
Semiconductor Cleaning Science and Technology 12 (SCST 12)

Editors:

T. Hattori

Hattori Consulting International
Chigasaki, Japan

J. Ruzyllo

The Pennsylvania State University
University Park, Pennsylvania, USA

P. Mertens

imec
Leuven, Belgium

R. Novak

Novak Consulting
Plymouth, Minnesota, USA

Sponsoring Division:



Electronics and Photonics



Published by

The Electrochemical Society

65 South Main Street, Building D
Pennington, NJ 08534-2839, USA

tel 609 737 1902

fax 609 737 2743

www.electrochem.org

ecstransactions™

Vol. 41, No. 5

Copyright 2011 by The Electrochemical Society.
All rights reserved.

This book has been registered with Copyright Clearance Center.
For further information, please contact the Copyright Clearance Center,
Salem, Massachusetts.

Published by:

The Electrochemical Society
65 South Main Street
Pennington, New Jersey 08534-2839, USA

Telephone 609.737.1902
Fax 609.737.2743
e-mail: ecs@electrochem.org
Web: www.electrochem.org

ISSN 1938-6737 (online)
ISSN 1938-5862 (print)
ISSN 2151-2051 (cd-rom)

ISBN 978-1-56677-905-0 (Hardcover)
ISBN 978-1-60768-259-2 (PDF)

Printed in the United States of America.

Table of Contents

Preface *iii*

Chapter 1 **Front-End-of-Line Cleaning**

Cleaning Challenges and Solutions for Advanced Technology Nodes <i>P. W. Mertens, R. Vos, W. Masayuki, S. Arnauts, H. Takahashi, D. Tsvetanova, D. Cuypers, S. Sioncke, N. Valckx, S. Brems, M. Hauptmann, and M. Heyns</i>	3
Investigation of Galvanic Corrosion Characteristics between Tantalum Nitride and Poly Silicon in Dilute HF Solutions <i>R. Govindarajan, M. Keswani, and S. Raghavan</i>	15
Metal Electrode Contact Cleaning in Small Dimension Phase Change Memory <i>J. Bae, W. Lee, D. Chung, I. Hwang, D. Ahn, and S. Nam</i>	23
Challenges of Wafer Surface Preparation in Advanced Technologies <i>S. Ku, M. Yeh, K. Huang, C. Yang, C. Chen, J. Chuang, S. Jang, and D. Huang</i>	31
Galvanic Corrosion of PN Junctions during the Dielectric Removal with HF for RMG Transistors <i>A. Pacco, F. Sebaai, S. Suhard, H. Struyf, S. De Gendt, R. Vos, A. Veloso, and P. W. Mertens</i>	37
Determining the Fundamental Kinetic Parameters for Rinsing and Cleaning of Hafnium-Based High-k Materials <i>D. Zamani, M. Keswani, J. Yan, S. Raghavan, and F. Shadman</i>	45
Development of a Wet Silicon Removal Process for Replacement Metal Gate and Sacrificial Fin <i>S. Suhard, F. Sebaai, A. Pacco, A. Veloso, L. Carbonell, M. Claes, H. Struyf, P. W. Mertens, and S. De Gendt</i>	51

Chapter 2

Physical Spray Cleaning

Observation of Removal Process of Thin Metal Film on Glass Surface by Steam-Water Mixed Spray: Application to Au Film Removal in LED Manufacturing <i>T. Sanada, K. Hashimoto, A. Hayashida, and M. Watanabe</i>	59
High-Speed Droplet Impact as an Elementary Process of Physical Cleaning <i>T. Fujikawa, Y. Tatekura, K. Kobayashi, T. Sanada, A. Hayashida, and M. Watanabe</i>	67
Analysis on Threshold Energy of Particle Removal in Spray Cleaning Technology <i>M. Sato, K. Sotoku, K. Yamaguchi, T. Tanaka, M. Kobayashi, and S. Nadahara</i>	75
Integrated Experimental and Numerical Study of Thermomechanical Resist Removal-Cleaning Performance Using Cryogenic Micro-Solid Nitrogen Spray <i>J. Ishimoto, D. Tan, U. Oh, T. Kubota, and S. Samukawa</i>	83

Chapter 3

Megasonic Cleaning

Effect of Dissolved CO ₂ in De-Ionized Water in Reducing Wafer Damage During Megasonic Cleaning in MegPie <i>S. Kumari, M. Keswani, S. Singh, M. Beck, E. Liebscher, L. Q. Toan, and S. Raghavan</i>	93
Effect of Acoustic Cavitation on Dissolved Gases and their Characterization during Megasonic Cleaning <i>B. Kang, M. Kim, S. Lee, H. Sohn, and J. Park</i>	101
Lattice Boltzmann Simulation of Cavitation and Particle Behavior Induced by Sonication Transducer <i>H. Kim and T. Kim</i>	109
Design, Fabrication, and Performance Test of a Quartz Horn Megasonic Waveguide for Semiconductor Cleaning <i>H. Kim, Y. Lee, and E. Lim</i>	115

Chapter 4

EUV Mask Cleaning

Improving Megasonic Exposure Uniformity for EUV Mask Substrate Cleaning <i>M. House, A. Rastegar, D. Dussault, and E. Liebscher</i>	123
Optimization of DIO ₃ with Megasonic Cleaning of Ru Capped EUVL Mask for Effective Carbon Contaminant Removal <i>S. Lee, B. Kang, M. Kim, J. Lim, J. Jeong, and J. Park</i>	131
Cleaning Challenges of EUV Mask Substrates, Blanks, and Patterned Mask <i>A. Rastegar, M. House, and A. John Kadaksham</i>	139

Chapter 5

Non-Silicon Material Cleaning

Processing of Mechanically Polished Surfaces of Bulk GaN Substrates <i>G. Nowak, G. Kamler, J. Weyher, and I. Grzegory</i>	149
Processing and Characterization of GaSb/High-k Dielectric Interfaces <i>E. Hwang, C. Eaton, S. Mujumdar, H. Madan, A. Ali, D. Bhatia, S. Datta, and J. Ruzyllo</i>	157
Wet Cleaning and Surface Preparation for Ge <i>H. Takahashi, M. Wada, J. Snow, R. Vos, P. W. Mertens, H. Shirakawa, and S. Nadahara</i>	163
Formation of Pyramidal Etch Pits Induced by Metallic Particles on Ge(100) Surfaces in Water <i>K. Arima, T. Kawase, K. Nishitani, A. Mura, K. Kawai, J. Uchikoshi, and M. Morita</i>	171
SiGe Alloys Sensitivity to Front-End Surface Preparations <i>G. Briend, P. Garnier, D. Jeanjean, N. Breil, O. Gourhant, D. Dutartre, D. Tanon-Pellissier, Y. Campidelli, G. Bidal, and D. Levy</i>	179

Chapter 6

Wafer Drying - Related Issues

Silicon Nano-Pillar Test Structures for Quantitative Evaluation of Wafer Drying Induced Pattern Collapse <i>I. Vos, D. Hellin, J. Vertommen, M. Demand, and W. Boullart</i>	189
--	-----

Drying Performance of Single IPA Dryer to Prevent Pattern Collapse and Watermark <i>D. Eom, K. Kim, and Y. Shin</i>	197
Investigation on the Drying Dynamics of Millimetric Water Droplets: Source of Watermarks on Silicon Wafers <i>N. Belmiloud, A. Tamaddon, P. W. Mertens, X. Xu, and H. Struyf</i>	205

Chapter 7

Particle Adhesion/Removal

A New Cleaning Technology Using the Effect of Freezing Water on Wafer Surface <i>K. Miya, N. Fujiwara, M. Kato, and A. Izumi</i>	215
Effect of Pump Pulsation on Particle Contamination on Wafer Surface in Wet Cleaning System <i>J. Lim, R. Venkatesh, and J. Park</i>	221
Nano Gas Cluster Dry Cleaning for Damage Free Particle Removal <i>M. Kim, B. Kang, S. Lee, D. Yoon, H. Choi, H. Kim, T. Kim, and J. Park</i>	229
Optimization of CO ₂ Gas Cluster Generation for Cleaning Application <i>H. Choi, H. Kim, D. Yoon, J. Lee, B. Kang, M. Kim, J. Park, and T. Kim</i>	237
Effects of Varying Surface Film Thickness on Particle Adhesion in Semiconductor Material-Based Systems <i>K. M. Smith, J. Butterbaugh, and S. Beaudoin</i>	243

Chapter 8

Photoresist Removal

Interactions between Developable Bottom Anti Reflective Materials and Surface Preparations <i>P. Garnier, G. Briend, D. Jeanjean, L. Babaud, and M. May</i>	253
Plasma Strip of Cold Implant Photoresist <i>S. Luo, C. Waldfried, I. Berry, and D. Roh</i>	257
Dry Strip Removal of Si-Containing Anti-Reflective Coating Photo Resist Stacks <i>D. T. Mattson, J. DeLuca, S. Luo, J. Tracy, and D. Roh</i>	263

PR and BARC Wet Strip in BEOL Patterning Using a UV-Enabled Aqueous Process <i>E. Kesters, Q. Le, M. Lux, G. Vereecke, H. Struyf, and S. De Gendt</i>	269
--	-----

Chapter 9 Analysis and Characterization

Water Motion over a Wafer Surface Rotating in a Single-Wafer Wet Cleaner <i>H. Habuka, S. Ohashi, T. Tsuchimochi, and T. Kinoshita</i>	279
Deoxygenation of Liquids for Advanced Semiconductors Processing <i>C. Gottschalk, U. Brammer, and Y. Le Tiec</i>	287
Surface Contamination Removal from Si PV Substrates Using A Biodegradable Chelating Agent and Detection of Cleaning Endpoints Using UV/VIS Spectroscopy <i>M. George, H. Treichel, D. Bohling, A. Goldstein, H. Litvak, S. Ostrowski, I. Mowat, and W. Kern</i>	295
Characterization of Semiconductor Surfaces during Surface Conditioning and Functionalization <i>Y. J. Chabal, O. Seitz, D. Aureau, P. Thissen, and T. Peixoto</i>	303
Characterization of Post Etch Residues on Patterned Porous Low- <i>k</i> Dielectric Using Multiple Internal Reflection Infrared Spectroscopy <i>S. Rimal, N. Ross, K. S. Pillai, K. Singh, and O. Chyan</i>	315
Electrochemical Impedance Spectroscopy (EIS) Analysis of BTA Removal by TMAH during Post Cu CMP Cleaning Process <i>R. Venkatesh, H. Kim, S. Ramanathan, and J. Park</i>	323
Author Index	331