

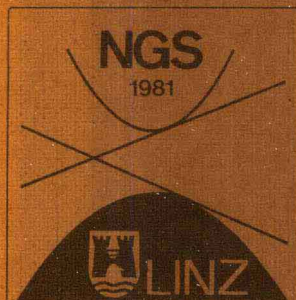
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Edited by J. Ehlers, München, K. Hepp, Zürich
R. Kippenhahn, München, H. A. Weidenmüller, Heidelberg
and J. Zittartz, Köln

152

Physics of Narrow Gap Semiconductors

Proceedings, Linz, Austria 1981



Edited by E. Gornik, H. Heinrich, and L. Palmetshofer



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Proceedings of the
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Physics of Narrow Gap Semiconductors
Held at Linz, Austria, September 14–17, 1981

Edited by E. Gornik, H. Heinrich, and L. Palmetshofer



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GENERAL INFORMATION

The Linz Conference on the Physics of Narrow Gap Semiconductors was organized by members of the Institut für Experimentalphysik of the Johannes Kepler University at Linz in Austria. The conference was sponsored by the International Union of Pure and Applied Physics, the European Physical Society and the Austrian Physical Society. Substantial financial support came from:

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I B M

FOREWORD

This volume contains the proceedings of the 4th International Conference on the Physics of Narrow Gap Semiconductors, which took place at the University of Linz from September 14 - 17, 1981. The series of conferences started in Dallas 1970 and was continued at Nice and Warsaw with intervals of about four years. Two Conferences on IV-VI compounds, 1968 in Giv-sur-Yvette and 1972 in Philadelphia, and a summer school in Nimes 1979 should be counted to this series of topical conferences showing the continuous development of this field.

This conference brought together about 180 scientists from 22 countries. The comparatively large number reflects the interest of the international scientific community in Narrow Gap Semiconductors, which appears to be still increasing today. The field has reached a certain point of maturity with respect to basic research. The program committee emphasized therefore topics of applied research by including more papers on crystal growth and device technology. A whole panel discussion was devoted to recent progress in material technology.

Highlights of this conference were the demonstration of nonlinear optical effects induced by multiwatt laser radiation and the fabrication of multilayer heterostructures produced by molecular beam epitaxy with narrow gap materials.

We hope that this conference elucidated existing problems in the field of Narrow Gap Semiconductors, stimulated further research and established personal contacts among the scientists on an international level.

E.Gornik

H.Heinrich

L.Palmetzhofer

M. Lannoo, J. Bourgoin

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C O N T E N T S

1. OPENING SESSION

Narrow Gap Semiconductors - The State of the Art	
W. Zawadzki	1

2. CRYSTAL GROWTH AND NEW MATERIALS

Growth of Some Important Narrow Gap Semiconductors	
A. Lopez-Otero	17
Electrical Transport and Magnetic Properties of MAS_3 ($\text{M}=\text{Ca}, \text{Sr}, \text{Eu}, \text{Ba}$), α - and β - EuP_3 and Their Alloys	
W. Bauhofer, M. Wittmann, W. Gmelin, H.G.v. Schnering	30
$\text{Tm}_{1-x}\text{Eu}_x\text{Se}$: New Narrow Gap Magnetic Semiconductors	
H. Boppart, P. Wachter	35
Electronic Properties of $\text{K}_x\text{Rb}_{1-x}\text{Au}$, an Indirect Small Gap Semiconductor	
F. Meloni, A. Baldereschi	43
Growth of Sb_2Te_3 Single Crystals by Hot-Wall-Epitaxy	
A. Krost, P. Grosse	49
THM Growth of PbTe	
R. Triboulet, G. Didier, A. Lasbley, F. Morales, B. Toulouse, C.M. Pelletier, R. Granger, S. Rolland	54
Misfit Strain in Epitaxial IV-VI Semiconductor Films	
E.J. Fantner, B. Ortner, W. Ruhs, A. Lopez-Otero	59
Structure Defects in $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ Solid Solution Hetero-compositions	
E.P. Bochkarev, V.M. Lakeenkov, M.I. Nikolaev, O.V. Pelevin	64
Influence of Impurity Doping on the Electrical Properties of LPE Grown $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ and $\text{PbSe}_{1-y}\text{Te}_y$	
Z. Feit, A. Zemel, D. Eger, I. Sternberg	69
Plasma Reflection Spectrum of the $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ Inhomogeneous Layers and Vapour Transport Process of $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$	
Yuan Shi-xin, Leng Jing, Yang Yong-nian, Xie Qin-xi, 19-lai, Si Sheng-lai, Yu Mei-fang	74
Molecular Beam Epitaxy of CdTe and $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$	
J.P. Faurie, A. Million	79

The Investigation of the Second Phase in $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ Crystals Song Bing-wen, He Jing-fu, Ren Wan-xing, Tang Jia-tian	82
Structural and Electrical Properties of As-Grown $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$ Epitaxial Layers Deposited by Cathodic Sputtering R. Roussille, R. Boch, M. Dupuy, G. Rolland	86
3. TWO-DIMENSIONAL SYSTEMS	
Interfacial Energy Bands for Narrow Gap Semiconductors F. Koch	92
2D-Subbands in III-V and Narrow Gap Semiconductors Y. Takada, K. Arai, Y. Uemura	101
4. OPTICS	
Giant Nonlinearities, Optical Bistability and the Optical Transistor in Narrow Gap Semiconductors S.D. Smith	113
Pulse Width Dependent Nonlinear Absorption in Small Gap Semiconductors C.R. Pidgeon, A.M. Johnston, I. Dempsey	123
Photo-Hall Measurements of High-Density Photoexcited Electrons in $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ F.J. Bartoli, C.A. Hoffman, J.R. Meyer, R.E. Allen	126
The Photoluminescence Study of $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$ Alloys B.L. Gelmont, V.I. Ivanov-Omskii, V.A. Maltseve, V.A. Smirnov	131
Plasmon-Assisted Recombination in Narrow Gap Semiconductors in a Magnetic Field P.A. Wolff, C. Verie, S.Y. Yuen, M.H. Weiler, L.R. Ram-Mohan	135
Calculation of the Auger Lifetime in Degenerate n-Type (Hg,Cd)Te T.N. Casselman	147
Excess Carrier Lifetime in $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ by Population Modulation Spectroscopy D.L. Polla, R.L. Aggarwal, J.A. Mroczkowski, J.F. Shanley, M.B. Reine	152
Laser Threshold and Recombination in $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ and $\text{PbS}_{1-x}\text{Se}_x$ D. Genzow, K.H. Herrmann, T.X. Hoai, M. Mockler, O. Ziep	158

Optical Studies of a High Density Electron-Hole Plasma in PbTe	
B.D. Schwartz, C.A. Huber, A.V. Nurmikko	163
Far Infrared Optical Properties of Cd_3P_2 and Cd_3As_2	
M.J. Gelten, C.M. van Es	167
A New Broadband Near-Millimeter Wave Detector Using Mercury-Cadmium-Telluride	
B.A. Weber, S.M. Kulpa	172

5. MAGNETO-OPTICS

Non-Linear Magneto-Optics in InSb Pumped by a c.w. Co Laser	
H.A. Mac Kenzie, R.B. Dennis, D.D.W. Voge, W.-L. Wang, S.D. Smith	178
Far Infrared Studies of the Bound and Free Carriers in n-InSb as a Function of Hydrostatic Pressure	
Z. Wasilewski, A.M. Davidson, P. Knowles, S. Porowski, R.A. Stradling	183
High Resolution Magneto-Optical Studies of Free and Bound Hole Excitations in InSb	
R. Kaplan, R.J. Wagner, D.G. Seiler, C.L. Littler, M.H. Weiler, W. Zawadzki	188
Two-Photon Spectroscopy in InSb with cw CO_2 Lasers	
D.G. Seiler, M.W. Goodwin, M.H. Weiler	192
Uniaxial-Stress-Enhanced Electron Spin Resonance in InSb	
F. Kuchar, R. Meisels, M. Kriechbaum	197
Optical Four-Wave Mixing in PbTe Epitaxial Layers	
H. Pascher	202
Spin-Flip Resonances in Cadmium Arsenide	
J. Thielemann, M.v. Ortenberg, F.A.P. Blom, K. Strobel	207
Peculiarities of the Band Structure of HgSe and Mixed Crystals $\text{Hg}_{1-x}\text{Cd}_x\text{Se}$ from the Interband Magnetoabsorption	
A. Mycielski, J. Kossut, M. Dobrowolska, W. Dobrowolski	211
Bandstructure of $\text{Pb}_{1-x}\text{Ge}_x\text{Te}$ in the C_{3v} -Phase	
E. Bangert	216
Band Structure of Cubic and Rhombohedral GeTe	
H.M. Polatoglou, G. Theodorou, N.A. Economou	221

6. LATTICE DYNAMICS AND PHASE TRANSITION

Dielectric Properties of (Pb,Sn,Ge)Te-Influences of Defects W. Jantsch	226
Phase Transitions and Optical Properties of IV-VI Compounds P.B. Littlewood	238
Lattice Dynamics and Phase Transitions of IV-VI Compounds W. Porod, P. Vogl	247
Pseudopotential Approach to Total Energy Calculations in Narrow Gap Semiconductors G. Mula	252
Lattice Dynamics and Phase Transitions in IV-VI Semiconducting Compounds A. Bussmann-Holder, W. Kress, H. Bilz, U. Schröder	257
Composition and Carrier Concentration Dependence of Structural Instabilities in PbTe-SnTe Alloys K. Murase, S. Nishi	261
Phonon and Electrical Resistivity Anomalies at the Displacive Phase Transition in $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ and $\text{Pb}_{1-x}\text{Ge}_x\text{Te}$ T. Suski, M. Baj, S. Katayama, K. Murase	266
Coupled Phase Transitions in $\text{Pb}_{1-x}\text{Ge}_x\text{Te}$ H. Yaraneri, A.D.C. Grassie, J.W. Loram	270
A Neutron Scattering Study of Lattice Dynamics of HgTe and HgSe H. Kepa, T. Giebultowicz, B. Buras, B. Lebech, K. Clausen ..	275

7. PANEL DISCUSSION ON TECHNOLOGY

H. Preier	280
New Aspects of the Material and Device Technology of Intrinsic Infrared Photodetectors J. Baars	280
HgCdTe Liquid Phase Epitaxial Growth Technology M.W. Scott	283
Lattice-Matched PbSnTe/PbTeSe Heterostructure Device Technology C.G. Fonstad	286
Lead Chalcogenide Diode Lasers: State of the Art and Applications H.M. Preier	289

8. SEMIMAGNETIC SEMICONDUCTORS

Magnetic Properties of Semimagnetic Semiconductors

R.R. Galazka 294

Magnetization of Narrow Gap Semimagnetic Semiconductors

 $\text{Hg}_{1-x}\text{Mn}_x\text{Te}$ and $\text{Hg}_{1-x}\text{Mn}_x\text{Se}$

W. Dobrowolski, M. v.Ortenberg, A.M. Sandauer, R.R. Galazka,

A. Mycielski, R. Pauthenet 302

Microwave and Far Infrared Magnetotransmission Studies in

 $\text{Hg}_{1-x}\text{Mn}_x\text{Se}$

R.E. Kremer, A.M. Witowski, M. Jaczynski, J.K. Furdyna 307

Acceptor States in Semimagnetic Semiconductors in a
Magnetic Field

T.R. Gawron, J. Trylski 312

Magneto-Optical Studies of Quaternary Semimagnetic Semi-
conductor Alloys $\text{Hg}_{1-x-y}\text{Cd}_x\text{Mn}_y\text{Te}$

R.S. Kim, Y. Mita, S. Takeyama, S. Narita 316

Infrared Magnetoabsorption in Zero Gap $\text{Hg}_{1-x}\text{Fe}_x\text{Te}$ and $\text{Hg}_{1-x}\text{Fe}_x\text{Se}$ Mixed Crystals

H. Serre, G. Bastard, C. Rigaux, J. Mycielski, J.K. Furdyna. 321

The Quantum Transport and the Magnetic Levels in $\text{Pb}_{1-x}\text{Mn}_x\text{Te}$

J. Niewodniczańska-Zawadzka, J. Kossut, A. Sandauer,

W. Dobrowolski 326

Shubnikov-De Haas Effects in $(\text{Cd}_{1-x}\text{Mn}_x)_3\text{As}_2$ Alloys

J.J. Neve, F.A.P. Blom 330

Theory of Magnetic Susceptibility of Narrow Gap Semi-
conductors

L. Falkovsky 335

9. SUPERLATTICES AND INTERCALATED COMPOUNDS

Advances in Synthesized Superlattices

L. Esaki 340

Electronic Properties of Graphite Intercalation Compounds

C. Rigaux, J. Blinowski 352

Comparison of Transport Properties in Various Semimetals
Systems

J.-P. Issi, J. Heremans, G. Dresselhaus, M.S. Dresselhaus .. 363

Optical Properties of $\text{PbTe-Pb}_{1-x}\text{Sn}_x\text{Te}$ Superlattices Prepared by a Hot Wall Technique	
H. Kinoshita, H. Fujiyasu, A. Ishida, H. Kuwabara	368

10. TRANSPORT

Screening of Impurities in Strong Magnetic Fields and Its Influence on the Transverse Conductivity	
K. Heift, Y. Ono, J. Hajdu	373
Anomalous Behaviour of the Magnetoresistance of $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ in the Extreme Quantum Limit	
G. De Vos, F. Herlach	378
Stationary and Time-Resolved Magnetotransport in n-Type $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$ and n-Type InSb in the Extreme Magnetic Quantum Limit	
B. Schlicht, G. Nimtz	383
Modification of the Classical Magnetic Freeze-Out Manifestations in n-Type $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ ($x > 18\%$) Due to the Presence of Resonant Levels	
A. Raymond, J.L. Robert, R.L. Aulombard, C.Bousquet, O. Valassiades, M. Royer	387
Ionized-Defect-Scattering Mobility in n-PbTe	
L. Palmetshofer, K.H. Gresslehner, L. Ratschbacher, A. Lopez-Otero	391
High Pressure Electron Mobility in Low Electron Concentration InSb Samples at 77K	
E. Litwin-Staszewska, W. Szymańska, R. Piotrkowski	397
Shubnikov de Haas Oscillations in $\text{Cd}_{3-x}\text{Zn}_x\text{As}_2$ Alloys	
M.J. Aubin, J. Beerens, J.C. Portal	401
Bi_2Se_3 and Bi_2Te_3 Single Crystals Doped with Sn Atoms	
M. Matyáš, M. Závětová, J. Horák, P. Lošťák	405
Ultrasonic Anomaly Near Zero-Gap State in $\text{Cd}_x\text{Hg}_{1-x}\text{Se}$	
K. Kumazaki	410
Size Effects in Thin Semimetal Wires	
N.B. Brandt, D.V. Gitsu, A.A. Nikolaeva, Ya.G. Ponomaryov ..	415

11. IMPURITIES AND RESONANT STATES

Pressure Spectroscopy of Localized Levels	
S. Porowski	420

First Order Phase Transition of Hall Coefficient Versus Magnetic Field, Under Hydrostatic Pressure Due to Freeze-Out on Acceptor State in $\text{Hg}_{0.836}\text{Cd}_{0.164}\text{Te}$	
M. Carvalho, C. Fau, M. Averous	430
Nonradiative Recombination at Deep Impurity Levels in p-Type $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$	
D.L. Polla, W. Scott, C.E. Jones	435
On the Thermodynamic Instability of n-Type HgCdTe , and on Acceptor Levels, Transport Properties, and Lifetime of p-Type HgCdTe	
B. Schlicht, A. Alpsancar, G. Nimtz, A.N.F. Schroeder	439
Ion-Implantation-Induced Defect Levels in $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$	
K.H. Gresslehner, L. Palmetshofer, H. Heinrich, N.C. Sharma	444
Photoluminescence of $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ ($x \sim 0.2$) Crystals Doped with Cd and In	
I.I. Zasavitsky, B.N. Matsonashvili, G.V. Flusov	449
Energy Levels of Native Defects in n- $\text{Pb}_{1-x}\text{Sn}_x\text{Se}$	
I.V. Kutcherenko, A.P. Shotov, A.E. Svistov	454
Localized "Deep" Defect States in $\text{PbSe}_x\text{Te}_{1-x}$ Mixed Crystals	
G. Brunthaler, K. Lischka, L. Palmetshofer	458
Strong Coupling Between the Resonant State and the Crystal Lattice in n- InSb	
L. Dmowski, M. Baj, P. Ioannides	463
Binding Energies of Charged Impurity Centres in Narrow Gap Materials with Large Lattice Polarizability	
R. Enderlein, F. Bechstedt, W. Hill	468

12. CLOSING SESSION

The Widening Application of Narrow-Gap Semiconductors - Closing Address at the 4th International Conference on the Physics of Narrow-Gap Semiconductors	
R.A. Stradling	473
Author Index	477
List of Participants (1981-10-27)	480

NARROW GAP SEMICONDUCTORS - THE STATE OF THE ART

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Motto: "Whatever is not forbidden - is allowed."

1. Introduction. This review attempts to present the state of the art in investigations of narrow gap semiconductors (NGS). I felt that after almost 25 years of its continuous development, counting from the classic Kane's paper on the band structure of InSb [1], the field deserves such an appraisal. NGS are characterised by some distinct features. Experimentally, they are more sensitive to external influences, such as temperature, magnetic field, electric field and deformation, than the standard semiconductor materials. Theoretically, they require a description, which is closely analogous to the relativistic quantum mechanics (Zawadzki [2]). The electrons in NGS combine features of free particles (continuous spectrum) and those of atomic state (energy gaps, spin-orbit interaction). This combination results in a variety of new physical phenomena. The review concentrates on such effects, particular to NGS.

The somewhat pretentious title probably promises too much and I should say what this article is not. Thus, it is not encyclopaedic in character, it does not follow the historical development and it is far from complete in quoting relevant literature. The author succumbed to the tendency of emphasizing his own work and the choice of subjects is unavoidably biased. Due to severe lack of space there are virtually no derivations quoted and the style is rather telegraphic. The review treats exclusively cubic materials with band extrema at the Γ point. Figures illustrate newer developments trying to avoid material shown in previous reviews. The aim of the presentation is to say what has been done, to mention how it has been achieved and to indicate some existing gaps and future possibilities.

2. Three - level Band Model. We introduce now the band model which is subsequently used in almost all calculations. It describes quite well the conduction bands in InSb-type semiconductors and in HgTe-type zero-gap materials. We consider an electron in a narrow-gap semiconductor in the presence of a static magnetic field $\vec{H}$ and a static scalar potential $U(\vec{r})$. The initial one-electron Hamiltonian for the problem reads

$$\left[\frac{1}{2m_0} p^2 + V_0(\vec{r}) + H_{so} + U(\vec{r}) \right] \Psi = \epsilon \Psi \quad (1)$$

where H_{so} is the spin-orbit interaction, $\vec{P} = \vec{p} + (e/c)\vec{A}$ in which $\vec{A}$ is the vector potential of magnetic field, V_0 is the periodic potential of the lattice and m_0 is the free electron mass. We look for solutions in the form

$$\Psi = \sum_1 f_1(\vec{r}) u_1(\vec{r}) \quad (2)$$

where the sum runs over all energy bands. f_1 are slowly varying enve-