2016 21st International Conference on Ion Implantation Technology (IIT 2016)

Tainan, Taiwan
26-30 September 2016

IEEE Catalog Number: CFP1644Y-POD
ISBN: 978-1-5090-2025-6

Copyright © 2016 by the Institute of Electrical and Electronics Engineers, Inc
All Rights Reserved

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

****** This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP1644Y-POD
ISBN (Print-On-Demand):	978-1-5090-2025-6
ISBN (Online):	978-1-5090-2024-9

Additional Copies of This Publication Are Available From:

Curran Associates, Inc
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: (845) 758-0400
Fax: (845) 758-2633
E-mail: curran@proceedings.com
Web: www.proceedings.com

Table of Contents

PREFACE ix

IN MEMORIAM x

INTERNATIONAL COMMITTEE xi

TECHNICAL PROGRAM COMMITTEE xii

SPONSORS xiii

SUPPORTING INSTITUTIONS xiv

Technical Papers

SEMICONDUCTOR DEVICES & PROCESS

Moore's Law Continues into the 1x-nm Era 1
Dick James

Implant and Anneal Technologies for Memory and CMOS Devices 11
Seung Woo Jin, J. C. Cha, H. S. Lee, S. H. Son, B. G. Kim and Y. S. Jung

Power Device Implants 16
Werner Schustereder

Ion Implantation Technology for Image Sensors 21
Nobukazu Teranishi

High & Low Dose USJ Implantation into Ge-Epi on Si Wafers: Dopant Activation, Damage Recovery and Mobility Effects 27
John Borland, Michiro Sugitani, Joshua Herman, Karium Huet, Walt Johnson, Lu Yu and Abhijeet Joshi

Surface Strained Ge-Cz Wafers by Sn-Implantation for High Electron and Hole Mobility 31
John Borland, Michiro Sugitani, S. S. Chaung, Y. J. Lee, Karim Huet, Abhijeet Joshi, Alan Wan, Larry Wong, Peter Horvath and Andrew Finley

Comparison of Experimental Emitter Saturation Current Densities and Simulated Defect Densities of Boron-Implanted Emitters 35
Jan Krügener, H. Jörg Osten, Fabian Kiefer and Robby Peibst

Electrical Deactivation of Boron in p+-Polycrystalline Silicon/SiOx/Crystalline Silicon Passivating Contacts for Silicon Solar Cells 39
Jan Krügener, Dominic Tetzlaff, Yvo Barnscheidt, Yevgeniya Larionova, Sina Reiter, Mircea Turcu, Tobias Wietler, Robby Peibst, Uwe Höhne and Jan-Dirk Kähler

ION BEAM PROCESSING

Modification of Biomaterials and Biomedical Devices by Plasma Immersion Ion Implantation & Deposition and Related Techniques 43
Paul K. Chu

Challenges and Solutions of 2-D (3-D) Device Doping Process and Doping Profiling Metrology 48
Shu Qin

Channeling, Self-PAI, and Self-Sputtering Effects of Ion Implantation versus Ion Species, Energy, and Dose - Data and Modeling 54
Shu Qin

Surface Modification and Activation with Gas Cluster Ion Beam 59
Tomoya Sasaki, Noriaki Toyoda and Isao Yamada

Effect of Ion Flux in Source-Drain Extension Ion Implantation for 10-nm Node FinFET and beyond on 300/450mm Platforms 62
Ming-Yi Shen, Adarsh Basavalingappa, Takeshi Hayakawa, Hidekazu Matsugi, Christopher Borst and Stock Chang

Investigation of Floating Gate Implantation Effect on 1Xnm NAND FLASH 66
Jeng-Hwa Liao, Zong-Jie Ko, Hsing-Ju Lin, Jung-Yu Hsieh, Ling-Wu Yang, Tahone Yang, Kuang-Chao Chen and Chih-Yuan Lu

A Hybrid Implant Doping Technique with Plasma Immersion Ion Implant (PIII) Process for 10 nm Fin Cannel of 3D-FET 69
Yi-Ju Chen, Ying-Tsan Tang, Chang-Hsien Lin, Chun-Chi Chen, Julian Duchaine, Yohann Spiegel, Frank Torregrossa, Laurent Roux, Jason Chen, Yun-Jie Wei, Yao-Ming Huang, Min-Chuan Hsiao, Yen-Chang Chen, Kai-Shin Li, Yao-Jen Lee, Min-Cheng Chen, Jia-Ming Shie and Wen-Kuan Yeh

Ion Implantation for Photovoltaic Applications: Review and Outlook for n-Type Silicon Solar Cells 72
Jan Krügener, H. Jörg Osten, Fabian Kiefer, Felix Haase and Robby Peibst

Fracture in Epitaxial InP on Si for InGaAs on Insulator Fabrication via Smart Cut™ 77
F. Mazen, S. Sollier, F. Madeira, F.-X. Darras, C. Veytizou, G. Gaudin, N. Rochat, J. P. Barnes, J. Widiez, S. Guissi and B. Colombeau

Ion Implantation of Polypropylene Films for the Manufacture of Thin Film Capacitors 81
Volker Häublein, Erwin Birnbaum, Heiner Ryssel, Lothar Frey and Märit Djupmyr

Phosphorus-Implanted Emitter Crystalline Silicon Solar Cell with AL-BSF 85
Katsuto Tanahashi, Masaaki Moriya, Yasuhiro Kida, Satoshi Utsunomiya, Tetsuo Fukuda, Katsuhiko Shirasawa and Hidetaka Takato

Surface Modification of PEEK with Gas Cluster Ion Beam Irradiation 89
Yuki Uozumi, Noriaki Toyoda and Isao Yamada

Sheet Resistance Dependence on Ion Angle Deviation 92
Yoji Kawasaki, Kazutaka Tsukahara, Makoto Sano, Sho Kawatsu, Masazumi Koike, Hiroyuki Kariya and Mitsuaki Kabasawa

Change of V-Curve Behavior Depending on Ion Angle Deviation in Channeling Condition 96
Makoto Sano, Kazutaka Tsukahara, Sho Kawatsu, Yoji Kawasaki and Masazumi Koike

Diffusion Suppression of Delta Doped Phosphorus in Germanium by Implantation of Nitrogen 100
Alexander Scheit, Thomas Lenke and Yuji Yamamoto

A Novel Method for Simultaneous on Wafer Level Monitoring of Ion Implantation Energy and Dose 104
Moriz Jelinek, Mario Lugger, Nicolas Siedl, Werner Schustereder, Christian Krueger and Mathias Wagner

MC3 V-Curve Characteristics in Low Energy Implantation 108
Sho Kawatsu, Toshiki Miyake, Makoto Sano, Yoji Kawasaki, Kazutaka Tsukahara, Masazumi Koike, Hiroyuki Kariya and Mitsuaki Kabasawa

ION SOURCES & MATERIALS

Novel Ion Source for the Production of Extended Sheet Beams 112
Thomas N. Horsky, Sami K. Hahto and Tetsuro Yamamoto

CUSPIG Ion Source for Large and Very Large Ribbon Ion Beam Systems 116
Nicholas R. White and August O. Westner

Advances in Ion Source Life: The AMAT Trident XP Source 120
Antonella Cucchetti, Alexander Perel, Craig Chaney, David Sporleder, Wayne LeBlanc, Morgan McCarty and Bob Lindberg

A Dual Microwave Antenna Plasma Source 124
Yusuke Kuwata, Toshiro Kasuya, Naoki Miyamoto, Shun Yamamoto, Yuta Watanabe and Motoi Wada

Utilization of Metal-Organic Frameworks for the Management of Gases Used in Ion Implantation 128
G. M. Tom, W. Morris, M. H. Weston, P. E. Fuller, P. W. Siu, C. R. Murdock, J. P. Siegfried and O. K. Farha

Extraction of a Metal Ion Beam from a Planar Magnetron Sputter Ion Source 132
Motoi Wada, Shoma Kanda, Yusuke Kuwata, Naoki Miyamoto and Kentaro Yoshioka

Development of a Full Metal Seal Low Energy Ion Source 136
Yuta Watanabe, Naoki Miyamoto, Toshiro Kasuya and Motoi Wada

Exemplary Ion Source for the Implanting of Halogen and Oxygen Based Dopant Gases 140
Tseh-Jen Hsieh and Neil K. Colvin

Development of a Low Energy Carbon Molecular Ion Source 144
Shun Yamamoto, Naoki Miyamoto, Toshiro Kasuya, Magdaleno R. Vasquez Jr. and Motoi Wada

Spatial Variation of Electron Energy Distribution Functions along to Field Lines on ECRIS 148
Yushi Kato, Takuya Nishiokada, Tomoki Nagaya, Shogo Hagino, Takuro Otsuka, Takuto Watanabe and Yuto Tsuda

Spatial Distribution of Multicharged Ions from Space Potentials Measured by Probe and Beam Methods on ECRIS 152
Yushi Kato, Takuya Nishiokada, Tomoki Nagaya, Shogo Hagino, Takuro Otsuka, Takuto Watanabe and Yuto Tsuda

Developing Pure Iron Evaporator and Production of Iron Ion Beam in Tandem-Type Electron Cyclotron Resonance Ion Source 156
Shogo Hagino, Takuro Otsuka, Takuto Watanabe, Masayuki Muramatsu, Atsushi Kitagawa, Yuto Tsuda and Yushi Kato

Optimization of Mid-Electrode Potential and Extraction Gap for Miscellaneous Ion Beam from Electron Cyclotron Resonance Ion Source 160
Takuro Otsuka, Takuya Nishiokada, Tomoki Nagaya, Shogo Hagino, Takuto Watanabe, Yuto Tsuda and Yushi Kato

Influence of Beam-Extraction Structure on the Ion Energy for Ultra-Shallow Implantation 164
N. Sakudo and N. Ikenaga

Improved Multi-Cusp Ion Source to Efficiently Extract B+ Beam and PHx+ Beam 168
Hiroaki Kai, Ippei Nishimura, Yutaka Inouchi, Takeshi Matsumoto and Junichi Tatemichi

EnrichedPLUS 72Germanium Tetrafluoride (EnPLUS 72GeF4) and Hydrogen (H2) Mixture for Implanter Performance Improvement 172
Barry Chambers, Ying Tang, Steve Bishop, Thomas Morel, Marc Biossat and Joseph Sweeney

Carbon Implantation Performance Improvement by Mixing Carbon Monoxide (CO) with Carbonyl Fluoride (COF2) and Carbon Dioxide (CO2) 176
Ying Tang, Sharad Yedave, Oleg Byl, Joseph Despres, Eric Tien, Steve Bishop and Joseph Sweeney

Hydrogen Selenide (H2Se) Dopant Gas for Selenium Implantation 180
Ying Tang, Sharad Yedave, Joseph Despres, Oleg Byl and Joseph Sweeney

Investigation of Boron Gas Mixtures for Beamline Implant 184
Ying Tang, Oleg Byl, Sharad Yedave, Joseph Despres and Joseph Sweeney

UpTime® Si2H6/SiF4 Mix for High Productivity Si Implant 188
Ashwini K. Sinha, Doug C. Heiderman, Robin Chiu, Bon-Woong Koo, David Sporleder, Stanley M. Smith and Frank Sinclair

Extension of the Source Lifetime in HC Ion Implanter with Dedicated Species 191
Edwin Su, Alan Chang, Kim Wu and Joe Tsai

ION BEAM SYSTEMS & TECHNIQUES

Advancement of Ion Implanters That Enabled Moore's Law and Evolution of Semiconductor Devices 195
Hiro Ito

Doping Process and Tool for Surface Treatment Using Large-Area Ion Beams 203
Yutaka Inouchi, Takeshi Matsumoto, Junichi Tatemichi, Masashi Konishi and Masao Naito

Medium Energy High Dose Ion Implanter 209
Brian Gori, Shengwu Chang, Bill Leavitt, Dave Timberlake, Christian Krüger, Werner Schustereder, Marie Welsch, Jeff Klein and Kurt Decker-Lucke

High Current Ion Implanter "LUXiON" 213
Yusuke Kuwata, Tetsuya Igo, Kohei Tanaka, Sami K. Hahto, Tetsuro Yamamoto, Hideyasu Une, Hirofumi Asai, Masayoshi Hino, Sei Umisedo, Karuppanan Sekar, Thormas N. Horsky, Yoshiki Nakashima and Nariaki Hamamoto

U3DS, a Compact Mass-Analyzer for Large High Current-Density Ribbon Ion Beams 217
Nicholas R. White

Method of Beam Energy Adjustment by Using Beam Parallelism 221
Haruka Sasaki, Hiroyuki Kariya, Masaki Ishikawa and Michiro Sugitani

Development of Plasma Flood Gun for Gen 5.5 Implanter 225
Tomokazu Nagao, Taro Hayakawa, Genki Takahashi, Yutaka Inouchi and Junichi Tatemichi

PAS PFG: A High Emission, Long Life Ribbon Flood 229
Michael Vella, Keith Allen, Gerhard Duerrhammer, Dustin Hacker, Nam Ngo, Michael Reilly and Florian Schaper

Low-Energy Electron Generator for Wafer Charge Neutralization 232
Greg Stratoti, Larry Ficarra, James Cummings, Peter Ewing, James Carroll, Frank Sinclair and Hiro Ito

Improving Material Choices for Advanced Semiconductor Processing 237
Th. Werninghaus, B. Mayr-Schmoelzer, M. O'Sullivan, F. Schaper, D. Hacker and M. Reilly

New Material Solution for Implant Processes Containing Halogens or Oxygen 241
Th. Werninghaus, B. Mayr-Schmölzer, M. O'Sullivan, F. Schaper, D. Hacker and M. Reilly

Process Robustness against Photoresist Outgassing in Single-Wafer High-Energy Implanters 244
Hiroyuki Kariya, Yoji Kawasaki, Haruka Sasaki, Fumiaki Sato, Kazuhiro Watanabe and Michiro Sugitani

Intentional Two-Dimensional Non-Uniform Dose Implant with High Dynamic Dose Range 248
Kazuhisa Ishibashi, Shiro Ninomiya, Toshio Yumiyama, Akihiro Ochi, Akira Funai, Mitsuaki Kabasawa, Mitsukuni Tsukihara and Kazuyoshi Ueno

High-Accuracy Two-Dimensional Intentional Non-Uniform Dose Implant: MIND 2.0 252
Shiro Ninomiya, Yasuharu Okamoto, Kazuhisa Ishibashi, Toshio Yumiyama, Akihiro Ochi, Yusuke Ueno, Mitsuaki Kabasawa and Mitsukuni Tsukihara

A Beam Quality Control Method in SAion Ion Implanter 256
Shiro Ninomiya, Takanori Yagita, Kazuhisa Ishibasi, Noriyuki Suetsugu and Mitsuaki Kabasawa

Simulation Study of Implantation Angle Variation and Its Impact on Device Performance 260
Ruey-Dar Chang and Po-Heng Lin

Beam Energy Purity on Axcelis XE High Energy Ion Implanter 264
Shu Satoh and Jonathan David

Surface Dopant Concentration Modulation for FinFet Applications 268
Shao Yu Hu, Ching-I Li, Ger-Pin Lin, Edwin Su, Kim Wu, Sandeep Mehta and Steve Walther

THERMAL PROCESSING

Dopant Activation and Deactivation Phenomena during Advanced Millisecond Anneal Cycles 272
P. J. Timans, M. Hagedorn, C. Pfahler, A. Cosceev, L. Rubin, M. Zwissler and A. Joshi

Annealing Behavior of Aluminum Implanted Germanium 276
Hiroshi Onoda, Yoshiki Nakashima, Tsutomu Nagayama, Shigeki Sakai, Abhijeet Joshi and Shigeaki Zaima

Thermal Stability of Cobalt Silicide on Polysilicon Implanted with Germanium 280
Zong-Jie Ko, Jeng-Hwa Liao, Hsin-Ju Lin, Jung-Yu Hsieh, Ling-Wu Yang, Tahone Yang, Kuang-Chao Chen and Chih-Yuan Lu

Nanosecond Laser Annealing for Phosphorous Activation in Ultra-Thin Implanted Silicon-On-Insulator Substrates 283
P. Acosta Alba, S. Kerdilès, B. Mathieu, R. Kachtouli, F. Mazzamuto, I. Toqué-Trésonne, K. Huet, P. Besson, M. Veillerot, F. Aussenac and C. Fenouillet-Béranger

New Flash Lamp Annealing Tool Equipped with an Ambient Control Feature Suitable for High-k Gate Stack Anneals 287
H. Kawarazaki, A. Ueda, M. Furukawa, T. Aoyama, S. Kato and I. Kobayashi

UV Excimer Laser Annealing for Next Generation Power Electronics 291
Toshiyuki Tabata, Sébastien Halty, Inès Toqué-Trésonne, Fulvio Mazzamuto, Karim Huet and Yoshihiro Mori

Dopant Activation Control Using a Soak Pulse in Flash Lamp Annealing 295
M. Abe, K. Fuse, S. Kato, T. Aoyama and I. Kobayashi

NEW TECHNOLOGIES

Deterministic Atom Placement by Ion Implantation: Few and Single Atom Devices for Quantum Computer Technology 299
David N. Jamieson, William I. L. Lawrie, Fay E. Hudson, Andrew S. Dzurak, Andrea Morello, Simon G. Robson, A. Melvin Jakob, Brett C. Johnson and Jeff C. McCallum

Formation of 5 nm Ultra Shallow Junction on 3D Devices Structures by Ion Energy Decoupled Plasma Doping 305
Y. S. Kim, YounGi Hong and Ivan Berry

ALD Process for Dopant-Rich Films on Si 310
Thomas E. Seidel, Jeffrey W. Elam, Michael I. Current and Anil U. Mane

Characteristics of SiF4 Plasma Doping (PLAD) 314
Shu Qin, Deven Raj, Y. Jeff Hu, Allen McTeer and Helen Maynard

Low Temperature Graphene Film Formation with Ethane Cluster Ion Implantation 318
Noriaki Toyoda and Isao Yamada

AUTHOR INDEX 323