TABLE OF CONTENTS

Preface iii

I. Shallow Trench Isolation 1

Chemical-Mechanical Polishing for Shallow Trench Isolation: A New Interpretation
Hongjiang Sun, Michael Olewine, Ralph Wall 3

Optimizing Planarity on STI Devices Using Conventional Oxide CMP Processes And Consumables
Jim Schlueter and Inki Kim 11

Economic Evaluation of Various Shallow Trench Isolation Module Options
Michael J. Berman, Jayashree Kalpathy-Cramer, Eric Kirchner 22

STI-CMP Process Control Improvement with Optical Endpoint Detection
Vance Dunton and Frank Szarka 30

STI CMP Process Development Using Standard Oxide Slurry
C. Shan Xu, Sri SrivatsanK. Y. Ramanujam, Willy Krusell 45

In-Line Silicon Substrate Topographical Measurement for STI CMP Process Margin Impact Study
Yong Xia, Jerry Liu, C. Shan Xu 48

Comparisons of Polisher Designs on the Performance of STI Planarization
K. Goh, F. Chen, S. Balakumar, G. Higelin, A. See, L. Chan, C. Lin, C. Chern 57

A Few Thoughts on the Alleviation of Dishing and Erosion during Chemical-Mechanical Planarization for Shallow Trench Isolation
Wei-Tsu Tseng, James Niu 71

II. Copper 81

Corrosion Control in Copper Damascene Process
Yoshio Homma, Seiichi Kondo, Noriyuki Sakuma, Kenji Hinode, Junji Noguchi, Naofumi Ohashi, Hizuru Yamaguchi, Nobuo Owada 83

Multi-level Pattern Effects in Copper CMP
Tae Park, Tamba Tugbawa, Duane Boning, Steve Hymes, Paul Lefevre, Tom Brown, Konstantin Smekalin, Gary Schwartz 94

Dissolution of Copper and Tantalum Films in Hydroxylamine Based Silica Slurries Under CMP Conditions
Wayne Huang, Srini Raghavan, Maria Peterson, Robert Small 101

Challenges of Electroplated Copper Film and Device Characteristics for Copper Slurry Design
Maria L. Peterson, Robert J. Small, Tuan Truong, Joo-Yun Lee 112

Chemical-Mechanical Planarization Issues in Patterning Copper and Aluminum Interconnects with Magnetic Liners
Ronald J. Gutmann, Bin Wang, Byung-Chan Lee, T. Paul Chow, David J. Duquette 118

Copper CMP: The Role of Barrier Metal Material and Its Effect on Dishing and Oxide Erosion
David A. Hansen, Gerry Moloney, Mike E. Witty 136

Evolution of Topography During First Step CMP of Cu-Plated Damascene Structures
Steve Hymes, Tom Brown, Paul LeFevre, Bob Mikkola, Ishmail Emesh, Rajeev Bajaj, Konstantin Smekalin, Yutao Ma, Fritz Redeker, Tae Park, Tamba Tugbawa, Duane Boning, John Nguyen 149

Characterization of Chemical Mechanical Polishing of Copper
Kapila Wijekoon, Stan Tsai, Doyle Bennett, Fritz Redeker 158

Defect Characterization and Control in the Development of a Copper CMP Process
Scott Steckenrider, Jamie Belliveau, Mark Burns 168

Cu CMP on Orbital Tool: Philosophy, Concepts and Implementation
Y. Gotkis, S. Guha, F. Dai, F. Mitchell, J. Nguyen, L. Shumway, F. Krupa, K. Holland 177

Study of Slurry Chemistry in Chemical Mechanical Polishing (CMP) of Copper
Seung-Mahn Lee, Uday Mahajan, Zhan Chen, Rajiv K. Singh 187

An Electrochemical Mechanism of Copper Removal During Chemical Mechanical Planarization
Carlyn Sainio, David J. Duquette 193

Material Properties of Annealed Electroplated Cu Thin Films and Their Effect on CMP
Ende Shan, Bo Dou, Igor C. Inanov, Chiu H. Ting 205

III. Dielectrics 215

Review and Experimental Analysis of Oxide CMP Models
David J. Stein, Dale L. Hetherington 217

Silicon Nitride Polish-Stop for CMP of BPSG Films on sub-0.25μm DRAMs
J. Stephens, D. Dobuzinsky, J. Gambino, W. Glashauser, K. Huckels, J. Hanebeck, M. Kraxenberger, M. Naeem, T. Rupp, V. Sardesai, K. Wangemann, M. Wise 234

Mechanistic Study of Dielectric Chemical Mechanical Polishing by Spectral and Scaling Analysis of Atomic Force Microscope Images
M. Verhoff 239

Direct CMP of Low ε Organic Layers by MnO_2 Slurry
Tohru Hara, Tomohiro Tomizawa, Toshiaki Kurosu, Toshiro K. Doy 261

Conventional and Slurry-free CMP of Polymer Layers for Gbit DRAM
Joachim Nuetzel, Junichiro Iba, Cynthia Fairchok, Ronald Schutz 270

Study of Micro-Defect on Oxide CMP in VLSI Circuit
Sang Yong Kim, Yong-Jin Seo, Chang-il Kim, Woo-Sun Lee, Eui-Goo Chang 275

Slurry Dispersion and Frictional Behaviors during Chemical-Mechanical Polishing of Silicon Dioxide
Wei-Tsu Tseng, Rick Lu, Ping-Lin Kuo, Chin-Lung Liao, Jen-Fin Lin 280

The Reduction of Micro-scratch Using Filter in Oxide Chemical Mechanical Polishing
Seon Jung Kim, Yang Won Lee, Yong Sik Kim, Sang Yong Kim, Kwang Ha Suh 287

IV. Metals 291

A New Approach for the Study of Chemical Mechanical Polishing
D. Devecchio, P. Schmutz, G. S. Frankel 293

Electrochemical Investigations during the Abrasion of Aluminum Thin Films in an Iodate Based Alumina Slurry
Yan Fang, Srini Raghavan, Gundu Sabde, Scott Meikle 301

In-Situ EIS Approaches to the Aluminum CMP Slurry Characterization
Jyh-Wei Hsu, Shao-Yu Chiu, I-Chung Tung, Ying-Lang Wang, Bau-Tong Dai, Ming-Shih Tsai, Ming-Shiann Feng, Han-C Shih 311

Some Aspects of Tungsten CMP Process with a Ferric Containing Slurry
Liming Zhang, Michele Cecchi, Milind Weling, Tekle Tafari 322

On Discrepancies between In-situ Electrochemical Measurements and Actual Removal Rates in Tungsten CMP
Dnyanesh Tamboli, Vimal Desai, Sudipta Seal, Kalpathy B. Sundaram 333

Characterization of Commercial Tungsten CMP Slurries for IC Device Manufacturing
Chai Kok Wei, A. K. Nanda, Neo Teck Leong 342

Effect of CMP Polish Conditions on the Step Height Reduction and on Local Removal Rate for 0.25μm CMOS Process
Chai Kok Wei, Law Kai Man, A. K. Nanda 348

Tungsten CMP: Reduction Behavior of Iodate Ion on Tungsten
M. Anik, K. Osseo-Asare 354

V. Consumables, Slurries 361

Chemical Mechanical Polishing with Selective Slurries
Michael R. Oliver 363

Optimal Size Distribution of CMP Slurries for Enhanced Polishing with Minimal Defects
G. B.Basim, J. J. Adler, U. Mahajan, R. K. Singh, B. M. Moudgil 369

Development of Grading and Control Technology of Particle Sizes Dispersed in CMP Slurry
Yukihiko Karasawa, Toshiroh Kakaki Doy, Kenichi Watanabe 382

Theoretical Analysis of the Adhesion of Asymmetrical Alumina Particles to Thin Films
Kevin Cooper, Anand Gupta, Stephen Beaudoin 391

Effect of Slurry Abrasive Size on Polish Rate and Surface Quality of Silicon Dioxide Films
Uday Mahajan, Seung-Mahn Lee, Rajiv K. Singh 396

CMP Characteristics According to Slurry Injection Position
Kyoung-Jun Kim, Sang-Tae Moon, Hae-Do Jeong 402

Filtration Effects on Chemical Mechanical Polishing Slurries
Rhonda J. Ewasiuk, Seungkwan Hong, Vimalkumar Desai, John Maze, Charles Storey, William Easter 408

VI. Consumables, Pads 421

Sensitivity of CMP Processes to Variations in Consumable Properties
S. Guha, S. Koppikar, D. White, A. Zutshi 423

The Effect of Pad Temperature on Manufacturing Process Control of W-CMP
Teng-Chun Tsai, Ping-Ho Lo, Fung-Lung Jaung, Clock Chung, Chih-Yueh Lee, Eric Hsu, Chia-Lin Hsu, Lu-Min Liu 434

Polishing Pits
Farid Malik, Masood Hasan 440

Characterization of the Composite Conditioning Aided by Ultrasonic Vibration
Heon-Deok Seo, Sung-Hoon Lee, Hae-Do Jeong 445

Pad Chargeability in CMP
Farid Malik, Masood Hasan 452

VII. Pre- and Post-CMP Cleaning 459

Challenges of Post Cu CMP Cleaning (II)
Hugh Li, Eugene Zao, Linda Jiang, Diane Hymes, John de Larios 461

Single Wafer Non-Contact Post-CMP Cleaning Using DI Water and Dilute Chemistry
A. A. Busnaina, N. Moumen, J. Piboontum 468

Comparing Contact and Non-Contact Technology for Post-CMP Cleaning
Katrina Mikhaylichenko, Mike Ravkin, David Stein, Dale Hetherington 477

Cleaning of Cu in the Cu Dual Damascene Process
Tohru Hara, Nobuyoshi Awaya 489

Post Copper CMP Cleaning: A Non-Contact Megasonic Method
M. Eissa, S. Joshi, G. Shinn, S. Rafie, B. Fraser 499

Achieving Reduced Water Consumption during Copper Post-CMP Cleaning
Robert Small, Zhefei Chen,Oana Leonte, Gordon Shaw 506

VIII. Process Integration 515

CMP Integration Issues for Sub-0.15μm Process Technologies
Milind Weling, Vance Dunton, Liming Zhang, Rao Annapragada 517

Process Integration Issues While Implementing Chemical Mechanical Planarization (CMP) Into Existing Process Technologies
Saket Chadda, Rakesh Sehgal, Laura Prowell, Keith Pierce, Stephanie Jones, Gary Frazier 534

Development of an Intelligent Chemical-Mechanical Polishing (CMP) System
Yamato Samitsu, Kazuo Kobayashi, Eiichi Yamamoto, Emile Kerba Yoshihiro Hayashi, Takahiro Onodera 546

IX. Monitoring 553

New Methods to Determine Endpoint and Real Time Removal Rate for Chemical Mechanical Polishing
Hsueh-Chung Chen, Juan Yuan Wu, Water Lur 555

Advancements in CMP Process Automation and Control
James Moyne 565

Integrated CMP Defect Monitoring Strategy
Wayne Chen, Mark Keefer, Andrew Zeng, Cheri Dennison, Raj Persaud, Deve Fletcher, Anantha Sethuraman 577

X. Modeling 591

Three-Dimensional Chemical Mechanical Polishing Process by BEM
Takafumi Yoshida 593

A Mathematical Model of Pattern Dependencies in Cu CMP Processes
Tamba Tugbawa, Tae Park, Duane Boning, Tony Pan, Ping Li, Steve Hymes, Tom Brown, Lawrence Camilletti 605

A Quantitative Model for Oxide Erosion in Chemical Mechanical Polishing of Tungsten
B. U. Yoon, I. K. Jeong, J. Y. Kim, J. W. Lee, S. R. Hah, J. T. Moon, S. I. Lee 616

A Model of Stacked Polishing Pad for 3-D CMP Simulation
Takafumi Yoshida 625

A Qualitative Stress-Based Model for Silicon Oxide Wafer Planarization
D. Castillo-Mejia, David Schroeder, Stephen Beaudoin 634

Subject Index 640

Author Index 642