

# **Defect Engineering in Semiconductor Growth, Processing and Device Technology**

Symposium held April 26-May 1, 1992, San Francisco, California, U.S.A.

EDITORS:

**S. Ashok**

The Pennsylvania State University  
University Park, Pennsylvania, U.S.A.

**J. Chevallier**

CNRS  
Meudon, France

**K. Sumino**

Tohoku University  
Sendai, Japan

**E. Weber**

University of California  
Berkeley, California, U.S.A.



---

MATERIALS RESEARCH SOCIETY  
Pittsburgh, Pennsylvania

## Contents

PREFACE	xvii
ACKNOWLEDGMENTS	xix
MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS	xx
<b>PART I: GROWN-IN DEFECTS IN BULK CRYSTALS</b>	
*DYNAMIC BEHAVIOR OF INTRINSIC POINT DEFECTS IN FZ AND CZ SILICON CRYSTALS Takao Abe and Hiroshi Takeno	3
*OXYGEN RELATED LATTICE DEFECTS IN SILICON: PRESENT STATUS Hugo Bender and Jan Vanhellemont	15
AN INVESTIGATION OF VACANCY CONCENTRATIONS IN BULK SILICON Horst Zimmermann and H. Ryssel	31
CHARACTERIZATION OF DEFECTS IN CZ-GROWN Si CRYSTALS WITH OSF RING Satoshi Ogushi, Masataka Hourai, and Tatuhiro Shigematsu	37
A STUDY OF DEFECTS IN CZOCHRALSKI-GROWN SILICON BY POSITRON ANNIHILATION SPECTROSCOPY S.C. Sharma, N. Hozhabri, R.C. Hyer, T. Hossain, S. Kim, F.O. Meyer, III, M.F. Pas, and A.E. Stephens	45
EVALUATION OF MICRODEFECTS IN AS-GROWN SILICON CRYSTALS H. Takeno, S. Ushio, and T. Takenaka	51
THE EFFECT OF D-DEFECT IN SILICON SINGLE CRYSTAL ON OXYGEN PRECIPITATION I. Fusegawa, N. Fujimaki, and H. Yamagishi	57
OXYGEN PRECIPITATION NONUNIFORMITY FOR THERMAL HISTORY AROUND 723K DURING CZ CRYSTAL GROWTH I. Fusegawa and H. Yamagishi	63
NUCLEATION OF OXYGEN PRECIPITATES IN A QUENCHED CZOCHRALSKI SILICON CRYSTAL A. Ikari, H. Haga, O. Yoda, A. Uedono, and Y. Ujihira	69
DEPTH PROFILES OF THERMAL DONORS IN CZOCHRALSKI-GROWN n-TYPE SILICON Yutaka Tokuda, Toshihisa Shimokata, Masayuki Katayama, and Tadashi Hattori	75
DISLOCATIONS AS SINKS FOR SELF-INTERSTITIALS IN GOLD DOPED FLOAT ZONE SILICON G. Mariani, B. Pichaud, W.J. Taylor, and W.-S. Yang	81
*ROLE OF IMPURITIES IN REDUCING GROWN-IN DISLOCATIONS IN COMPOUND SEMICONDUCTOR CRYSTALS Koji Sumino	87

\*Invited Paper

PERSISTENT PHOTO-HALL PHENOMENON AND NEAR-BAND EDGE ABSORPTION IN LIGHTLY n-TYPE LEC GaAs S. Tüzemen and M.R. Brozel	99
STUDY OF MEDIUM-DEEP TRAPS IN UNDOPED GaAs GROWN BY ARSENIC-PRESSURE CONTROLLED CZ METHOD Hiroyuki Shiraki, Yutaka Tokuda, and Koichi Sassa	105
POINT DEFECT ASSISTED CRYSTAL GROWTH OF BULK ZnSe K. Terashima, E. Tokizaki, H. Kondo, S. Tanigawa, A. Uedono, S. Watauchi, and Y. Ujihira	111
MICROSTRUCTURAL AND MICROCHEMICAL CHARACTERISATION OF CuInSe <sub>2</sub> INGOTS GROWN BY THE VERTICAL BRIDGMAN TECHNIQUE C.A. Mullan, S.M. Casey, C. Jones, C.J. Kiely, M. Imanieh, and R.D. Tomlinson	117
STABILITY AGAINST CONCENTRATION FLUCTUATIONS IN COMPOUND SEMICONDUCTORS P.J. Desre	123
THE THERMAL STABILITY OF HEAVILY CARBON-DOPED GaAs GROWN BY METALORGANIC MOLECULAR BEAM EPITAXY Hyunchul Sohn, E.R. Weber, S. Nozaki, M. Konagai, and K. Takahashi	129
THERMAL STABILITY OF SiH <sub>n</sub> CONFIGURATIONS IN FZ SILICON SINGLE CRYSTALS Masami Kouketsu and Seiichi Isomae	135
<b>PART II: GROWN-IN DEFECTS IN THIN FILMS</b>	
*IMPURITY AND STOICHIOMETRY CONTROL IN ATOMIC LAYER EPITAXY H. Yokoyama, K. Ikuta, and N. Inoue	143
THIN OXIDE DEFECTS RESULTING FROM PLASMA INDUCED WAFER CHARGING Sychyi Fang and James P. McVittie	151
HIGH RESISTIVITY GaSb AND GaAs PRODUCED BY MBE GROWTH AT ELEVATED TEMPERATURES A.Y. Polyakov, A.G. Milnes, M. Stam, R.G. Wilson, Z.Q. Fang, P. Raichoudhury, and R.J. Hillard	157
DEFECT STRUCTURES IN HETEROEPITAXIAL InAs/GaAs AND GaAs/InAs GROWN BY ATOMIC LAYER MOLECULAR BEAM EPITAXY S.I. Molina, G. Aragon, and R. Garcia	163
OPTIMIZATION OF MBE OF CdTe/CdTe: REFINEMENT IN STRUCTURAL QUALITY EVALUATION OF MBE GROWN (111) CdTe M.B. Lee, T. Fanning, D. Di Marzio, L.G. Casagrande, and M. Dudley	169
MOSAIC SPREAD OF THE HETEROEPITAXIAL STRUCTURES FROM RENNINGER SCAN S.L. Morelhão and L.P. Cardoso	175
NOBLE GAS INCORPORATION IN SPUTTERED AND ION BEAM ASSISTED GROWN SILICON FILMS A. van Veen, M.J.W. Greuter, L. Niesen, B. Nielsen, and K.G. Lynn	181

\*Invited Paper

EFFECT OF ELECTRON IRRADIATION AND EXCESS Cd ON ION-ASSISTED DOPING OF p-CdTe THIN FILMS	187
D. Kim, A.L. Fahrenbruch, A. Lopez-Otero, and R.H. Bube	

### PART III: DEFECT CHARACTERIZATION

*APPLICATION OF TRANSMISSION ELECTRON MICROSCOPY TO SOLVING DEFECT ISSUES IN III-V ALLOY SEMICONDUCTORS AND DEVICES	197
O. Ueda	
ATOMIC STRUCTURES OF PLANAR DEFECTS IN Si AND GaAs	209
S. Takeda, S. Muto, and M. Hirata	
RAPID STRUCTURAL DEFECT MAPPING OF BULK II-VI SEMICONDUCTORS USING WHITE-BEAM SYNCHROTRON TOPOGRAPHY AND X-RAY ROCKING CURVE ANALYSIS	215
Don Di Marzio, Louis G. Casagrande, Myung B. Lee, Thomas Fanning, and Michael Dudley	
*RECOMBINATION ACTIVITY OF INDIVIDUAL EXTENDED DEFECTS IN SILICON	223
A. Cavallini and A. Castaldini	
EVALUATION OF VACANCY-TYPE DEFECTS IN SIMOX SUBSTRATES BY A SLOW POSITRON BEAM AND A PULSED POSITRON BEAM	235
H. Kametani, H. Akiyama, Y. Yamaguchi, M. Koumaru, L. Wei, Y. Tabuki, S. Tanigawa, A. Uedono, S. Watauchi, Y. Ujihira, R. Suzuki, H. Ohgaki, and T. Mikado	
TRANSMISSION ELECTRON MICROSCOPY OF HYDROGEN-INDUCED DEFECTS IN LOW TEMPERATURE EPITAXIAL SILICON	241
G.B. Anderson, C.C. Tsai, and R. Thompson	
RELAXATION DEFECT CHARACTERIZATION OF RTCVD Si <sub>1-x</sub> Ge <sub>x</sub> /Si HETEROSTRUCTURES BY ELECTRICAL AND OPTICAL TECHNIQUES	247
A. Souifi, G. Bremond, T. Benyattou, G. Guillot, and D. Dutartre	
POINT DEFECT DETECTOR STUDIES OF Ge <sup>+</sup> IMPLANTED SILICON UPON OXIDATION	253
H.L. Meng, S. Prussin, and K.S. Jones	
THE SENSITIVITY OF RENNINGER SCAN INTENSITIES WITH Al CONTENT IN Ga <sub>1-x</sub> Al <sub>x</sub> As/GaAs SAMPLES	259
J.M. Sasaki, C. Campos, and L.P. Cardoso	
INFLUENCE OF SURFACE RELAXATION AND MULTI-DISLOCATION STRAIN FIELD INTERACTIONS ON X-RAY TOPOGRAPHIC IMAGES OF DISLOCATIONS IN SEMICONDUCTOR MATERIALS	265
Jun Wu, Thomas Fanning, Michael Dudley, Vijay Shastry, and Peter Anderson	
INFRARED ABSORPTION BY FREE CARRIERS IN Si AND INFLUENCE ON OXYGEN DETERMINATION BY FTIR-SPECTROSCOPY	271
L. Köster and F. Bittersberger	
CHARACTERIZATION OF DEFECTS IN HEAVILY Si-DOPED GaAs BY A MONOENERGETIC POSITRON BEAM	277
A. Uedono, Y. Ujihira, L. Wei, and S. Tanigawa	

\*Invited Paper

MONOENERGETIC POSITRON BEAM STUDIES OF OXYGEN IN SINGLE CRYSTAL SILICON — STRESS INDUCED CLUSTERING OF OXYGEN ATOMS IN SILICON	283
R. Nagai, E. Takeda, Y. Tabuki, L. Wei, and S. Tanigawa	
EL2 RELATED ANOMALOUS SPLITTING IN THE PHOTOREFLECTANCE RESPONSE OF SEMI-INSULATING GaAs	289
C. Durbin, J. Estrera, R. Glosser, W. Duncan, R.L. Henry, P. Nordquist, N. Bottka, and D.K. Gaskill	
EVALUATION USING A NONCONTACT LASER BEAM INDUCED CONDUCTIVITY/CURRENT METHOD FOR THE SILICON-ON-INSULATOR MADE BY WAFER BONDING	295
A. Usami, T. Nakai, H. Fujiwara, S. Ishigami, T. Wada, K. Matsuki, and T. Takeuchi	
OPTICAL STUDY OF THE Fe <sup>3+</sup> -RELATED EMISSION AT 0.5 eV IN InP:Fe	301
Klaus Pressel, G. Bohnert, A. Dörnen, and K. Thonke	
THE LACK OF TRAPPING CENTERS FOR POSITRONS AT THE INTERFACE OF W/Si SYSTEM AND THE INVESTIGATION OF THE DEPLETION LAYER IN THE SCHOTTKY BARRIER BY POSITRONS AS TEST CHARGE SIMULATING HOLES	307
S. Tanigawa, Y. Tabuki, L. Wei, K. Hinode, N. Kobayashi, T. Onai, and N. Owada	
CHARACTERIZATION OF METAL-OXIDE-SILICON INTERFACE BY MONOENERGETIC POSITRON BEAM	313
Yuzuru Ohji, Akira Uedono, Long Wei, Yasushi Tabuki, and Shoichiro Tanigawa	
THE INTERFACIAL REACTIONS IN Ti/Si AND Ni/Si SYSTEMS OBSERVED BY A MONOENERGETIC POSITRON BEAM	319
S. Tanigawa, L. Wei, and Y. Tabuki	
DEFECTS INTRODUCED BY LOW DOSE Be-IMPLANTATION PROBED BY A MONOENERGETIC POSITRON BEAM	325
A. Uedono, Y. Ujihira, L. Wei, Y. Tabuki, S. Tanigawa, K. Wada, and H. Nakanishi	
POSITRON ANNIHILATION AND ELECTRON SPIN RESONANCE OF ELECTRON-IRRADIATED 3C-SiC	331
Hisayoshi Itoh, Masahito Yoshikawa, Long Wei, Shoichiro Tanigawa, Isamu Nashiyama, Shunji Misawa, Hajime Okumura, and Sadafumi Yoshida	
ELECTRON IRRADIATED InP: A POSITRON ANNIHILATION STUDY	337
T. Bretagnon, S. Dannefaer, and D. Kerr	
THE STUDY OF Si, Se AND O-IMPLANTED GaAs BY SLOW POSITRONS	343
S. Fujii, S. Shikata, L. Wei, and S. Tanigawa	
STUDY OF ELECTRICAL PROPERTIES OF DEFECTS IN SOI FILMS BY WAFER BONDING	349
Akira Usami, Taichi Natori, Akira Ito, Shun-ichiro Ishigami, Yutaka Tokuda, and Takao Wada	

#### PART IV: HYDROGEN INTERACTION WITH SEMICONDUCTORS

*THE EFFECT OF HYDROGENATION ON THE ELECTRICAL PROPERTIES OF CRYSTALLINE SILICON Jacques I. Pankove	357
*HYDROGEN IN COMPOUND SEMICONDUCTORS N.M. Johnson	369
THERMAL STABILITY OF HYDROGENATION PROCESSES INTO MULTICRYSTALLINE SILICON Jean-Claude Muller, Bouchaib Hartiti, Hussain Younis, and Paul Siffert	383
ANOMALOUS BEHAVIOR IN THE RESISTIVITY OF N-I-N POLYSILICON RESISTORS AFTER HYDROGENATION Chad B. Moore and Dieter G. Ast	389
HYDROGEN PASSIVATION AND REACTIVATION OF BISTABLE THERMAL DONORS IN SILICON D.I. Bohne, P. Deak, and J. Weber	395
LOCAL BONDING STRUCTURE OF HYDROGEN IN CRYSTALLINE SILICON: NMR AND TEM STUDIES J.B. Boyce, N.M. Johnson, S.E. Ready, J. Walker, and G.B. Anderson	401
MECHANISM OF ENHANCED HYDROGEN DIFFUSION IN SOLAR CELL SILICON Bhushan L. Sopori	407
PASSIVATION OF SURFACE AND BULK DEFECTS IN InP Sathya Balasubramanian, Vikram Kumar, N. Balasubramanian, and V. Premachandran	413
HYDROGEN PASSIVATION AND REACTIVATION OF DX CENTERS IN Se-DOPED AND Si-DOPED AlGaAs — A COMPARISON G. Roos, N.M. Johnson, C. Herring, and J.S. Harris, Jr.	419
THE EFFECT OF HYDROGEN TREATMENT ON ELECTRICAL PROPERTIES OF AlGaAsSb A.Y. Polyakov, M. Stam, A.G. Milnes, R.G. Wilson, A.E. Bochkarev, P. Raichoudhury, R.J. Hillard, and S.J. Pearton	425
PASSIVATING COMPLEXES IN Cd DOPED GaAs AND InP: MICROSCOPIC PROPERTIES AND ELECTRICAL EFFECTS N. Moriya, M. Deicher, R. Kalish, R. Keller, R. Magerle, W. Pfeiffer, P. Pross, H. Skudlik, Th. Wichert, H. Wolf, and Isolde Collaboration	431
PLASMA HYDROGENATION STUDIES ON LOW-TEMPERATURE MBE-GROWN GaAs O.S. Nakagawa, S. Ashok, K. Zhang, D.L. Miller, and W.K. Chung	437
NUCLEAR MAGNETIC RESONANCE STUDIES OF DEUTERIUM IN SILICON Karen Carr Bustillo, Eugene E. Haller, and Jeffrey A. Reimer	443
DONOR REACTIVATION KINETICS AND HYDROGEN REDISTRIBUTION IN THE SPACE CHARGE LAYER OF N-TYPE SILICON Y.-A. Wu, G. Roos, N.M. Johnson, and C. Herring	449
THE ELECTRONIC STATES AND DYNAMICAL PROPERTIES OF HYDROGEN BOUND TO CARBON IN SILICON Yoichi Kamiura, Fumio Hashimoto, and Minoru Yoneta	455

\*Invited Paper

DIFFUSION OF HYDROGEN AND HYDROGEN-DOPANT INTERACTIONS IN Si DOPED GaAs AND GaAlAs ALLOYS J. Chevallier, B. Machayekhi, C. Grattapain, R. Rahbi, and B. Theys	461
OPTICAL EMISSION STUDY OF THE ENERGY LEVELS OF Ga-VACANCY/ HYDROGEN COMPLEXES IN N AND P-TYPE GaAs A. Amore Bonapasta, B. Bonanni, M. Capizzi, L. Cherubini, V. Emiliani, A. Frova, and F. Sarto	467
COMPARISON OF TRAPPING STATES AT SiO <sub>2</sub> /Si INTERFACES ON Si(100), (110), AND (111) PREPARED BY PLASMA-ASSISTED OXIDATION AND OXIDE DEPOSITION, AND BY EXPOSURE TO ATOMIC H PRIOR TO OXIDATION AND DEPOSITION T. Yasuda, Y. Ma, S. Habermehl, and G. Lucovsky	473
EXTERNAL GETTERING AND HYDROGENATION EFFECTS ON ELECTRICAL PROPERTIES OF MULTICRYSTALLINE SILICON WAFERS I. Perichaud and S. Martinuzzi	481
<b>PART V: DEFECT PROPERTIES AND REACTIONS</b>	
*ELECTRICAL AND OPTICAL PROPERTIES OF TITANIUM, VANADIUM, MOLYBDENUM, AND TUNGSTEN RELATED DEFECTS IN SILICON K. Schmalz, H.G. Grimmeiss, H. Pettersson, and L. Tilly	489
TRANSFORMATION OF GOLD IN N-TYPE SILICON FROM A NEW DEEP LEVEL TO THE GOLD ACCEPTOR LEVEL Einar Ö. Sveinbjörnsson and Olof Engström	501
PROOF OF THE ACCEPTOR STATE OF THE TRIGONAL IRON-BORON PAIR IN SILICON BY ELECTRON PARAMAGNETIC RESONANCE MEASUREMENTS W. Gehlhoff and U. Rehse	507
*EXCITONIC MECHANISM OF RARE EARTH EXCITATION IN II-VI AND III-V SEMICONDUCTORS Marek Godlewski	513
*DONOR-ACCEPTOR PAIRS IN SILICON H.E. Altink, T. Gregorkiewicz, and C.A.J. Ammerlaan	525
THE EFFECT OF VACANCIES GROWN INTO SILICON ON GOLD DIFFUSION R.K. Graupner, J.A. Van Vechten, P. Harwood, and T.K. Monson	537
ENHANCEMENT OF LONG-WAVELENGTH PHOTOLUMINESCENCE DUE TO HEAT-TREATMENT IN Si-DOPED GaAs M. Suezawa, A. Kasuya, Y. Nishina, and K. Sumino	543
FORMATION MECHANISM AND RECOMBINATION-ENHANCED DISSOCIATION OF A HYDROGEN-CARBON COMPLEX IN SILICON Yoichi Kamiura, Fumio Hashimoto, and Minoru Yoneta	549
METASTABLE DEFECTS OF IRON-BORON PAIR IN SILICON H. Nakashima and T. Sadoh	555
PROCESS PHYSICS OF THE IRON-BORON PAIR RECOMBINATION AND DISSOCIATION IN p-TYPE SILICON W. Wijaranakula	561

ORIGINS OF THE GAP STATES IN POLYCRYSTALLINE SILICON: TIGHT-BINDING CALCULATIONS OF TWIST BOUNDARIES M. Kohyama, S. Kose, and R. Yamamoto	567
EFFECT OF FLUORINE ON THE DOPANT DIFFUSION OF THROUGH-OXIDE IMPLANTED BORON IN Si — A CORRELATION WITH MICROSTRUCTURAL DEFECTS J.G. Huang, A. Lam, and R.J. Jaccodine	573
EVIDENCE FOR METASTABLE STATE OF DX CENTER IN $Al_xGa_{1-x}As$ Subhasis Ghosh and Vikram Kumar	579
EFFECTS OF HYDROGEN OR NITROGEN ON GROWTH OF OXYGEN-RELATED DEFECTS IN GERMANIUM Noboru Makihara, Kazuyoshi Ito, Kaoru Mizuno, and Kotaro Ono	585
INTERACTION OF SOLUTE In ATOMS WITH DISLOCATIONS IN LEC GaAs N. Burle-Durbec, A. Rakotobe, B. Pichaud, and F. Minari	591
SIMILARITY OF VACANCY CREATION MECHANISMS IN Si DOPED GaAs AND Ga DOPED ZnSe OBSERVED BY A MONOENERGETIC POSITRON BEAM S. Tanigawa, J.L. Lee, L. Wei, M. Kawabe, T. Miyajima, H. Okuyama, K. Akimoto, and Y. Mori	597
DEFECT-IMPURITY INTERACTION IN IRRADIATED n-GaAs F.P. Korshunov, T.A. Prokhorenko, N.A. Sobolev, and E.A. Kudriavtseva	603
EBIC ANALYSIS OF GETTERING AT Si-Si(Ge) HETEROEPITAXIAL MISFIT DISLOCATIONS AS A FUNCTION OF IMPURITY DECORATION H.R. Kirk, Z.J. Radzinski, E.A. Fitzgerald, and G.A. Rozgonyi	609
METALLIC IMPURITIES IN n- AND p-TYPE SILICON: DLTS STUDIES Aditya Agarwal, Z.J. Radzinski, Z. Buczkowski, F. Shimura, and G.A. Rozgonyi	615
THE INFLUENCE OF STRESSES ON THE SURFACE-NEAR DEFECT STRUCTURE M. Reiche and W. Nitzsche	621
<b>PART VI: DEFECTS INDUCED BY PROCESSING</b>	
*DEFECT ANALYSES IN VLSI DEVICES BY TEM OBSERVATION AND PROCESS SIMULATION H. Mikoshiba, N. Nishio, T. Matsumoto, H. Kikuchi, T. Kitano, and H. Kaneko	629
*ELECTRIC DEGRADATION AND DEFECT FORMATION OF SILICON DUE TO Cu, Fe, AND Ni CONTAMINATION Shunta Naito and Tsuneo Nakashizu	641
CONTROL OF PROCESS-INDUCED DEFECTS IN THE FORMATION OF SINGLE AND MULTIPLE LAYER DIELECTRIC STRUCTURES FOR Si SEMICONDUCTOR DEVICES S.S. He, D.J. Stephens, Y. Ma, T. Yasuda, S. Habermehl, and G. Lucovsky	653
EVIDENCE FOR A DEFECT-ASSISTED LOW RESISTIVE CONDUCTIVITY IN CW LASER BEAM MIXED Au/Te/Au/GaAs CONTACTS J. Watté, R.E. Silverans, H. Münder, and K. Wuyts	659

\*Invited Paper



THE INFLUENCE OF THERMAL TREATMENT ON DEFECT CHARACTERISTICS IN CZ-SILICON WAFERS INVESTIGATED BY POSITRON ANNIHILATION SPECTROSCOPY P. Mascher, W. Puff, S. Hahn, K.H. Cho, and B.Y. Lee	665
HEAT-TREATMENT INDUCED DEFECTS IN CZ-SILICON S. Dannefaer, T. Bretagnon, K. Abdurahman, D. Kerr, and S. Hahn	671
A LIFETIME STUDY OF OXYGEN AGGLOMERATION INDUCED DEFECTS IN CZ SILICON CRYSTAL BY SURFACE PHOTOVOLTAGE (SPV) Kamal Mishra, W. Huber, and Jacek Lagowski	677
CHARACTERISTICS OF OXYGEN PRECIPITATION IN SILICON WAFERS PREANNEALED AT 723K I. Fusegawa, E. Iino, T. Hirohata, and H. Yamagishi	683
PHOTOLUMINESCENCE AND PHOTOACOUSTIC SPECTROSCOPY OF SI SINGLE- AND MULTI-STEP INGOT- AND WAFER-ANNEALED GaAs CRYSTALS O. Ka, O. Oda, S. Shigetomi, T. Ikari, Y. Makita, and A. Yamada	689
DETAILED PHOTOLUMINESCENCE STUDIES OF HEAT-TREATED InP Klaus Pressel, C. Hiller, G. Bohnert, F. Prinz, and A. Dörnen	695
EFFECTS OF CONCURRENT Co OR Ti SILICIDATION ON TRANSIENT DIFFUSION AND END-OF-RANGE DAMAGE IN PHOSPHORUS IMPLANTED SILICON J.W. Honeycutt, J. Ravi, and G.A. Rozgonyi	701
DEFECT ANNIHILATION IN CZOCHRALSKI-GROWN SILICON DURING OUT-DIFFUSION PROCESS PROBED WITH VARIABLE-ENERGY POSITRON BEAM T. Kitano, L. Wei, Y. Tabuki, S. Tanigawa, and H. Mikoshiba	707
POLYSILICON/SILICON INTERFACES: EFFECT OF PROCESSING PARAMETERS ON PHYSICAL AND ELECTRICAL PROPERTIES K. Srikrishna, M. Moinpour, and B. Landau	713
CARRIER PROFILE VARIATIONS OF A CHANNEL CONDUCTIVE LAYER THROUGH PHOSPHO-SILICATE-GLASS CAP ANNEALING OF N+ Si-IMPLANTED GaAs CRYSTALS Yasuyuki Saito	719
STRESS-RELATED DEFECTS IN IMPLANTED LOCOS + TRENCH-ISOLATED STRUCTURES Barbara Vasquez and N. David Theodore	725
RAPID THERMAL ANNEALING OF NEUTRON TRANSMUTATION DOPED CZOCHRALSKI SILICON G.M. Berezina, F.P. Korshunov, N.A. Sobolev, A.V. Voevodova, and A.A. Stuk	731

#### PART VII: DEFECTS IN DEVICES

*EFFECTS OF FLUORINE ON MOS PROPERTIES T.P. Ma	741
*LOW FREQUENCY NOISE IN SMALL MOS DEVICES Michael J. Uren	751

\*Invited Paper

USE OF SELECTIVE AREA DEFECT CREATION FOR ISOLATION OF III-V MULTILAYER STRUCTURES	763
S.J. Pearton, F. Ren, T.R. Fullowan, A. Katz, W.S. Hobson, C.R. Abernathy, J.R. Lothian, L.A. D'Asaro, R.G. Elliman, M.C. Ridgway, C. Jagadish, and J.S. Williams	
EFFECTS OF DELIBERATE METAL CONTAMINATION ON CCD IMAGERS	769
William C. McColgin, J.P. Lavine, J. Kyan, D.N. Nichols, J.B. Russell, and C.V. Stancampiano	
*SOME POSSIBILITIES OF USING DEFECTS FOR APPLICATIONS IN SEMICONDUCTORS	775
Michel Lannoo	
COMPARISON OF MESA-ETCHED AND ION-IMPLANTED $\text{Ge}_x\text{Si}_{1-x}$ HETEROJUNCTION BIPOLAR TRANSISTORS	785
D.W. Greve and M. Racanelli	
DRAIN CURRENT DLTS SPECTRA AND GaAs SUBSTRATE CRYSTAL EFFECT ON LOW-FREQUENCY-OSCILLATIONS ON Si-IMPLANTED MESFETS	791
Yasuyuki Saito, Tohru Suga, Kazuhiko Inoue, Tatsuro Mitani, Yutaka Tomizawa, Johji Nishio, Kazutaka Terashima, Tohru Katsumata, Katsuyoshi Fukuda, Shoichi Washizuka, Satao Yashiro, Shigeoki Takami, Masahiro Nakajima, and Masayuki Watanabe	
COMPARISON OF CURRENT-INDUCED MIGRATION OF Be AND C IN GaAs/AlGaAs HBTs	797
F. Ren, T.R. Fullowan, J.R. Lothian, P.W. Wisk, C.R. Abernathy, R.F. Kopf, A.B. Emerson, S.W. Downey, and S.J. Pearton	
DEVICE DEGRADATION ON A FULL-FRAME CCD IMAGE SENSOR WITH A TRANSPARENT GATE ELECTRODE	803
Biy-Cheng Hseih, S. Kosman, Y.C. Lo, K. Jayakar, M. Mehra, P. Roselle, and W.C. Chang	
ROOM TEMPERATURE LOCAL TAILORING OF ELECTRONIC PROPERTIES OF $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ BY APPLICATION OF AN EXTERNAL ELECTRIC FIELD	809
Konstantin Gartsman, Leonid Chernyak, Jean Marc Gilet, Robert Triboulet, and David Cahen	
IMPROVEMENT OF GATE OXIDE INTEGRITY CHARACTERISTICS IN CZ-GROWN Si CRYSTALS BY $\text{H}_2$ ANNEALING	815
N. Adachi, H. Nishikawa, Y. Komatsu, H. Hourai, M. Sano, and T. Shigematsu	
<b>PART VIII: QUANTUM WELLS, SUPERLATTICES AND INTERFACES</b>	
*VACANCY PROMOTED INTERDIFFUSION IN QUANTUM WELLS AND APPLICATIONS TO OPTOELECTRONIC DEVICES	823
M. Ghisoni, A.W. Rivers, K. Lee, G. Parry, X. Zhang, A. Staton-Bevan, M. Pate, G. Hill, C. Button, and J.S. Roberts	
*CONTROL OF ORDERING-DISORDERING DEFECT PARAMETERS FOR THE REALIZATION OF EFFICIENT OPTO-ELECTRONIC DEVICES	835
J.P. André and P. Bellon	

*VISIBLE LUMINESCENCE FROM SILICON: QUANTUM CONFINEMENT OR SILOXENE? M.S. Brandt, H.D. Fuchs, A. Höpner, M. Rosenbauer, M. Stutzmann, J. Weber, M. Cardona, and H.J. Queisser	849
A CONSISTENT MODEL FOR DISORDERING OF GaAs/AlAs-SUPERLATTICES DURING ZINC DIFFUSION H. Zimmermann, T.Y. Tan, and U. Goesele	861
MECHANISMS FOR N-TYPE IMPURITY-INDUCED DISORDERING OF AlGaAs/GaAs SUPERLATTICES B.L. Olmsted, S.N. Houde-Walter, and R. Enrique Viturro	867
DISORDERING AND CHARACTERIZATION STUDIES OF <sup>69</sup> GaAs/ <sup>71</sup> GaAs ISOTOPE SUPERLATTICE STRUCTURES: THE EFFECT OF OUTDIFFUSION OF THE SUBSTRATE DOPANT Si T.Y. Tan, H.M. You, S. Yu, U.M. Göesele, W. Jäger, F. Zypman, R. Tsu, and S.-T. Lee	873
HYDROGEN PASSIVATION OF DEFECTS IN InGaAs/Al <sub>x</sub> Ga <sub>1-x</sub> As QUANTUM WELLS S.M. Lord, G. Roos, B. Pezeshki, J.S. Harris, Jr., and N.M. Johnson	881
ELECTRON ACCUMULATION IN AlGaSb/InAs QW SYSTEM — EVIDENCE FOR COEXISTENCE OF DEEP ACCEPTOR AND DONOR S. Ideshita, A. Furukawa, Y. Mochizuki, and M. Mizuta	887
EFFECT OF Al COMPOSITION ON THE DEEP LEVEL DONORS OF Al <sub>x</sub> Ga <sub>1-x</sub> Sb/InAs SINGLE QUANTUM WELLS Ikai Lo, W.C. Mitchel, C.E. Stutz, K.R. Evans, and M.O. Manasreh	893
EFFECT OF LT GaAs ON EPITAXIAL Al/GaAs SCHOTTKY DIODE CHARACTERISTICS Kai Zhang and D.L. Miller	899
EFFECTS OF RAPID THERMAL ANNEALING ON Si <sub>n</sub> CAPPED MBE GaAs Akira Ito, Akira Usami, Hiroyuki Ueda, Hiroyuki Kano, and Takao Wada	905
THE DIFFUSIVITY-MOBILITY RATIO UNDER STRONG MAGNETIC FIELD IN SMALL GAP SUPERLATTICES WITH GRADED STRUCTURES Kamakhya P. Ghatak and Badal De	911
<b>PART IX: GETTERING AND RELATED PHENOMENA</b>	
*MECHANISMS OF TRANSITION-ELEMENT-GETTERING IN SILICON Dieter Gilles	917
*DEFECT CONTROL IN Cz SILICON F.G. Kirscht, S.B. Kim, J.J. Yeh, P.D. Wildes, and P. Zaumseil	929
*GETTERING AND GETTERING STABILITY OF METALS AT OXIDE PARTICLES IN SILICON R. Falster, Z. Laczik, G.R. Booker, A.R. Bhatti, and P. Török	945
RELAXATION-INDUCED GETTERING OF METAL IMPURITIES IN SILICON: MICROSCOPIC PROPERTIES OF EFFECTIVE GETTERING SITES M. Seibt	957
INTRINSIC GETTERING OF IRON IN CZOCHRALSKI SILICON CRYSTALS M. Aoki, A. Hara, and A. Ohsawa	963

\*Invited Paper

INFLUENCE OF RAPID THERMAL ANNEALING ON RECOMBINATION PROPERTIES OF POLYCRYSTALLINE SILICON M. Kittler and W. Seifert	969
GETTERING OF DISSOLVED AND SEGREGATED IMPURITIES IN MULTICRYSTALLINE SILICON WAFERS M. Stemmer, I. Perichaud, and S. Martinuzzi	975
USE OF POROUS SILICON TO MINIMIZE OXIDATION INDUCED STACKING FAULT DEFECTS IN SILICON S.-Y. Shieh and J.W. Evans	981
PHOSPHORUS GETTERING BY RAPID THERMAL PROCESSING Bouchaib Hartiti, Abdelilah Slaoui, Jean-Claude Muller, and Paul Siffert	987
THE EFFECTS OF IRON CONTAMINATION ON THIN OXIDE BREAKDOWN — EXPERIMENTAL AND MODELING Worth B. Henley, Lubek Jastrzebski, and Nadim F. Haddad	993
ELECTRONIC THEORY OF GETTERING AND PASSIVATION OF IMPURITIES IN SEMICONDUCTORS K. Masuda-Jindo	999
IMPURITY GETTERING IN SILICON BY THIN POLYCRYSTALLINE FILMS Y. Hayamizu, S. Ushio, and T. Takenaka	1005
EFFECTS OF LAMP PULSES ON THE OXYGEN-PRECIPI-TATION-GETTERING OF Cr IN CZOCHRALSKI GROWN Si N-E. Chabane-Sari, S. Krieger-Kaddour, C. Vinante, and D. Barbier	1011
H STATES, IMPURITY PASSIVATION AND GETTERING STUDIES IN H-IMPLANTED Si CRYSTALS Bulat N. Mukashev and Serikbol Zh. Tokmoldin	1017
<b>PART X: ION IMPLANTATION, DRY PROCESSING AND RADIATION EFFECTS</b>	
*DEFECTS INTRODUCED BY PLASMA PROCESSING OF SILICON J.L. Benton	1027
DAMAGE TO CRYSTALLINE SILICON FOLLOWING IMPLANTATION BY LOW ENERGY SILICON IONS Y. Levin, N. Herbots, and S. Dunham	1037
EFFECTS OF SILICON ION IMPLANTATION UPON THIN GATE OXIDE INTEGRITY G.-S. Lee, J.-G. Park, S.-P. Choi, C.-H. Shin, Y.-B. Sun, Y.-S. Kwak, C.-K. Shin, W.L. Smith, and S. Hahn	1043
PASSIVATION OF ION-BEAM-INDUCED DEFECTS AT AND AROUND THE Si-SiO <sub>2</sub> INTERFACE BY ION BEAM HYDROGENATION S. Kar, K. Srikanth, and S. Ashok	1049
B <sup>+</sup> , P <sup>+</sup> , As <sup>+</sup> AND Si <sup>+</sup> ION IMPLANTATION INDUCED DEFECTS IN SILICON STUDIED BY A VARIABLE-ENERGY POSITRON BEAM Jun Sugiura, Makoto Ogasawara, Akira Uedono, Long Wei, and Shoichiro Tanigawa	1055
DEFECT FORMATION BY ION IMPLANTATION IN Cz-Si STUDIED BY A MONOENERGETIC POSITRON BEAM A. Uedono, Y. Ujihira, L. Wei, Y. Tabuki, S. Tanigawa, J. Sugiura, M. Ogasawara, and M. Tamura	1061

NONCONTACT CHARACTERIZATION FOR ULTRAVIOLET LIGHT IRRADIATION EFFECT ON Si-SiO <sub>2</sub> INTERFACE K. Katayama and F. Shimura	1067
DRY ETCHING OF INDIUM PHOSPHIDE P. Bond, D. Sengupta, Kevin G. Orrman-Rossiter, G.K. Reeves, and P.J.K. Paterson	1073
GENERATION OF DEFECTS AND STRAIN BY ION IMPLANTATION IN Ge(100) SINGLE CRYSTALS, AND IN PSEUDOMORPHIC Ge <sub>x</sub> Si <sub>1-x</sub> FILMS GROWN ON Si(100) D.Y.C. Lie, A. Vantomme, F. Eisen, M.-A. Nicolet, V. Arbet-Engels, and K.L. Wang	1079
SIMULTANEOUS IMPLANT ACTIVATION AND ISOLATION FORMATION IN GaAs IN A SINGLE HIGH-TEMPERATURE ANNEAL Kei-Yu Ko, S. Chen, G. Braunstein, L.-R. Zheng, and S.-T. Lee	1085
DOPANT DEPENDENT EXTENDED DEFECT NUCLEATION AND GROWTH KINETICS IN SILICON DURING 1 MeV ELECTRON IRRADIATION Albert Romano-Rodriguez and Jan Vanhellemont	1091
STUDIES OF THE EFFECTS OF ION-IMPLANTATION AND ELECTRON BEAM IRRADIATION ON CuInSe <sub>2</sub> SINGLE CRYSTALS C.A. Mullan, C.J. Kiely, A. Rockett, M. Imanieh, M.V. Yakushev, and R.D. Tomlinson	1097
FORMATION OF END-OF-RANGE DEFECTS IN SILICON AT LOW TEMPERATURES M. Seibt, J. Imschweiler, and H.-A. Hefner	1103
ELECTRONIC LEVELS AND PROPERTIES OF THE SELFINTERSTITIALS IN IRRADIATED SILICON Kh.A. Abdullin, B.N. Mukashev, M.F. Tamendarov, and T.B. Tashenov	1109
THE GROWTH OF EFFECTIVE POTENTIAL BARRIER HEIGHT IN Au/(100) n-GaP CONTACT INDUCED BY PHOSPHOROUS ION IMPLANTATION Anatol I. Ivashchenko, F.Ya. Kopanskaya, A.I. Solomonov, and V.P. Tarchenko	1115
ION IMPLANTATION DEFECT CHARACTERIZATION BY HIGH-RESOLUTION X-RAY DIFFRACTION Jos G.E. Klappe, István Bársony, and Tom W. Ryan	1121
VACANCY-TYPE DEFECTS IN PROTON-BOMBARDED InP C. Ascheron, R. Krause, A. Polity, H. Sobotta, and V. Riede	1127
AUTHOR INDEX	1133
SUBJECT INDEX	1139