

Table of Contents

Acknowledgements

SiO₂ removal and drying

I.

Etching of Silicon Dioxide with Gas Phase HF and Water: Initiation, Bulk Etching, and Termination.

G. Montaño-Miranda and A.J. Muscat

3

Evaluation of the Plasmaless Gaseous Etching Process

Y. Hagimoto, H. Ugajin, D. Miyakoshi, H. Iwamoto, Y. Muraki and T. Orii

7

Single Wafer Hydrophobic Surface Preparation on 300mm by HF Vapor

T. Salvétat, O. Pollet, P. Besson and N. Rochat

11

Insights into HF-Last Processes and Particle Performance in a Single Wafer Spin Cleaning Tool

G. Chen and I. Kashkoush

15

Implementing an In Situ Surface Preparation Prior to Ni Deposition for Ni Salicide Processes

K.W. Chang, S. Bolton, M. Rossow, R. Gregory, J. Jiang, D. Jawarani, S. Zollner, D. Denning and J. Cheek

19

Electrical Impact of Various Arsenic-Residues Cleanings

Y.S. Tan, S.P. Chiew, Z. Yang, Z. Ismail, F. Goh, C. Lim, V. Sih, E.P. Yu and G.B. Cheng

23

Elimination of Watermark on Extremely High-Doped Poly-Silicon Surfaces Using HF-Vapor Cleaning

K.H. Lee, J. Ghekiere, J.B. Shim, E.J. Bergman, G.H. Kim, B.K. Choi, K.J. Oh and G.M. Choi

27

Surface chemistry of Si and Ge

II.

Passivation Studies of Germanium Surfaces

J.Y. Kim, J. McVittie, K. Saraswat and Y. Nishi

33

Germanium Surface Passivation Using Ozone Gaseous Phase

V. Loup, P. Besson, O. Pollet, E. Martinez, E. Richard and S. Lhostis

37

Surface States and Recombination Loss on Wet-Chemically Passivated Si Studied by Surface Photovoltage (SPV) and Photoluminescence (PL)

H. Angermann and J. Rappich

41

Surface Microroughness of Silicon in Wet Process and its Minimization

H. Morinaga, K. Shimaoka and T. Ohmi

45

Oxidation of Si Surface Utilizing SCCO₂

K. Saito, T. Kitajima, M. Kohn, I. Mizobata, T. Iwata and S. Hirae

49

Single-Wafer Wet Chemical Oxide Formation for Pre-ALD High-k Deposition on 300 mm Wafer

K. Sano, A. Izumi, A. Eitoku, J. Snow, L. Nyns, S. Kubicek, R. Singanamalla, O. Richard, T. Conard, R. Vos and P.W. Mertens

53

Effect of SC-1 Treatment in Thermal Wall Oxide on Nanoscale STI Gap-Filling by O₃/TEOS CVD

S.C. Lee, C.K. Ryu, S.W. Park, G.A. Jin, S.D. Kim, K.H. Yang, S.H. Kwak, S.H. Lim, Y.J. Kim, S.M. Park, C.S. Jang and S.K. Park

57

FEOL selective wet etching and corrosion

III.

Etch Rate Profile Characterization of High-κ Materials

A. Votta, E. Bellandi, R. Piagge, M. Caniatti, F. Pipia and M. Alessandri

63

Critical Thickness Threshold in HfO₂ Layers

P. Besson, V. Loup, T. Salvétat, N. Rochat, S. Lhostis, S. Favier, K. Dabertrand and V. Cosnier

67

Surface Preparation Challenge on Nitrided Gate Oxides P. Garnier, D. Barge, J. Bienacel, B. Tavel, N. Cabuil, D. Lévy and K. Barla	71
Development of a New TaN Etchant for Metal Gate M.S. Lee, S.Y. Kim, J.H. Cha, J.N. Han, I.S. Park, K.T. Lee, C.K. Hong, H.K. Cho and J.T. Moon	75
Peracetic Acid as Active Species in Mixtures for Selective Etching of SiGe/Si Layer Systems – Aspects of Chemistry and Analytics M. Guder, B.O. Kolbesen, C. Delattre, C. Fischer, H. Schier and G. Wagner	79
A Wet Etching Technique to Reveal Threading Dislocations in Thin Germanium Layers L. Souriau, V. Terzieva, M. Meuris and M. Caymax	83
Galvanic Corrosion of Stacked Metal Gate Electrodes during Cleaning in HF Solutions S. Garaud, R. Vos, D. Shamiryan, V. Paraschiv, P.W. Mertens, J. Franssaer and S. De Gendt	87
The Dynamic Aspects of Electrochemical Reaction Cells in Selectively Inducing Defects on Silicon Surface L.Y. Sheng, J. De Greve, E. De Backer, P. Verpoort, J. Ackaert and F. Bauwens	91
FEOL photo resist removal and substrate loss	IV.
Wafer Cleaning Using Supercritical CO₂ in Semiconductor and Nanoelectronic Device Fabrication K. Saga and T. Hattori	97
All-Wet Stripping of FEOL Photoresist Using Mixtures of Sulphuric Acid E. Bellandi, M. Alessandri, S. Detterbeck, S.A. Henry, L. Archer, T. Hellweg, M. Kagerer and L. Brilz	105
All Wet Stripping of Implanted Photoresist K.K. Christenson, J.W. Butterbaugh, T.J. Wagener, N.P. Lee, B. Schwab, M. Fussy and J. Diedrick	109
Study of a Metal Gate and Silicon Selective “Dry Ash Only” Process for Combined Extension and Halo Implanted Photo Resist G. Mannaert, M.R. Baklanov, D. Goossens, J. Vertommen and W. Boullart	113
High Dose Implant Stripping and Residue Removal with Sequential Plasma and Vacuum Aerosol Processes K.A. Reinhardt, K. Makhamreh and G. Tannous	117
Confined Chemical Cleaning: A Novel Concept Evaluated for Front End of Line Applications I. Vos, S. Peeters, R. Verbeeck, W. Boullart and J. Vertommen	121
Impact of RF Oxygen Plasma on Thermal Oxide Etch-Rate E. Bellandi, A. Votta, F. Pipia, M. Ferrerio, C. De Marco, S. Alba and M. Alessandri	125
I: Ultra-Shallow Junction Cleaning: Metrology for Evaluating Dopant Loss and Substrate Erosion M.S. Ameen, A.K. Srivastava and I.L. Berry	129
II: Ultra-Shallow Junction Cleaning: Methodologies for Process and Chemistry Optimization A.K. Srivastava, K.P. Han, M.S. Ameen, I.L. Berry and S. Rounds	133
Effect of Dopants on the Dissolution Behavior of Silicon Substrates in HF-Based Cleaning Solutions S. Abu Jeriban, I. Guiot, L. Bacherius, J. Proost, E. Sleenckx, R. Vos and P.W. Mertens	139
The Effect of Various Process Induced Damages on Wet Etching Rate Difference H.G. Yoon, S.H. Lee, W.J. Kim, G.M. Choi and Y.W. Song	143
Particles: removal and damage	V.
How Bubbles (Can) Clean C.D. Ohl, R. Dijkink, M. Arora and D. Lohse	151
Aging Phenomena in the Removal of Nano-Particles from Si Wafers G. Vereecke, J. Veltens, K.D. Xu, A. Eitoku, K. Sano, S. Arnauts, K. Kenis, J. Snow, C. Vinckier and P.W. Mertens	155

Adhesion and Removal of Silica and Ceria Particles on the Wafer Surfaces in STI and Poly Si CMP	
Y.K. Hong, Y.J. Kang, J.G. Park, S.Y. Han, S.K. Yun, B.U. Yoon and C.K. Hong	159
Particle-Substrate Interaction Forces in a Non-Polar Liquid	
F. Barbagini, W. Fyen, J. Van Hoeymissen, P.W. Mertens and J. Fransaer	165
Interaction Forces between Oxide and Silica-Modified Terpolymer Abrasive and their Impact on CMP and Post-CMP	
S. Armini, R. Burtovyy, I. Luzinov, C.M. Whelan, K. Maex and M. Moinpour	169
Particle Deposition and Removal from Ge Wafers	
S. Sioncke, M. Lux, W. Fyen, M. Meuris, P.W. Mertens and A. Theuwis	173
A Study of a Single-Wafer Process in Metal Contact Hole Cleaning	
J.Y. Park, J.K. Song, H.M. Kim, H.K. Cho, T.G. Kim, B.H. Moon, E.S. Rho, L. Archer and W.H. Cho	177
The Active Role of Etch Products in Particle Removal by SC-1 Solutions	
A. Pfeuffer, W. Bensch, A. Lechner and H. Okorn-Schmidt	181
New FEOL Cleaning Technology for Advanced Devices beyond 45 nm Node	
H. Tomita, Y. Yamada, H. Nagashima, N. Ishikawa and Y. Taniguchi	185
In Situ Particle Removal Studies Using an Optical Particle Counter	
D.M. Knotter, R. Te Brake and M. Enkelaar	189
Removal of Nano-Particles by Mixed-Fluid Jet: Evaluation of Cleaning Performance and Comparison with Megasonic	
G. Vereecke, T. Veltens, A. Eitoku, K. Sano, G. Doumen, W. Fyen, K. Wostyn, J. Snow and P.W. Mertens	193
Modeling of Shock Wave Emission during Acoustically-Driven Cavitation-Induced Cleaning Processes	
V. Minsier and J. Proost	197
Ex Situ Bubble Generation, Enhancing the Particle Removal Rate for Single Wafer Megasonic Cleaning Processes	
F. Holsteyns, T. Janssens, S. Arnauts, W. Van der Putte, V. Minsier, J. Brunner, J. Straka and P.W. Mertens	201
New Brush Scrubbing Techniques for a Wafer Bevel, Apex and Edge	
H. Ugajin, H. Iwamoto, E. Hide, N. Hiraoka and T. Okumura	205
Low Si Recess on Cleaning Process by Dilute HF/SC-1 with Megasonic	
J.H. Cha, C.S. Mun, D.H. Kang, W.G. Shim, K.T. Lee, C.K. Hong, H.K. Cho and J.T. Moon	209
Preparation, Characterization, and Damage-Free Processing of Advanced Multiple-Gate FETs	
J.M. Lauerhaas, R. Cleavelin, W.Z. Xiong, K. Mochizuki, K. Sherman, H.C. Lee, B. Clappin, T. Schulz and K. Schrufer	213
Impact of Re-Gasified Water on Megasonic Cleaning	
B.C. Goh, F. Goh, C. Lim, Z. Ismail and M.S. Zhou	217
The Removal of Silica Particles from Micron Wide Trenches by Megasonic Cleaning	
K. Wostyn, V. Quenette, G. Vereecke and P.W. Mertens	221
Is there Gas Entrapped on Submerged Silicon Wafers? Visualizing Nano-Scale Bubbles with Cavitation	
B. Borkent, N. Bremond, M. Arora, C.D. Ohl and D. Lohse	225
Acoustic Field Analysis of a T Type Waveguide in Single Wafer Megasonic Cleaning and its Effect on Particle Removal	
Y.L. Lee, E.S. Lim, K.J. Kang, H.S. Kim, T.G. Kim, S.H. Lee and J.G. Park	229
Study of the Dynamics of Local Particle Removal Efficiencies Using Localized Haze Maps	
T. Janssens, F. Holsteyns, K. Kenis, S. Arnauts, T. Bearda, K. Wostyn, G. Simpson, A. Steinbach and P.W. Mertens	233
Effect of Ozone Supply Methods on PRE in Alkaline Ozone Solutions	
S.H. Lee, T.G. Kim, T.Y. Kwon, J.G. Park, S.I. Bae, G.H. Lee and I.J. Kim	237
Contamination control	VI.
Challenges of Single-Wafer Wet Cleaning for Low Temperature Pre-Epitaxial Treatment of SiGe	
K. Sano, F.E. Leys, G. Dilliwai, R. Loo, P.W. Mertens, J. Snow, A. Izumi and A. Eitoku	243

Estimation of Detrimental Impact of New Metal Candidates in Advanced Microelectronics Y. Borde, A. Danel, A. Roche, A. Grouillet and M. Veillerot	247
Plastic Containers Contamination by Volatile Acids : Accumulation, Release and Transfer to Cu-Surfaces during Wafers Storage H. Fontaine and M. Veillerot	251
A Study on Germanium as a Contaminant Source in Semiconductor Fabrication Process D.W. Hwang, J.S. Lee, P.K. Jun, Y.K. Lee and S.K. Chae	255
Implementation of a System for Metal Contamination Control Based on Classification Criteria T. Bearda, G. Catana, D. Hellin and R. Vos	259
Study of Static Electricity in Wafer Cleaning Process M. Wada, T. Sueto, H. Takahashi, N. Hayashi and A. Eitoku	263

Metrology

VII.

Mapping of Metallic Contamination Using TXRF A. Danel, Y. Borde, M. Veillerot, N. Cabuil, H. Kono and M. Yamagami	269
Investigation of Metallic Contamination Analysis Using Vapor Phase Decomposition – Droplet Collection – Total Reflection X-Ray Fluorescence (VPD-DC-TXRF) for Pt-Group Elements on Silicon Wafers D. Hellin, N. Valckx, J. Rip, S. De Gendt and C. Vinckier	273
X-Ray Spectrometry for Wafer Contamination Analysis and Speciation as Well as for Reference-Free Nanolayer Characterization B. Beckhoff, R. Fliegauf, M. Kolbe, M. Müller, B. Pollakowski, J. Weser and G. Ulm	277
Advanced Metrologies for Cleans Characterization: ARXPS, GIXF and NEXAFS T. Conard, S. List, M. Claes and B. Beckhoff	281
Advanced TXRF Analysis: Background Reduction when Measuring High-k Materials and Mapping Metallic Contamination C. Sparks, J. Barnett, D.K. Michelson, C. Gondran, S.C. Song, A. Martinez, H. Takahara, H. Murakami and T. Kinashi	285
Novel Full Wafer Inspection Technology for Non-Visual Residue Defects R. Bryant, J. Hickson and J. Hawthorne	289

Post CMP cleaning

VIII.

A Study on Water-Mark Defects in Copper/Low-k Chemical Mechanical Polishing J.H. Han, J.E. Koo, K.S. Choi, B.L. Park, J.H. Chung, S.R. Hah, S.Y. Lee, Y.J. Kang and J.G. Park	295
Effect of an Organic Inhibitor in High pH Chemical Rinse on the Platen for Cu-CMP S. Petitdidier, K. Bartosh, C. Trouiller, A. Couvrat, J. Liu and M. Zaleski	299
The Dependence of Chemical Mechanical Polishing Residue Removal on Post-Cleaning Treatments J.G. Choi, H.G. Yoon, W.J. Kim, G.M. Choi, Y.W. Song and J.G. Park	303
A Novel Surface Cleaning for Copper Interconnection Using Ammonium Decomposed Species Generated by Hot Wire A. Izumi and T. Ueno	307

BEOL and Contact cleaning

IX.

Improvement of Contact Clean Using Single-Wafer Clean Process for 90nm and Beyond J.W. Nam, A. Zagrebelny, R. Blumenthal, J. Block, M. Duray and B. Aegerter	313
Effects of Bias, Pressure and Temperature in Plasma Damage of Ultra Low-k Films A.M. Urbanowicz, A. Humbert, G. Mannaert, Z. Tokei and M.R. Baklanov	317
Impact of Plasma and Diluted HF on a CoWP Material D. Rébiscoul, L. Broussous, N. Lopez, A. Roman, R. Kachtouli, L.G. Gosset, J. Guilan, D. Louis and G. Passemard	321

Photoresist Characterization and Wet Strip after Low-k Dry Etch M. Claes, Q.T. Le, J. Keldermans, E. Kesters, M. Lux, A. Franquet, G. Vereecke, P.W. Mertens, M.M. Frank, R. Carleer, P. Adriaensens and D. Vanderzande	325
Implications of the Selectiveness of Cu Chelators on Cu⁰, Cu(I)O and Cu(II)O Powders J. Macdougall, C. Reid and L. McGhee	329
Impact of Organic Acid and Gas Bubbling on Copper and Copper Oxide Etch-Rates in Diluted HF Solution D. Rébiscoul, N. Lopez, L. Broussous, D. Louis and G. Passemard	333
Marangoni Dryer Integrated High Performance Cleaner for Cu/Low k Post Strip Clean for 45nm Technology Node and Beyond J.S. Tang, W. Lu, B. Xi, E. Martinez, F. Li, A. Ko, C. Todd and J.T.C. Lee	337
Effect of Pressure Pulsation on Post-Etch Photoresist Stripping on Low-k Films in Supercritical CO₂ H. Kiyose, K. Saito, I. Mizobata, T. Iwata, S. Hirae, K. Saga, H. Kuniyasu and T. Hattori	341
Optimization of a SC CO₂ Post-Etch Cleaning for Copper Interconnections D. Rébiscoul, V. Perrut, C. Ventosa, M. Assous, D. Louis and G. Passemard	345
Study of Resist Strip Chemistries for Ultra Low-k/Cu Interconnect H. Xu, T. David, Y. Xu, V. Tarasov, N. Possémé and D. Louis	351
Effect of Wafer Rotation on Photoresist Stripping in Supercritical CO₂ K. Saga, H. Kuniyasu, T. Hattori, K. Saito, I. Mizobata, T. Iwata and S. Hirae	355
Metal Hard Mask Employed Cu/Low k Film Post Ash and Wet Clean Process Optimization and Integration into 65nm Manufacturing Flow M.C. Lin, M.Q. Wang, J. Lai, R. Huang, C.M. Weng, J.H. Liao, J.S. Tang, C.H. Weng, W. Lu, H.W. Chen and J.T.C. Lee	359
Mechanism and Principles of Post Etch Al Cleaning with Inorganic Acids S. Verhaverbeke, R. Gouk, J. Papanu and H.W. Chen	363
AlCu Metal Line Corrosion: A Case Study F. Pipia, A. Votta, G. Obetti, E. Bellandi, M. Alessandri and T. Nolan	367
Copper Surface Analysis with ToF-SIMS: Spectra Interpretation and Stability Issues C. Trouiller, S. Petitdidier, X. Ravanel, L. Broussous, M. Juhel, L.F.T. Kwakman and C. Wyon	371
Influence of the Process Conditions of a Polishing Rinse after CuCMP A. Filippini, S. Petitdidier, C. Trouiller, A. Couvrat, M.C. Luche and E. Sabouret	375
Wet Process Developments for Electrical Properties Improvement Of 3D MIM Capacitors C.T. Richard, D. Benoit, S. Cremer, L. Dubost, B. Iteprat, M. Vincent, E. De Bock, C. Perrot, C. Rossato, M. Proust and S. Guillaumet	379