (Paris) Vol. 266, No. 11, March 11, 1968, pp. 720-723.

Abstract: In this paper, theory and experiment results for the effect of pressure on $Cd_{0.11}Hg_{0.89}Te$ are given.

Keywords: Band Gap, Pressure (effects of), Mole Fraction (effects of), Photovoltaic, Semimetal - Semiconductor Transition

47. McAvoy, N., Richard, H. L., McElroy, J. H., and Richards, W. E.: 10.6-Micron Laser Communications System Experiment for ATS-F and ATS-G. NASA TM X-524-68-206, Goddard Space Flight Center, Greenbelt, Maryland, May 1968.

Abstract: This report describes a heterodyne communication system experiment to be flown on ATS-F and ATS-G. One of the components of that system is a mercury cadmium telluride photodetector. The temperature dependence of its performance is discussed.

Keywords: Signal-to-Noise Ratio, Detectivity (D*), Temperature (effects of), CO_2 Laser, Bandwidth

48. Lashkarev, V. E.: A^{II} B^{VI} Semiconducting Compounds. Soviet Physics - Semiconductors, Vol. 1, No. 11, May 1, 1968, pp. 1372-1374.

Abstract: Interest in II-VI semiconductors (which are compounds of Zn, Cd, and Hg with S, Se, and Te), investigated intensively during the last 10-15 years, continues to increase. This is due to the remarkable properties of these compounds, the chief of which is their high sensitivity to a wide range of electromagnetic radiations from γ rays to infrared radiation, as well as to corpuscular ionizing radiations.

Keywords: II-VI Compounds, Forbidden Band, Crystal Structure, Carrier Mobility, Luminescence

49. Schmitt, J. L. and Speerschneider, C. J.: Phase Diagram of $Hg_{1-x}Cd_xTe$. Infrared Physics, Vol. 8, No. 3, Oct. 1968, pp. 247-253.

Abstract: The $Hg_{1-x}Cd_xTe$ (T, x) phase diagrams of T. C. Harman and A. J. Strauss and of B. Ray and P. M. Spencer are examined. The apparent discrepancy between them is resolved by presenting a (P, T) phase diagram for $Hg_{0.8}Cd_{0.2}Te$ and showing that each (T, x) curve can be fitted at x = 0.2 by appropriate choices by P_{Hg}. Segregation coefficient data are presented which help identify the more practical (T, x) curves.

Keywords: Phase Diagram, Temperature-Composition Equilibrium, Segregation Coefficient, Pressure (effects of), Temperature (effects of), Mole Fraction (control of)

50. Packard, R. D.: Mercury Cadmium Telluride as a 1 to 20-Micrometer Wavelength Infrared Detector for Space Applications. NASA TN D-4904, Nov. 1968.

Abstract: Mercury cadmium telluride (HgCdTe) offers attractive possibilities for fast, elevated-operating-temperature infrared detection from 1- to 20-micrometer wavelengths, particularly in the 8- to 14-micrometer wavelength region for which it was developed. HgCdTe is considered for use in satellites for terrestrial, atmospheric and ocean mapping; infrared astronomy, and optical communications. Its chemical stability in the space environment is open to some question; however, experimental data so far accumulated at NASA-ERC indicate that it is marginally adequate for such purposes. Some attention is given to the possibility of operation using (passive) space radiative cooling; this would eliminate the need for cryogens and provide a much longer operating lifetime as well as reductions in size and weight of the detector system.

Keywords: Entropies, Heats of Formation, Heats of Decomposition, Pressure (effects of), Temperature (effects of), Thermal Noise, Generation-Recombination Noise, Space Environment (effect of)

51. McElroy, J. H., McAvoy, N., Richard, H. L., Richards, W. E., and Flagiello, S. C.: An Advanced 10.6-Micron Laser Communication Experiment. NASA TM X-524-68-478, Nov. 1968.

Abstract: Required developments are examined for carbon dioxide laser intersatellite communication systems to meet NASA requirements for the period of the mid-1970's. Mercury cadmium telluride is one of the materials proposed for the infrared mixer and requirements in sensitivity and frequency response are analyzed.

Keywor 's: CO_2 Laser, Signal-to-Noise Ratio, Detectivity (D*), Temperature (effects of), Frequency Response

52. Foss, N. A.: Formation of $Hg_{1-x}Cd_xTe$ by Hg Ion Bombardment of CdTe Single Crystals. Journal of Applied Physics, Vol. 39, No. 13, Dec. 1968, pp. 6029-6031.

Abstract: Layers of $Hg_{1-x}Cd_xTe$ have been formed by Hg^+ ion bombardment of intrinsic CdTe single crystals. Spectral photoresponse measurements indicate a variation in x through the thickness of the $Hg_{1-x}Cd_xTe$ ranging from $x \simeq 0.2$, at the surface, to $x = 1$ corresponding to a bandgap of 0.12 and 1.5 eV, respectively. The material has a conductivity of typically 10^{-5} $(ohm\text{-}cm)^{-1}$ at 77°K and a 2 micrometer thickness in the region where $x \leq 0.3$.

Keyword: Preparation, Response, Photoconductivity, Conductivity, Mole Fraction (control of)

53. Long, D.: Calculation of Ionized-Impurity Scattering Mobility of Electrons in $Hg_{1-x}Cd_xTe$. Physical Review, Vol. 176, No. 3, Dec. 15, 1968, pp. 923-927.

Abstract: A study is made of the magnitude of the ionized-imputity scattering mobility of conduction electrons in n-type $Hg_{1-x}Cd_xTe$ at 4.2°K, covering the alloy composition range $0<x<0.3$. Calculations of the mobility have been made, assuming the Born approximation for scattering by singly ionized donors in degenerate material having a nonparabolic conduction band. They account well for available mobility data.

Keyword: Energy Gap, Carrier Mobility, Hall Mobility, n-Type, Ionized-Impurity Scattering, Mobility, Born Approximation

54. Dzuiba, E. Z.: Preparation of $Cd_xHg_{1-x}Te$ Crystals by the Vertical-Zone Melting Method. Journal of the Electrochemical Society, Vol. 116, No. 1, Jan. 1969, pp. 104-106.

Abstract: The solid solution system $Cd_xHg_{1-x}Te$ has become in recent years an object of intensive scientific research because of its interesting electrical and optical properties and because of theoretical considerations, such as the theory of its energy band structure. This paper gives results on the preparation of homogeneous $Cd_xHg_{1-x}Te$ crystals.

Keywords: Preparation, Solid Solutions, Homogenous Crystals, Temperature-Composition Equilibrium, Crystal Structure, Mole Fraction (control of)

55. Zitter, R. N.: Saturated Optical Absorption Through Band Filling in Semiconductors. Applied Physics Letters, Vol. 14, No. 2, Jan. 15, 1969, pp. 73-74.

Abstract: If a monochromatic light beam absorbed by a semiconductor generates enough carriers to fill band states up to and including those of the optical transition, the optical absorption will be saturated and a condition of transparency should result. Analysis shows that in this regime the absorption coefficient varies inversely with light intensity.

Keywords: Absorption Coefficient, Occupation Probabilities, Absorption, CO_2 Laser, Carrier Concentration, Saturated Absorption, Saturation

56. Mocker, H. W.: A 10.6 μ Optical Heterodyne Communication System. Applied Optics, Vol. 8, No. 3, March 1969, pp. 667-684.

Abstract: A 10.6-μm optical heterodyne communication system is described that uses two stable single-mode and single-frequency CO_2 lasers of high frequency stability. Wavelength control on both lasers allows the use of one and the same transition of the rotation-vibration band of CO_2 around 10.6μm. The system has a bandwidth of 1 MHz, and simultaneous operation in baseband and on a 50-kHz carrier has been achieved.

Heterodyne detection with mercury cadmium telluride detectors yielded signal-to-noise ratios within 3 dB of the coherent photon noise limit.

Keywords: CO_2 Laser, Heterodyne Detection, Signal-to-Noise Ratio, Frequency Response, Bias, Bandwidth, Transit Time

57. McElroy, J. H., Cohen, S. C., and Walker, H. E.: First Summary Design Report, ATS-F Laser Communication Experiment, Infrared Mixer and Radiation Cooler Subsystem. NASA TM X-524-69-227, Goddard Space Flight Center, Greenbelt, Maryland, April 1969.

Abstract: Mercury cadmium telluride is analyzed for use as an infrared mixer material for a heterodyne communication system to be flown on the ATS-F satellite. The effect of varying temperature on mixer performance is analyzed.

Keywords: DC-Biased Photoconductor, Gain, Bias, Thermal Noise, Generation-Recombination Noise, Signal-to-Noise Ratio, Energy Gap, Electron Effective Mass, Hole Effective Mass, Conductivity, Temperature (effects of), CO_2 Laser, Heterodyne Detection, Carrier Lifetime, Response Time

58. Bartlett, B. E., Charlton, D. E., Dunn, W. E., Ellen, P. C., Jenner, M. D., and Jervis, M. H.: Background Limited Photoconductive HgCdTe Detectors for use in the 8-14 Micron Atmospheric Window. Infrared Physics, Vol. 9, No. 1, May 1969, pp. 35-36.

Abstract: This letter describes the achievement of background limited performance in HgCdTe photoconductive detectors operating at 77°K.

Keywords: Resistivity, Responsivity, Noise Equivalent Resistance, Response Time, Detectivity (D*), Noise Spectrum

59. Wiley, J. D. and Dexter, R. N.: Helicons and Nonresonant Cyclotron Absorption in Semiconductors. Physical Review, Vol. 181, No. 3, May 15, 1969, pp. 1181-1190.

Abstract: We have used microwave helicons of 23 and 70 GHz and nonresonant cyclotron absorption to measure the carrier densities, effective masses, and mobilities of electrons in $Hg_{1-x}Cd_xTe$ for $0.135 \leq x \leq 0.203$. Most measurements were made at 77°K, but some values are reported for 1.3°K. Carrier concentrations at 77°K ranged from 8×10^{20} to $2 \times 10^{22} m^{-3}$ and were sufficiently low to enable us to measure m* close to the conduction band edge. The mass values, in the range $0.004m_0$-$0.010m_0$, are in good agreement with values calculated from Kane's expression for the conduction band using literature values for the energy gap, its variation with temperature and alloy concentration, and the momentum matrix element, P. One specimen with x = 0.149 was studied from 77 to 185°K. Over this range the mobility was closely proportional to T^{-2}. The variation of electron density permitted an estimate of the effective mass of the holes, $m_h^* = 0.71m_0$.

Keywords: Energy Gap, Matrix Element, Electron Effective Mass, Carrier Concentration, Mobility, Hole Effective Mass, Helicons, Nonresonant Cyclotron Absorption, Band Structure

3. ALPHABETICAL LISTING OF AUTHORS

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