



# International Conference on Defects in Semiconductors 2013

Proceedings of the 27th International Conference on Defects  
in Semiconductors, ICDS-2013

---

## **Bologna, Italy**

21-26 July 2013

### **Editors**

**Anna Cavallini**

University of Bologna, Bologna, Italy

**Stefan K. Estreicher**

Texas Tech University, Texas, USA

All papers have been peer reviewed.

### **Sponsoring Organizations**

Fraunhofer Institute for Solar Energy (ISE)

Department of Physics and Astronomy of the University of Bologna

Enrico Fermi Center



Melville, New York, 2014  
AIP Proceedings

Volume 1583

## Editors

### Anna Cavallini

University of Bologna  
Department of Physics and Astronomy  
Viale Berti Pichat 6/2  
40127 Bologna  
Italy

E-mail: [anna.cavallini@unibo.it](mailto:anna.cavallini@unibo.it)

### Stefan K. Estreicher

Texas Tech University  
Physics Department  
Lubbock, TX 79409-1051  
USA

E-mail: [stefan.estreicher@ttu.edu](mailto:stefan.estreicher@ttu.edu)

Schematic portion of  $\text{SnO}_2$  containing a Sn interstitial. Larger (blue) atoms represent O, smaller (black) atoms represent Sn, with the Sn interstitial shown in pink. "Special" O sites are shown in green and are labeled 1, 2, 3.

Authorization to photocopy items for internal or personal use, beyond the free copying permitted under the 1978 U.S. Copyright Law (see statement below), is granted by the AIP Publishing LLC for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$30.00 per copy is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923, USA: <http://www.copyright.com>. For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Services is: 978-0-7354-1215-6/14/\$30.00



© 2014 AIP Publishing LLC

No claim is made to original U.S. Government works.

Permission is granted to quote from the AIP Conference Proceedings with the customary acknowledgment of the source. Republication of an article or portions thereof (e.g., extensive excerpts, figures, tables, etc.) in original form or in translation, as well as other types of reuse (e.g., in course packs) require formal permission from AIP Publishing and may be subject to fees. As a courtesy, the author of the original proceedings article should be informed of any request for republication/reuse. Permission may be obtained online using RightsLink. Locate the article online at <http://proceedings.aip.org>, then simply click on the RightsLink icon/"Permissions/Reprints" link found in the article abstract. You may also address requests to: AIP Publishing Office of Rights and Permissions, Suite 1N01, 2 Huntington Quadrangle, Melville, NY 11747-4502, USA; Fax: 516-576-2450; Tel.: 516-576-2268; E-mail: [rights@aip.org](mailto:rights@aip.org).

ISBN 978-0-7354-1215-6  
ISSN 0094-243X  
Printed in the United States of America

*AIP Conference Proceedings, Volume 1583*  
**International Conference on Defects in Semiconductors 2013**  
**Proceedings of the 27th International Conference on Defects in Semiconductors,**  
**ICDS-2013**

**Table of Contents**

<b>Preface: 27th International Conference on Defects in Semiconductors (ICDS-2013)</b> Anna Cavallini and Stefan K. Estreicher	1
<b>DEFECTS IN SI AND GE</b>	
<b>Donor-vacancy pairs in irradiated n-Ge: A searching look at the problem</b> Vadim Emtsev and Gagik Oganessian	3
<b>Stress and doping impact on intrinsic point defects in silicon and germanium</b> Jan Vanhellefont, Eiji Kamiyama, and Koji Sueoka	8
<b>Anharmonic local vibration of carbon in crystalline silicon</b> Hiroshi Yamada-Kaneta and Haruhiko Ono	13
<b>Behavior of nitrogen in Si crystal during irradiation and post-annealing</b> Naohisa Inoue, Hidenori Oyama, Kaori Watanabe, Hirofumi Seki, and Yuichi Kawamura	19
<b>Influence of the doping on the lattice sites of Fe in Si</b> D. J. Silva, U. Wahl, J. G. Correia, and J. P. Araújo	24
<b>The effect of dipole boron centers on the electroluminescence of nanoscale silicon p<sup>+</sup>-n junctions</b> Nikolay Bagraev, Leonid Klyachkin, Roman Kuzmin, Anna Malyarenko, and Vladimir Mashkov	28
<b>Carrier transport on dislocations in silicon</b> M. Reiche, M. Kittler, H.-M. Krause, and H. Übensee	33
<b>Laplace DLTS investigation of transition metal-hydrogen complexes in germanium</b> Y. Gurinskaya and A. Mesli	37
<b>Cascade phonon-assisted trapping of positrons by divacancies in n-FZ-Si(P) single crystals irradiated with 15 MeV protons</b> N. Yu. Arutyunov, V. V. Emtsev, R. Krause-Rehberg, C. Kessler, M. Elsayed, G. A. Oganessian, and V. V. Kozlovski	41

<b>Transient luminescence induced by electrical refilling of charge carrier traps of dislocation network at hydrophilically bonded Si wafers interface</b>	46
Anton Bondarenko and Oleg Vyvenko	
<b>Hydrogen decoration of radiation damage induced defect structures</b>	51
S. Kirnstötter, M. Faccinelli, W. Schustereder, J. G. Laven, H.-J. Schulze, and P. Hadley	
<b>Transition dynamics for Mu acceptor states in Si<sub>1-x</sub>Ge<sub>x</sub> alloys</b>	56
G. Jayarathna, R. L. Lichti, P. W. Mengyan, Y. G. Celebi, B. B. Baker, B. R. Carroll, and I. Yonenaga	
<b>Surface-induced charge at the Ge (001) surface and its interaction with self-interstitials</b>	60
Eiji Kamiyama, Koji Sueoka, and Jan Vanhellemont	
<b>Extended defect generation by Xenon implantation in silicon</b>	64
I. Mica, M. L. Polignano, A. G. Mauri, D. Codegoni, S. Grasso, C. Pozzi, V. Soncini, P. Targa, and K. Vad	
<b>Dynamics of hydrogen in silicon</b>	69
Koun Shirai, Ikutaro Hamada, and Hiroshi Katayama-Yoshida	
<b>The interaction between divacancies and shallow dopants in irradiated Ge:Sn</b>	75
L. I. Khirunencko, Yu. V. Pomezov, M. G. Sosnin, N. V. Abrosimov, and H. Riemann	
<b>Ferromagnetic ordering of Cr and Fe doped <i>p</i>-type diamond: An <i>ab initio</i> study</b>	80
E. M. Benecha and E. B. Lombardi	
<b>Has substitutional nickel two acceptor- and one donor-level in Si?</b>	85
L. Scheffler, VI. Kolkovsky, and J. Weber	
<b>Structural and luminescent properties of electron-irradiated silicon</b>	90
N. A. Sobolev, P. N. Aruev, A. E. Kalyadin, E. I. Shek, V. V. Zabrodskiy, A. S. Loshachenko, K. F. Shtel'makh, V. I. Vdovin, Luelue Xiang, and Deren Yang	
<b>The influence of flash lamp annealing on the minority carrier lifetime of Czochralski silicon wafers</b>	94
G. Kissinger, D. Kot, and A. Sattler	

<b>Complexes of self-interstitials with oxygen atoms in Ge</b>	
L. I. Khirunenko, Yu. V. Pomozov, M. G. Sosnin, N. V. Abrosimov, and H. Riemann	100
<b>Pd-vacancy complex in Ge: TDPAC and ab initio study</b>	
Adurafimihan A. Abiona, Williams Kemp, and Heiko Timmers	105
<b>HRTEM and XPS study of nanoparticle formation in Zn<sup>+</sup> ion implanted Si</b>	
Vladimir V. Privezentsev, Natalya Yu. Tabachkova, and Yurii Yu. Lebedinskii	109
<b>Effect of dynamics on the elastic softening of vacancies in Si</b>	
Koun Shirai and Jun Ishisada	114
<b>Effects of Sb doping on strain relaxation in SiGe film on Si substrate</b>	
Yoshifumi Yamashita, Kan Tanemoto, Akihiro Tanaka, and Tatsuya Fushimi	119
<b>Formation and annealing of boron-oxygen defects in irradiated silicon and silicon-germanium n<sup>+</sup>-p structures</b>	
L. F. Makarenko, S. B. Lastovskii, F. P. Korshunov, M. Moll, I. Pintilie, and N. V. Abrosimov	123
<b>DEFECTS IN COMPOUND SEMICONDUCTORS</b>	
<b>Carrier-capture characteristics of point defects in GaN and ZnO</b>	
Michael A. Reshchikov	127
<b>Structural investigation of the C-O complex in GaAs</b>	
H. Ch. Alt, A. Kersch, and H. E. Wagner	132
<b>Nanoscale order in ZnSe:(Mg, O)</b>	
Vyacheslav A. Elyukhin	136
<b>Surface defect states in MBE-grown CdTe layers</b>	
Karolina Olender, Tadeusz Wosinski, Krzysztof Fronc, Zbigniew Tkaczyk, Sergij Chusnutdinow, and Grzegorz Karczewski	140
<b>Investigation of deep level defects in CdTe thin films</b>	
H. Shankar, A. Castaldini, E. Dieguez, E. Dauksta, A. Medvid, S. Rubio, and A. Cavallini	145
<b>Ordered defect compounds in CuInSe<sub>2</sub> for photovoltaic solar cell application</b>	
K. Sato and H. Katayama-Yoshida	150
<b>Irradiation and annealing of p-type silicon carbide</b>	
Alexander A. Lebedev, Elena V. Bogdanova, Maria V. Grigor'eva, Sergey P. Lebedev, and Vitaly V. Kozlovski	156

<b>Electrical and optical properties of stacking faults introduced by plastic deformation in 4H-SiC</b>	161
B. Pichaud, G. Regula, and E. B. Yakimov	
<b>Interface defects in SiC power MOSFETs - An electrically detected magnetic resonance study based on spin dependent recombination</b>	165
Gernot Gruber, Peter Hadley, Markus Koch, Dethard Peters, and Thomas Aichinger	
<b>Reassignment of the <math>O_{Se}-V_{Cd}</math> complex in CdSe</b>	169
Dirk Bastin, E. V. Lavrov, and J. Weber	
<b>Defect studies in MBE grown <math>GaSb_{1-x}Bi_x</math> layers</b>	174
N. Segercrantz, J. Kujala, F. Tuomisto, J. Slotte, Y. Song, and S. Wang	
<b>Thickness dependence of electrical transport: A test for surface conduction in topological insulators</b>	178
Sourabh Barua and K. P. Rajeev	
<b>DEFECTS IN MAGNETIC SEMICONDUCTORS</b>	
<b>Magnetic domain wall manipulation in (Ga,Mn)As nanostructures for spintronic applications</b>	182
Tadeusz Wosinski, Tomasz Andrearczyk, Tadeusz Figielski, Karolina Olender, Jerzy Wrobel, and Janusz Sadowski	
<b>Magneto-optical properties and recombination dynamics of isoelectronic bound excitons in ZnO</b>	186
S. L. Chen, W. M. Chen, and I. A. Buyanova	
<b>Magnetic fields and fluctuations in weakly Mn doped <math>ZnGeP_2</math></b>	190
P. W. Mengyan, R. L. Lichti, Y. G. Celebi, B. B. Baker, B. R. Carroll, E. Catak, K. T. Zawilski, and P. G. Schunemann	
<b>ADVANCED DEFECT CHARACTERIZATION</b>	
<b>Metastable hydrogen-related defects in epitaxial n-GaAs studied by Laplace deep level transient spectroscopy</b>	195
O. A. Soltanovich, Vl. Kolkovsky, E. B. Yakimov, and J. Weber	
<b>Recombination, emission and EBIC contrast of metallic precipitate embedded in a semiconductor matrix</b>	199
R-J Tarento, M. Debez, D. E. Mekki, and A. Djemel	
<b>Nonradiative coherent carrier captures and defect reaction at deep-level defects via phonon-kick mechanism</b>	204
Masaki Wakita, Kei Suzuki, and Yuzo Shinozuka	

<b>Injection dependent lifetime spectroscopy with a varying pulse length</b>	208
Nadine Schüler, Kay Dornich, and Jürgen R. Niklas	
<b>Metastable light induced defects in pentacene</b>	212
R. Liguori, S. Aprano, and A. Rubino	
<b>Controlling ferromagnetism of (In,Fe)As semiconductors by electron doping</b>	217
Nguyen Dang Vu, Tetsuya Fukushima, Kazunori Sato, and Hiroshi Katayama-Yoshida	
<b>Characterization of few-layered graphene grown by carbon implantation</b>	221
Kin Kiong Lee, Jeffrey C. McCallum, and David N. Jamieson	
<b>First-principles core-level X-ray photoelectron spectroscopy calculation on arsenic defects in silicon crystal</b>	226
Hiroki Kishi, Miki Miyazawa, Naoki Matsushima, and Jun Yamauchi	
<b>DEFECTS IN NANOSTRUCTURES</b>	
<b>Solid phase epitaxial regrowth of germanium containing nanoporous structures formed by ion implantation</b>	230
B. C. Johnson, L. Deam, K. K. Lee, S. Rubanov, and J. C. McCallum	
<b>Photoluminescence of ZnO–SiO<sub>2</sub> nanocomposite and its excitation wavelength dependence</b>	235
K. Sowri Babu, A. R. C. Reddy, Ch. Sujatha, and K. V. G. Reddy	
<b>Negative-U centers as a basis of topological edge channels</b>	238
Nikolay Bagraev, Eduard Danilovskii, Wolfgang Gehlhoff, Leonid Klyachkin, Andrey Kudryavtsev, Anna Malyarenko, and Vladimir Mashkov	
<b>N-V<sub>Si</sub>-related center in non-irradiated 6H SiC nanostructure</b>	243
Nikolay Bagraev, Eduard Danilovskii, Dmitrii Gets, Ekaterina Kalabukhova, Leonid Klyachkin, Anna Malyarenko, Dariya Savchenko, and Bella Shanina	
<b>Deep-level transient spectroscopy of InAs/GaAs quantum dot superlattices</b>	248
M. M. Sobolev, V. N. Nevedomskii, R. V. Zolotareva, A. P. Vasil'ev, and V. M. Ustinov	
<b>Transport and optical properties of c-axis oriented wedge shaped GaN nanowall network grown by molecular beam epitaxy</b>	252
H. P. Bhasker, Varun Thakur, Manoj Kesaria, S. M. Shivaprasad, and S. Dhar	

<b>Electrically-detected ESR in silicon nanostructures inserted in microcavities</b>	
Nikolay Bagraev, Eduard Danilovskii, Wolfgang Gehlhoff, Dmitrii Gets, Leonid Klyachkin, Andrey Kudryavtsev, Roman Kuzmin, Anna Malyarenko, Vladimir Mashkov, and Vladimir Romanov	259
<b>Defect level characterization of silicon nanowire arrays: Towards novel experimental paradigms</b>	
Stefania Carapezzi, Antonio Castaldini, Alessia Irrera, and Anna Cavallini	263
<b>Low energy electron beam irradiation effect on optical properties of nanopillar MQW InGaN/GaN structures</b>	
E. B. Yakimov, P. S. Vergeles, A. Y. Polyakov, Dae-Woo Jeon, and In-Hwan Lee	268
<b>Defect properties of ZnO nanowires</b>	
J. E. Stehr, M. Devika, N. Koteswara Reddy, C. W. Tu, W. M. Chen, and I. A. Buyanova	272
<b>DEFECTS IN NITRIDES</b>	
<b>The Mg impurity in nitride alloys</b>	
M. E. Zvanut, W. R. Willoughby, U. R. Sunay, D. D. Koleske, A. A. Allerman, Ke Wang, Tsutomu Araki, and Yasushi Nanishi	277
<b>Carrier capture efficiency in InGaN/GaN LEDs: Role of high temperature annealing</b>	
Vinattieri, F. Batignani, F. Bogani, M. Meneghini, G. Meneghesso, E. Zanoni, D. Zhu, and C. J. Humphreys	282
<b>Surface photovoltage in heavily doped GaN:Si,Zn</b>	
J. D. McNamara, A. Behrends, M. S. Mohajerani, A. Bakin, A. Waag, A. A. Baski, and M. A. Reshchikov	287
<b>Temperature dependence of photoconductivity in Zn-doped GaN</b>	
Michael A. Reshchikov	292
<b>Charge transfer in Fe-doped GaN: The role of the donor</b>	
Ustun Sunay, J. Dashdorj, M. E. Zvanut, J. G. Harrison, J. H. Leach, and K. Udary	297
<b>Electrical properties of dislocations in III-Nitrides</b>	
D. Cavalcoli, A. Minj, S. Pandey, and A. Cavallini	301
<b>Tunnel optical radiation in <math>\text{In}_x\text{Ga}_{1-x}\text{N}</math></b>	
Dimiter Alexandrov and Shawn Skerget	305



<b>Reaction-kinetics model for threading dislocation density reduction in GaN porous layer</b> D. M. Artemiev, T. S. Orlova, V. E. Bougrov, M. A. Odnoblyudov, and A. E. Romanov	310
<b>Microscopic, electrical and optical studies on InGaN/GaN quantum wells based LED devices</b> Geeta Rani Mutta, Giulia Venturi, Antonio Castaldini, Anna Cavallini, Matteo Meneghini, Enrico Zanoni, Gaudenzio Meneghesso, Dandan Zhu, and Colin Humphreys	315
<b>DEFECTS IN OXIDES</b>	
<b>Defects and persistent conductivity in SrTiO<sub>3</sub></b> Matthew D. McCluskey and Marianne C. Tarun	319
<b>Motional characteristics of positively charged muonium defects in In<sub>2</sub>O<sub>3</sub></b> B. B. Baker, Y. G. Celebi, R. L. Lichti, P. W. Mengyan, and E. Catak	323
<b>Electroluminescence from ZnO/Si heterojunctions fabricated by PLD with bias voltage application</b> Yuuki Seno, Daisuke Konno, Takao Komiyama, Yasunori Chonan, Hiroyuki Yamaguchi, and Takashi Aoyama	327
<b>Defect-induced magnetism in cobalt-doped ZnO epilayers</b> G. Ciatto, A. Di Trolino, E. Fonda, P. Alippi, A. Polimeni, M. Capizzi, G. Varvaro, and A. Amore Bonapasta	332
<b>Annealing effects of ZnO nanoparticles on photoluminescence spectra</b> S. Seto, S. Yamada, and K. Suzuki	337
<b>Hydrogen at zinc vacancy of ZnO: An EPR and ESEEM study</b> N. T. Son, J. Isoya, I. G. Ivanov, T. Ohshima, and E. Janzén	341
<b>Confirmation of freely rotating H<sub>2</sub> in ZnO</b> S. G. Koch, E. V. Lavrov, and J. Weber	345
<b>Piezospectroscopic study of substitutional Ni in ZnO</b> E. V. Lavrov, F. Herklotz, and Y. S. Kutin	350
<b>Experimental evidence of V<sub>O</sub>-Zn<sub>i</sub> complex to be intrinsic donor in bulk ZnO</b> M. Asghar, K. Mahmood, M.-A. Hasan, R. Tsu, and I. T. Ferguson	355
<b>Contrasting the theoretical properties of hydrogen in SnO<sub>2</sub>, In<sub>2</sub>O<sub>3</sub>, and TiO<sub>2</sub></b> W. Beall Fowler, Michael Stavola, and Figen Bekisli	359

<b>Effect of post-deposition annealing on structural and optical properties of RF magnetron sputtered <math>\beta</math>-Ga<sub>2</sub>O<sub>3</sub> films</b>	
R. Aida, K. Minami, K. Ishibashi, J. Kudou, M. Takahara, I. Tsunoda, K. Takakura, T. Nakashima, M. Shibuya, and K. Murakami	364
<b>Vacancy complexes in Sb-doped SnO<sub>2</sub></b>	
E. Korhonen, F. Tuomisto, O. Bierwagen, J. S. Speck, M. E. White, and Z. Galazka	368
<b>Author Index</b>	372