

## **CURRICULUM VITA**

**Timothy S. Cale**

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### **Degrees:**

Ph.D. (Ch.E.) University of Houston, 1980  
B.S. (Ch.E.) Arizona State University, 1976

### **Academic Experience:**

1997 – present CEO, Process Evolution, Ltd.  
2007 – present Research Professor, School of Materials, Arizona State University  
1998 – 2007 Professor of Chemical Engineering, Rensselaer Polytechnic Institute  
2003 – 2007 Adjunct Professor, College of Nanoscale Science and Engineering, University at Albany  
2004 – 2005 Visiting Professor, Department of Chemical Engineering, Vanderbilt University  
1998 – 2004 Director, Focus Center – New York, Rensselaer: Interconnections for Hyperintegration  
1993 - 1995 Director, Center for Solid State Electronics Research, ASU  
1991 - 1997 Professor of Engineering, ASU  
1990 - 1992 Assistant Chair of Chemical Engineering, ASU  
1986 - 1991 Associate Professor of Engineering, ASU  
1981 – 1986 Assistant Professor of Engineering, ASU  
1981 Post-Doctoral Fellow, University of Houston

### **Other Industrial Experience:**

1991 – 1997 Motorola (summers, leaves)  
1986 Intel Corp., Process Engineer (summer)  
1976 Monsanto Company, Process Engineer

### **Professional Societies and Activities:**

AIChE, IEEE, AVS The Science & Technology Society, ECS, MRS  
Reviewer for: NSF, ACS-PRF, DOE, ASME, AVS, MRS, ECS, AIChE, Physical Reviews, Thin Solid Films  
Program Committee for the 2006 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD) 2006  
Program Committee of the AVS Second International Conference on Materials and Interfaces, February 2000-2006  
Executive Committee for Chemical Mechanical Planarization for Multilevel Interconnection Conference (CMP-MIC) 2005-7  
Executive Committee for VLSI Multilevel Interconnection Conference (VMIC) 2004-6  
Associate Editor, IEEE Transactions on Semiconductor Manufacturing, 2001 - present  
Keynote “A Conformal Voxel Method for Consistent Extraction in Complex Grain Structure Level-Set Simulations”, to be presented during the International Conference on Computational and Experimental Engineering and Sciences”, Dec. 1-6, 2005, Chennai, India  
Chair of the Fifth AVS International Conference on Microelectronics and Interfaces, held March 1-4, 2004, Santa Clara, CA  
Editor for Thin Film Materials, Processes, and Reliability, G. S. Mathad, T. S. Cale, D. Collins, M. Engelhardt, F. Leverd, and H. S. Rathore, eds., ECS PV 2003-13, ECS, 2003  
Editor for Advanced Metallization 2002 (AMC 2002), B.M. Melnick, T.S. Cale, S. Zaima, and T. Ohta, eds., MRS, 2003  
Lecturer during the State-of-the-Art Short Course on Chemical Mechanical Planarization for ULSI Multilevel Interconnection, Feb. 23, 2004  
Executive Committee for the conference, “International Symposium on Applied Plasma Science”, Kobe Japan, September 2003  
Program Committee for the 2003 International Conference on Simulation of Semiconductor Processes and Devices: SISPAD 2003, September 2003

Keynote "Simulation of Materials Processing on the Island, Grain and Reactor Scales", presented during Multiscale Materials Modelling, London, England, June 17-20, 2002  
Program Co-Chair for the Advanced Metallization Conference 2002, October 1-3, 2002, San Diego, CA  
Executive Committee for the conference, "International Symposium on Applied Plasma Science", Fairbanks, Alaska, July 2001  
Executive Committee for the conference on "Advanced Metalization for ULSI Applications", 1991-2003.  
Guest editor of a special issue of *Thin Solid Films*, "Process and Materials Modeling in IC Fabrication", April 2000  
Guest editor for First AVS International Conference on Materials and Processing in Microelectronics, in *J. Vac. Sci. Tech. B* **17(5)**, 1999  
Keynote presentation: "Opportunities for Materials Modeling in Microelectronics", presented during the Multiscale Materials Modeling Symposium of the 1999 Meeting of the International Union of Materials Research Societies, June 1999, Beijing, China  
Co-Chair of First AVS International Conference on Materials and Processing in Microelectronics, held March, 1999  
Instructor during Chemical Mechanical Polishing Workshop, held May 1998, San Diego, CA  
Co-Chair of Symposium on Advanced Metalization in Microelectronics, held during the International Conference on Metallurgical Coatings and Thin Films, 1993-98  
Member of the University Advisory Committee, Semiconductor Research Corporation, 1995-1997  
Co-authored the winner of the Norman Hackerman Best Paper Award from the Electrochemical Society in 1994  
Member of the US Delegation to the workshop "Korea-United States Design and Manufacturing", November, 17-19, 1993, Taejon, Korea  
Editor for Advanced Metallization For ULSI Applications 1992, with F. Pintchovski, MRS, 1993.  
Instructor for short course on Advanced Metalization, 1992 and 1993  
Faculty Advisor (past) to: AIChE (1981-1988), Tau Beta Pi (1981-1992)  
Program Co-Chair for the 1992 International Workshop on Advanced Metalization for ULSI Applications, held October 19-22, 1992  
Associate Editor for Advanced Metallization For ULSI Applications, MRS, 1992  
Organizer for "Technology Transfer Conference on EVOLVE", held 1992, 1994 and 1997, sponsored by the Semiconductor Research Corporation  
Chair of numerous sessions on transport and reaction in microelectronics for AIChE, AVS, MRS and ECS

**Research Interests:**

Semiconductor materials process fundamentals, design, optimization and control; experimental and theoretical studies on thin film deposition, etch and planarization processes; reaction engineering; applied mathematics

**Teaching Interests:**

Semiconductor materials processing, reaction engineering, applied mathematics

**Selected External Grants and Contracts:**

Interconnect Focus Center: Interconnections for Hyperintegration", MARCO/DARPA and NYSTAR, PI with 7 others at RPI, 2006-2009, \$2.95 M per year.

"Interconnect Focus Center: Interconnections for Hyperintegration", MARCO/DARPA and NYSTAR, PI with 3 Co-PIs at RPI, 2003-2006, \$2.95 M per year.

"Predictive Modeling and Simulation", Interconnect Focus Center: Interconnections for Hyperintegration", MARCO/DARPA and NYSTAR, 2005, \$620,000.

"Predictive Modeling and Simulation", Interconnect Focus Center: Interconnections for Hyperintegration", MARCO/DARPA and NYSTAR, 2005, \$560,000.

"Predictive Modeling and Simulation", Interconnect Focus Center: Interconnections for Hyperintegration", MARCO/DARPA and NYSTAR, 2004, \$970,000.

"Interconnect Focus Center: Interconnections for Gigascale Integration", MARCO/DARPA and NYSTAR, Project Director, PI with 4 Co-PIs at RPI, 2003, \$3.25 M per year.

“Microstructure Evolution and Multiscale Modeling”, Interconnect Focus Center: Interconnections for Gigascale Integration, MARCO/DARPA and NYSSTF, 2003, \$460 K per year.

“Magnetic Alignment of Substrates”, Interconnect Focus Center: Interconnections for Gigascale Integration, MARCO/DARPA and NYSSTF, 2003, \$270 K per year.

“Interconnect Focus Center: Interconnections for Gigascale Integration”, MARCO/DARPA and NYSSTF, Project Director, PI with 5 Co-PIs at RPI, 2002, \$3.43 M per year.

“Microstructure Evolution and Multiscale Modeling”, Interconnect Focus Center: Interconnections for Gigascale Integration, MARCO/DARPA and NYSSTF, 2002, \$590 K per year.

“Magnetic Alignment of Substrates”, Interconnect Focus Center: Interconnections for Gigascale Integration, MARCO/DARPA and NYSSTF, 2002, \$299 K per year.

“Interconnect Focus Center: Interconnections for Gigascale Integration”, MARCO/DARPA and NYSSTF, Project Director, PI with 6 Co-PIs at RPI, 2000/01, \$3.29 M per year.

“Microstructure Evolution and Multiscale Modeling”, Interconnect Focus Center: Interconnections for Gigascale Integration, MARCO/DARPA and NYSSTF, 2001, \$590,000 per year.

“Modeling Polycrystalline Film Processing and Evolution”, IBM, \$208,000, 1999. (D. F. Richards is Co-PI.)

“Interconnect Focus Center: Interconnections for Gigascale Integration”, MARCO/DARPA and NYSSTF, Project Director, PI with 16 Co-PIs at RPI, 1998 – 2000, \$3.15 M per year.

“Microstructure Evolution and Multiscale Modeling”, Interconnect Focus Center: Interconnections for Gigascale Integration, MARCO/DARPA and NYSSTF, 1998-2000, \$325,000 per year.

"Using Topography and Composition to Establish Kinetic and Transport Models", Semiconductor Research Corporation", 7/97-9/98, \$50,000.

"Using Topography and Composition to Establish Kinetic and Transport Models", Semiconductor Research Corporation", 7/96-6/97, \$50,000.

“Design Methodologies for Reactive Processes”, Semiconductor Research Corporation”, 4/96-7/97, \$240,000. (G. B. Raupp is Co-P.I.)

“Precursor Evaluation for Aluminum CVD”, Materials Research Corp., 1/96-7/97, \$75,000.

“Rotating Disk Reactor for Aluminum CVD”, Materials Research Corp., 3/96-3/99, \$230,000.

“Graduate Research Traineeships”, NSF, 6/95-6/98, \$500,000. (V. A. Burrows is P.I.)

"Silicon-Based Nanostructures: Experiment and Modeling", ONR, 6/95-5/98, \$3.7 M. (Co-P.I. with D. Ferry and four others)

"Using Topography and Composition to Establish Kinetic and Transport Models", Semiconductor Research Corporation", 7/95-6/96, \$50,000.

"Process Development Tools for Single Wafer Reactors", Semiconductor Research Corporation, 1/95-3/96, \$175,000. (G. B. Raupp is Co-P.I.)

"Development and Validation of Etch Process Simulator", Motorola, 5/94-5/95, \$74,500.

"Development of an Aluminum CVD Process", Materials Research Corporation, 1/94-12/95, \$89,000.

"Using Films Deposited in Features to Establish Kinetic and Transport Models", NSF, 2/94-12/98, \$214,000. (G. B. Raupp is Co-P.I.)

"Process Development Tools for Single Wafer Reactors", Semiconductor Research Corporation, 1/94-12/94, \$140,000. (G. B. Raupp is Co-P.I.)

"Single Wafer Plasma Reactor Simulator", AFOSR (AASERT), 3/94-3/97, \$89,000.

"Technology Transfer of EVOLVE", Semiconductor Research Corporation, 8/93-7/94, \$115,000.

"Process Development Tools for Single Wafer Reactors", Semiconductor Research Corporation, 1/93-12/93, \$140,000. (G. B. Raupp is Co-P.I.)

Equipment Donation; Spectrum 202 LPCVD Reactor System, Motorola, Inc., \$90,000. (G. B. Raupp is Co-P.I.)

Equipment Donation; Spectrum 202 Reactors", Materials Research Corp., Inc., \$560,000. (G. B. Raupp is Co-P.I.)

"Mathematical Modeling for Simulation and Control of Semiconductor Processes", DARPA, 10/92-9/95, \$693,000. (Co-P.I. with P. Crouch).

"Interdisciplinary Undergraduate Program in Materials Science and Processing", NSF, 10/1/92-9/30/95, \$350,000. (Jim Mayer P.I., 14 others and myself contributing)

"Heteroepitaxy of Ternary SiGeC", AFOSR, 4/1/93-3/31/96, \$1,508,000. (Jim Mayer is P.I., 9 others and myself contributing)

"Process Development Tools for Single Wafer Reactors", Semiconductor Research Corporation, 1/92-12/92, \$140,000. (G. B. Raupp is Co-P.I.)

"Process Development Tools for Single Wafer Reactors", Semiconductor Research Corporation, 1/91-12/91, \$105,000. (Co-P.I. with G. B. Raupp)

"Programmed Rate Chemical Vapor Deposition", NSF, 3/90-3/94, \$255,059. (G. B. Raupp is Co-P.I.)

"Process Development Tools for Single Wafer LPCVD Reactors: Step Coverage Prediction", Semiconductor Research Corporation, 1/90-12/90, \$95,503. (Co-P.I. with G. B. Raupp)

"Equipment: Process Development Tools for Single Wafer LPCVD Reactors: Step Coverage Prediction", Semiconductor Research Corporation, 1/90-12/90, \$20,500. (Co-P.I. with G. B. Raupp)

"Measurement of Axial Catalyst Temperature Profiles", NSF, 1987-90, \$112,270.

"Low Reynolds Number Transport in Packed Beds", ACS-PRF(AC), 1985-87, \$35,000.

"Desiccant Materials Assessment and Development", Gas Research Institute, 1985-86, \$74,100. (I. Zwiebel was Co-P.I.)

"Magnetochemistry of Adsorbates and Catalysts", Council for Chemical Research, 1984, \$5,000.

"Magnetic Crystallite Thermometry", ACS-PRF(G), 1983-85, \$15,000.

"Magnetic Crystallite Thermometry", NSF Initiation, 1983-85, \$52,400.

"SHE Superconducting Magnet - Magnetometer", NSF Equipment, 1983-85, \$150,600. (Co-P.I. with W. S. Glausinger)

#### **Publications:**

339. "Evaluations of Bonding and Thinning Integrity of Stacked Wafers for Three Dimensional (3D) Integration", Yongchai Kwon, Anurag Jindal, Rod Augur, Jongwon Seok, Timothy S. Cale, Ronald J. Gutmann, and Jian-Qiang Lu, , *J. Electrochem. Soc.*, submitted.

338. "Strain Energy Driven and Curvature Driven Grain Boundary Migration in 3D-IC Cu Vias", C.A. Awo-Affouda, M.O. Bloomfield, T.S. Cale, in 2007 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), IEEE, 2007, in press.

337. (invited chapter) "Grain Continuum Modelling of Material Behaviour", M.O. Bloomfield and T.S. Cale, in Multiscale Materials Modeling in Structural Engineering, Z.X. Guo, ed., Woodhead Publishing, 2007, pp. 148-188.

336. "Modeling Multiscale Effects of Transients During Chemical Vapor Deposition", M.K. Gobbert and T.S. Cale, *Surface and Coatings Technology* **201(22-23)**, 8830-37 (2007).

335. "Two Deterministic Approaches to Topography Evolution", M.O. Bloomfield, M.K. Gobbert and T.S. Cale, *Surface and Coatings Technology* **201(22-23)**, 8873-77 (2007).

334. "Thermally Induced Stresses in 3D-IC Inter-wafer Interconnects: A Combined Grain-Continuum and Continuum Approach", M.O. Bloomfield, D.N. Bentz, J.-Q. Lu, R.J. Gutmann and T.S. Cale, *Microelect. Eng.* (2007), doi:10.1016/j.mee.2007.06.006.
333. "Hybrid Grain-Continuum Model for Thermo-Mechanical Stresses in Polycrystalline Cu 3D IC Vias", M.O. Bloomfield, D. N. Bentz, V. Sukarev, T. S. Cale, in *2007 IEEE International Reliability Physics Symposium Proceedings*, IEEE, 2007, pp. 644-5.
332. "Fine Keyed Alignment and Bonding for Wafer-Level 3D ICs", S.H. Lee, F. Niklaus, J.J. McMahon, J. Yu, R.J. Kumar, H.-F. Li, R.J. Gutmann, T.S. Cale, J.-Q. Lu, in *Materials, Technology and Reliability of Low-k Dielectrics and Copper Interconnects*, T.Y. Tsui, Y-C. Joo, A.A. Volinsky, M. Lane, L. Michaelson (eds.), MRS Symposium Proceedings Vol. 914, 2006, paper 0914-F10-05.
331. "Stress Induced Grain Boundary Migration in Polycrystalline Copper," D.N. Bentz, M.O. Bloomfield, and T.S. Cale, *Journal of Electronic Materials*, in press.
330. "Applying Grain Continuum Models to Stress Induced Grain Evolution in Next Generation Integrated Circuit Interconnects," D.N. Bentz, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann and T.S. Cale, in *Comsol Users Conference Proceedings*, J. Hiller (ed.), Comsol, 2006, pp. 309-317.
329. "Stress Induced Migration in Polycrystalline Films: a Time-Scale Analysis," M.O. Bloomfield, D.N. Bentz, J.-Q. Lu, R.J. Gutmann, and T. S. Cale, in , in *Proceedings Twenty Third International VLSI Multilevel Interconnection Conference*, T. Wade (ed.), IMIC, 2006, pp. 234-239.
328. "Critical Adhesion Energy at the Interface between Benzocyclobutene and Silicon Nitride Layers", Yongchai Kwon, Jongwon Seok, Jian-Qiang Lu, Timothy S. Cale, and Ronald J. Gutmann, *J. Electrochem. Soc.*, accepted.
327. "Mechanical Models of Polycrystalline 3D-IC Interwafer Vias," D.N. Bentz, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann, and T.S. Cale, in *Advanced Metallization Conference (AMC) 2006*, MRS, 2007, pp. 275-80.
326. "Stress Induced Grain Boundary Migration in Polycrystalline Cu Lines," D.N. Bentz, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann, and T.S. Cale, in *Proceedings of International Conference on Multiscale Materials Modeling (MMM)*, P. Gumsch (ed.), Fraunhofer IRB Verlag, 2006, pp. 404-407.
325. "Grain Based Modeling of Stress-Induced Copper Migration for 3D-IC Interwafer Vias," D.N. Bentz, M.O. Bloomfield, H. Huang, J.-Q. Lu, R. J. Gutmann, and T.S. Cale, in *2006 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD)*, IEEE, 2006, pp. 345-348.
324. "Influences of Grain Structure on Thermally Induced Stresses in 3D IC Inter-wafer Vias," D.N. Bentz, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann, and T.S. Cale, *Journal of Computational Electronics* **5(4)**, 327-331 (2006).
323. "Grain-focused Microstructure Simulations: Stress-Induced Evolution of Polycrystalline Films," D.N. Bentz, M.O. Bloomfield, and T.S. Cale, in *11th International Ceramics Congress Advances in Science and Technology*, Trans Tech Pub., 2006, pp. 1178-1183.
322. "Effect of Knudsen Number on Transient Times During Chemical Vapor Deposition", Matthias K. Gobbert and Timothy S. Cale, *Int. J. Multiscale Comp. Eng.* **4(3)**, 319-335 (2006).
321. "Atomistic Modeling of Electron Transport in Self-Assembled Arene-Based Molecular Wires", X-Y, Liu, J.E. Reynolds, C. Wells, J. Welch, and T.S. Cale, in *2005 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD 2005)*, IEEE, 2005, pp. 271-274.
320. "Three-dimensional Ehrlich-Schwoebel Barriers for W", Z. Xu, L. G. Zhou, J. Wang, T. S. Cale, H. Huang, submitted to *Computers, Materials & Continua* **5(1)**, 43-47 (2006).
319. "Modeling Thermal Stresses of Copper Interconnects in 3D IC Structures", Daniel N. Bentz, Jing Zhang, Max Bloomfield, Jian-Qiang Lu, Ronald J. Gutmann and Timothy S. Cale, in *Proceeding of the COMSOL Multiphysics Conference 2005*, J. Hiller (ed.), COMSOL, 2005, pp. 321-326.

318. "Thermally Induced Stresses in 3D ICs", Max Bloomfield, Jing Zhang, Daniel N. Bentz, Jian-Qiang Lu, Ronald J. Gutmann and Timothy S. Cale, in Advanced Metallization Conference (2005), MRS, 2006, pp. 649-654.
317. "Molecular Caulk: Enabling aspects for ultra-low  $\kappa$  dielectric integration", Jay J. Senkevich, Brad P. Carrow, Benjamin W. Woods, Dae-lok Bae, Timothy S. Cale and Pei-I Wang, in Advanced Metallization Conference (2005), MRS, 2006, pp. 375-379.
316. (invited) "Thermal Stresses in 3D IC Interwafer Vias", Daniel N. Bentz, Jing Zhang, Max O. Bloomfield, Jian-Qiang Lu, Ronald J. Gutmann and Timothy S. Cale, in Proceedings of the Twenty Second International VLSI Multilevel Interconnect Conference (VMIC), T. Wade (ed.), IMIC, 2005, pp. 89-96.
315. (invited) "Wafer-Level 3D Integration Technology Platforms for ICs and MEMs", F. Niklaus, J.-Q. Lu, J. J. McMahon, J. Yu, S. H. Lee, T. S. Cale, R. J. Gutmann, , in Proceedings of the Twenty Second International VLSI Multilevel Interconnect Conference (VMIC), T. Wade (ed.), IMIC, 2005, pp. 486-493.
314. "Adhesive Wafer Bonding using Partially Cured Benzocyclobutene (BCB) for 3D Integration", F. Niklaus, R.J. Kumar, J.J. McMahon, J. Yu, J.-Q. Lu, T.S. Cale, and R.J. Gutmann, *J. Electrochem. Soc.* **153(4)**, G291-5 (2006).
313. "Critical Adhesion Energy of Benzocyclobutene (BCB)-Bonded Wafers", Yongchai Kwon, Jongwon Seok, Jian-Qiang Lu, Timothy S. Cale, and Ronald J. Gutmann, *J. Electrochem. Soc.* **153(4)**, G237-52 (2006).
312. "A Kinetic Transport and Reaction Model and Simulator for Rarefied Gas Flow in the Transition Regime", Matthias K. Gobbert and Timothy S. Cale, *J. Comp. Phys.* **213**, 591-612 (2006).
311. "A Galerkin Method for the Simulation of the Transient 2-D/2-D and 3-D/3-D Linear Boltzmann Equation", Matthias K. Gobbert, Samuel G. Webster, and Timothy S. Cale, *J. Sci. Comp.*, (published online Feb. 17, 2006); **30(2)**, 237-273 (2007).
310. "Modeling Thermal Stresses in 3D IC Inter-Wafer Interconnects", Jing Zhang, Max O. Bloomfield, Jian-Qiang Lu, Ronald Gutmann, and Timothy S. Cale, *IEEE Trans. Semi. Manuf.* **19(4)**, 437-448 (2006).
309. "Metallization of Sealed Porous MSQ", Timothy S. Cale, Dae-lok Bae, Christopher Jezewski and Jay J. Senkevich, in Silicon Nitride and Silicon Dioxide Thin Insulating Films and Other Emerging Dielectrics VIII, R. E. Sah, M. J. Deen, J. Zhang, J. Yota, and Y. Kamakura, eds., Proc. Vol. 2005-01, ECS, 2005, pp. 521-534.
308. "Thermal Stresses in 3D IC Interwafer Interconnects", Jing Zhang, Max O. Bloomfield, Jian-Qiang Lu, Ronald J. Gutmann, and Timothy S. Cale, *Micro. Eng.* **82**, 534-547 (2005).
307. "Effects of Bonding Process Parameters on Wafer-to-Wafer Alignment Accuracy in Benzocyclobutene (BCB) Dielectric Wafer Bonding", Frank Niklaus, R. J. Kumar, J. J. McMahon, J. Yu, T. Matthias, M. Wimplinger, P. Lindner, J. -Q. Lu, T. S. Cale and R. J. Gutmann, in Materials, Technology and Reliability of Advanced Interconnects – 2005 Symposium, MRS Symp. Proc. V 863, MRS, 2005, pp. 534-547.
306. "Cluster Computing for Transient Simulations of the Linear Boltzmann Equation on Irregular Three-Dimensional Domains", Matthias K. Gobbert, Mark L. Breitenbach and Timothy S. Cale, in Lecture Notes in Computer Science Vol. 3516, Vaidy S. Sunderam, Geert Dick van Albada, Peter M. A. Sloom, and Jack J. Dongarra, eds., Springer-Verlag, 2005, pp. 41-48.
305. "The Use of Conformal Voxels for Consistent Extractions from Multiple Level-Set Fields", Max O. Bloomfield, David F. Richards, and Timothy S. Cale, in Lecture Notes in Computer Science Vol. 3516, Vaidy S. Sunderam, Geert Dick van Albada, Peter M. A. Sloom, and Jack J. Dongarra, eds., Springer-Verlag, 2005, pp. 49 -56.
304. "First-Principles Modeling of Electronic Transport in  $\pi$ -Stacked Molecular Junctions", X.-Y. Liu, J. E. Reynolds, C. Wells, J. Welch, and T. S. Cale, *J. Appl. Phys.* **98**, 033712 (2005); also in *Virtual Journal of Nanoscale Science and Technology* **12(8)** (2005).
303. "Study of the Step Coverage by Using Evolve Simulation Program and Comparison of the Contact Resistance values for different Contact Openings by Using Two-Step and One-Step Titanium Nitride Barrier Process", Ardy Sidhwa, Chuck Spinner, Todd Gandy, Mike Goulding, William Brown, Hameed

- Naseem, Richard Ulrich, Simon Ang, Late Sherwood Charlton, Vinay Prasad and Timothy Cale, *IEEE Trans. Semi. Manuf.* **18(1)**, 163-173 (2005).
302. "Effects of Substrate/Film Temperature on Properties of Reactively Sputtered Tantalum Oxide Films", Pushkar Jain, Jasbir S. Juneja, Vinay Bhagwat, Eugene J. Rymaszewski, Toh -Ming Lu, and Timothy S. Cale, *J. Vac. Sci. Tech. A* **23(3)**, 512-519 (2005).
301. "Material removal model for chemical-mechanical polishing considering wafer flexibility and edge effects", Jongwon Seok, Cyriaque P. Sukam, Andrew T. Kim, John A. Tichy, Timothy S. Cale, *Wear* **257(5-6)**, 496-508 (2004).
300. "Simulation of Microstructure Formation during Thin Film Deposition", Max O. Bloomfield and Timothy S. Cale, in Simulation of Semiconductor Processes and Devices 2004, G. Wachutka and G. Schrag, eds., Springer Verlag 2004, pp. 232-6.
299. "Elastic Properties of Nanoplates: Electronic and Atomic Factors", L. G. Zhou, H. W. Shim, H. Huang and T. S. Cale, in Proceedings of the Second International Conference on Multiscale Materials Modeling, Nasr M. Ghoniem (ed.), UCLA, 2004, pp. 582-584.
298. (invited) "Multiscale Transport and Thin Film Microstructure Development", M. O. Bloomfield, T. S. Cale and H. Huang, in Proceedings of the Second International Conference on Multiscale Materials Modeling, Nasr M. Ghoniem (ed.), UCLA, 2004, p. 577.
297. "Multiscale Modeling for Interconnects – A Grain Focus", Timothy S. Cale, Max O. Bloomfield and Hanchen Huang, submitted to ECS.
296. "Applications of Plasma Coatings in Artificial Joints: An Overview", H. Liang, Bing Shi, Aaron Fairchild and Timothy Cale, *Vacuum* **73**, 317-326 (2004).
295. "Multiscale Modeling for Interconnects: Status and Opportunities", Timothy S. Cale, Max O. Bloomfield, Xiang-Yang Liu and Hanchen Huang, James E. Reynolds, Christopher Wells, John T. Welch, and Alain E. Kaloyeros, 2004 Proceedings of the 21st International VLSI Multilevel Interconnection Conference (VMIC), T. Wade, ed., IMIC, 2004, pp. 343-350.
294. "Nanoplate Elasticity under Surface Reconstruction", Hyun Woo Shim, L. G. Zhou, Hanchen Huang, and Timothy S. Cale, *App. Phy. Lett.* **86**, 151912 (2005).
293. "Diffusion Barriers on Cu Surfaces and Near Steps", Jian Wang, Hanchen Huang, Timothy S. Cale, *Modelling Simul. Mater. Sci. Eng.* **12**, 1209-1225 (2004).
292. "Adhesion of Sputter-deposited Ta to Porous Methyl Silsesquioxane Pore Sealed with Molecular Caulk" Dae-Lok Bae, Christopher Jezewski, Timothy S. Cale, and Jay J. Senkevich, *CVD* **11(4)**, 191-194 (2005).
291. "Formation of body-centered-cubic tantalum via sputtering on low-*k* dielectrics at low temperatures", Jay J. Senkevich, Tansel Karabacak, Dae-Lok Bae, and Timothy S. Cale, *J. Vac. Sci. Tech.* **B24(2)**, 534-538 (2006).
290. "Thermal Cycling Effects on Bond Strength and Residual Stress in Benzocyclobutene (BCB)-Bonded Wafers" by Yongchai Kwon, Jongwon Seok, Jian-Qiang Lu, Timothy S. Cale, and Ronald J. Gutmann, submitted to *J. Electrochem. Soc.* **152(4)**, G286-G294 (2005).
289. "Back-End Compatibility of Bonding and Thinning Processes for a Wafer-Level 3D Interconnect Technology Platform", S. Pozder, J.Q. Lu, Y. Kwon, S. Zollner, J. Yu, J.J. McMahon, T.S. Cale, K. Yu, and R.J. Gutmann, in Proc. of the IEEE 2004 International Interconnect Technology Conference, IEEE, 2004, pp. 102-104.
288. (invited) "Planarization Issues in Wafer-Level 3D Integration", Jian-Qiang Lu, G. Rajagopalan, M. Gupta, Timothy S. Cale and Ronald J. Gutmann, in Advances in Chemical Mechanical Polishing, MRS Symp. Proc. Vol. 816, MRS, 2004, pp. 217-228.
287. "Evaluation of Thin Dielectric-Glue Wafer-Bonding for Three-Dimensional Integrated Circuit-Applications", Yongchai Kwon, Jian Yu, Jay J McMahon, Jian-Qiang Lu, Timothy S Cale and Ronald J Gutmann, in Materials, Technology and Reliability for Advanced Interconnects and Low-k Dielectrics - 2004, MRS Symp. Proc. Vol. 812, MRS, 2004, pp. 321-326.

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2. "Size Effect on the Magnetic Moment Density of Dispersed Nickel", T. S. Cale, J. T. Richardson and J. J. Ginestra, *Appl. Phys. Lett.* **42(8)**, 744 (1983).
1. "Crystallite Size Distributions and Stabilities of Homogeneously Deposited Ni/SiO<sub>2</sub> Catalysts", J. T. Richardson, R. J. Dubus, J. G. Crump, P. Desai, U. Osterwalder and T. S. Cale, in Preparation of Catalysts

II. Scientific Bases for the Preparation of Heterogeneous Catalysts, B. Delmon, P. Grange, P. Jacobs and G. Poncelet, eds., Elsevier Scientific Publishing Company, 1978, pp. 131.

**Selected Presentations:** (since 1990)

(Invited) "Virtual Processing on Nanostructured Materials", M. O. Bloomfield and T. S. Cale, Arizona's Second Annual Nanotechnology Symposium, Scottsdale, AZ, March 23, 2007

"Stress Induced Grain Evolution in 3D-IC Inter-Wafer Interconnects, M. O. Bloomfield, D. N. Bentz, T. S. Cale, Materials for Advanced Metallization, Bruges, Belgium, March 4-7, 2007.

"Applying Grain Continuum Models to Stress Induced Grain Evolution in Next Generation Integrated Circuit Interconnects," D.N. Bentz, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann and T.S. Cale, COMSOL User Conference 2006 Boston, Boston, MA, October 22-24, 2006.

"Mechanical Models and Evolution of Polycrystalline 3D-IC Interwafer Vias," D.N. Bentz, M.O. Bloomfield, J.-Q Lu, R.J. Gutmann, and T.S. Cale, Advanced Metallization Conference (AMC) 2006, San Diego, CA, October 17-19, 2006.

"Stress-Induced Grain Evolution for 3D IC Reliability," M.O. Bloomfield, D.N. Bentz, J.-Q Lu, R. J. Gutmann, and T.S. Cale, Twenty Third International VLSI Multilevel Interconnection Conference, Fremont CA, September 25-28, 2006.

"Stress Induced Grain Boundary Migration in Polycrystalline Via Structures," D.N. Bentz, M.O. Bloomfield, J.-Q Lu, R. J. Gutmann, and T.S. Cale, Multiscale Materials Modeling Third International Conference, Freiburg, Germany September 18-22, 2006.

"Grain Based Modeling of Stress Induced Cooper Migration for 3D-IC Interwafer Vias," D.N. Bentz, M.O. Bloomfield, H. Huang, J.-Q Lu, R.J. Gutmann, and T.S. Cale, The 2006 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD '06), Monterey, CA, September 6-8, 2006.

"Stress-Induced Grain Boundary Migration In Polycrystalline Films," D.N. Bentz, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann, and T.S. Cale, 7th World Congress on Computational Mechanics, Los Angeles, CA, July 16-22, 2006.

"Next-Generation IC Interconnect Modeling using a Grain Continuum Approach," D.N. Bentz, M.O. Bloomfield, and T.S. Cale, Comsol Reaction Engineering Workshop, Troy, NY, June 27, 2006.

"Grain-focused Microstructure Simulations: Stress-Induced Evolution of Polycrystalline Films," D.N. Bentz, M.O. Bloomfield, and T.S. Cale, 11th International Conferences on Modern Materials and Technologies, Acireale, Sicily, Italy, June 4-9, 2006.

"Influences of Grain Structure on Thermally Induced Stresses in 3D IC Inter-wafer Vias," D.N. Bentz, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann, and T.S. Cale, 11th International Workshop on Computational Electronics, Vienna, Austria, May 25-27, 2006.

"Fine Keyed Alignment and Bonding for Wafer-Level 3D ICs", S.H. Lee, F. Niklaus, J.J. McMahon, J. Yu, R.J. Kumar, H.-F. Li, R.J. Gutmann, T.S. Cale, J.-Q. Lu, MRS Spring Meeting Paper F10.5, April 21, 2006, San Francisco, CA.

"Introducing Grain Structure Into Thermo-Mechanical Models of 3D-IC Inter-wafer Vias," D.N. Bentz, M.O. Bloomfield, J.-Q Lu, R. J. Gutmann, and T.S. Cale, 7th International Conference on Microelectronics and Interfaces (ICMI'06), Austin, TX, March 6-8, 2006.

(keynote) "A Conformal Voxel Method for Consistent Extraction in Complex Grain Structure Level-Set Simulations", Max O. Bloomfield, David F. Richards and Timothy S. Cale, International Conference on Computational and Experimental Engineering and Sciences", Dec. 1-6, 2005, Chennai, India.

“Consistent Extraction of Multiple Level Sets Using the Conformal Voxels Method”, Max Bloomfield and Timothy S. Cale, AIChE Meeting, Oct. 31 – Nov. 4, 2005, Cincinnati, OH.

“Grain Focused Simulation of Zirconia Cvd”, Max Bloomfield, Zhe Song, Bridget R. Rogers, and Timothy S. Cale, AIChE Meeting, Oct. 31 – Nov. 4, 2005, Cincinnati, OH.

“Modeling Thermal Stresses of Copper Interconnects in 3D IC Structures”, Daniel N. Bentz, Jing Zhang, Max Bloomfield, Jian-Qiang Lu, Ronald J. Gutmann and Timothy S. Cale, FEMLAB Conference 2005, Oct. 23-25, 2005, Boston, MA.

“Thermal Stresses in 3D IC Interwafer Vias”, Daniel N. Bentz, Jing Zhang, Max O. Bloomfield, Jian-Qiang Lu, Ronald J. Gutmann and Timothy S. Cale, Twenty-Second International VLSI Multilevel Interconnection Conference (VMIC), Oct. 4-6, 2005, Fremont, CA.

“Thermally Induced Stresses in 3D ICs”, Max Bloomfield, Jing Zhang, Daniel N. Bentz, Jian-Qiang Lu, Ronald J. Gutmann and Timothy S. Cale, Advanced Metallization Conference (2005), Sept. 27-29, 2005, Colorado Springs, CO.

“Molecular Caulk: Enabling aspects for ultra-low  $\kappa$  dielectric integration”, Jay J. Senkevich, Brad P. Carrow, Benjamin W. Woods, Dae-lok Bae, Timothy S. Cale and Pei-I Wang, Advanced Metallization Conference (2005), Sept. 27-29, 2005, Colorado Springs, CO.

“Grain-Focused Simulation of Zirconia CVD”, Max. O. Bloomfield, Zhe Song, Bridget R. Rogers, Timothy S. Cale, 6<sup>th</sup> Pacific Rim Conference on Ceramic and Glass Technology, Sept. 12-16, 2005, Maui, Hawaii.

(invited) “There and Back Again: Managing Discrete-to-Continuum-to-Discrete Transitions”, M. O. Bloomfield, H. Huang and T. S. Cale, European Conference on Materials (EuroMat 2005), September 5-9, 2005, Prague, CZ.

“Atomistic Modeling of Electron Transport in Self-Assembled Arene-Based Molecular Wires”, X-Y, Liu, J.E. Reynolds, C. Wells, J. Welch, and T.S. Cale, 2005 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD 2005), September 1-3, 2005, Tokyo Japan.

“Cluster Computing for Transient Simulations of the Linear Boltzmann Equation on Irregular Three-Dimensional Domains”, Matthias K. Gobbert, Mark L. Breitenbach and Timothy S. Cale, International Conference on Computational Science, May 22-25, 2005, Atlanta, GA.

“The Use of Conformal Voxels for Consistent Extractions from Multiple Level-Set Fields”, Max O. Bloomfield, David F. Richards, and Timothy S. Cale, Second International Workshop on Simulation of Multiphysics Multiscale Systems and International Conference on Computational Science, May 22-25, 2005, Atlanta, GA.

“A Cross-linkable Poly(p-xylylene) Derivative to Protect Ultra-Low  $\kappa$  Dielectrics”, Brad P Carrow, Jay J. Senkevich, Toh-Ming Lu, Timothy S. Cale, Yunqing Chen, and Hassaram Bakhru, Presentation B2.10, Spring 2005 Materials Research Society meeting, April 28 – May 1, 2005, San Francisco, CA.

“Effects of Bonding Process Parameters on Wafer-to-Wafer Alignment Accuracy in Benzocyclobutene (BCB) Dielectric Wafer Bonding”, Frank Niklaus, R. J. Kumar, J. J. McMahon, J. Yu, T. Matthias, M. Wimplinger, P. Lindner, J. -Q. Lu, T. S. Cale and R. J. Gutmann, Presentation B10.8, Spring 2005 Materials Research Society meeting, April 28 – May1, 2005, San Francisco, CA.

“Thermal Stress in 3D IC Interwafer Interconnects”, J. Zhang, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann, and T.S. Cale, MAM2005 - Materials for Advanced Metallization Conference 2005, March 6 - 9, 2005, Dresden, Germany.

“A Finite Element Study of Thermal Stress in 3D IC Structures”, J. Zhang, M.O. Bloomfield, J.-Q. Lu, R.J. Gutmann, and T.S. Cale, AVS 6th International Conference on Microelectronics and Interfaces (ICMI'05), March 21 - 23, 2005, Santa Clara, CA

“Diffusion Barriers and Nanostructure Design”, J. Wang, H. Huang, and T. S. Cale, Presentation U5.11, Fall 2004 Meeting of the Materials Research Society, Nov. 29 – Dec. 3, 2004, Boston, MA.

“Atomistic Electron Transport Modeling of  $\pi$ -Stacked Molecular Interconnects”, X.-Y. Liu, J.E. Reynolds, C. Wells, J. Welch, and T.S. Cale, Presentation III.9, Fall 2004 Meeting of the Materials Research Society, Nov. 29 – Dec. 3, 2004, Boston, MA.

“Elastic Properties of Silicon Nanoplates”, H. W. Shim, L. G. Zhou, H. Huang, and T. S. Cale, Presentation T4.5, Fall 2004 Meeting of the Materials Research Society, Nov. 29 – Dec. 3, 2004, Boston, MA.

“Microstructure Modeling of MOCVD Zirconium Oxide Deposition”, M. O. Bloomfield, Z. Song, B. R. Rogers and T. S. Cale, AVS 51<sup>st</sup> International Symposium and Exhibition, Nov. 14-19, 2004, Anaheim, CA.

“Physical and Chemical Characterization of MOCVD Zirconia Films Deposited on Hydrogen-Terminated and Native Oxide Si Surfaces”, B. R. Rogers, Z. Song, R. D. Geil, R. A. Weller, M. O. Bloomfield and T. S. Cale, AVS 51<sup>st</sup> International Symposium and Exhibition, Nov. 14-19, 2004, Anaheim, CA.

(invited) “Multiscale Transport and Thin Film Microstructure Development”, M. O. Bloomfield, H. Huang and T. S. Cale, 2<sup>nd</sup> International Conference on Multiscale Materials Modeling (MMM-II), Oct. 11-15, 2004, Los Angeles, CA.

“Mechanics of Nanoplates and Nanowires”, Hanchen Huang, L. G. Zhou, H. W. Shim and T. S. Cale, 2<sup>nd</sup> International Conference on Multiscale Materials Modeling (MMM-II), Oct. 11-15, 2004, Los Angeles, CA.

“Multiscale Modeling for Interconnects – A Grain Focus”, Timothy S. Cale, Max O. Bloomfield and Hanchen Huang, 2004 Meeting of the Electrochemical Society, Oct. 3-8, 2004, Honolulu, Hawaii.

“Wafer-Level Three-Dimensional ICs: A Better Solution Than SoCs and SiPs?”, R. J. Gutmann, J.-Q. Lu and T. S. Cale, 1<sup>st</sup> International Wafer Level Packaging Conference, Oct. 10-12, 2004, San Jose, CA.

(invited) “Multiscale Modeling for Interconnects: Status and Opportunities”, Timothy S. Cale, Max O. Bloomfield, Xiang-Yang Liu and Hanchen Huang, James E. Reynolds, Christopher Wells, John T. Welch, and Alain E. Kaloyeros, 21<sup>st</sup> International VLSI Multilevel Interconnection Conference (VMIC), Sept. 30 – Oct. 2, 2004, Waikoloa Beach, Hawaii.

(invited) “Ballistic Transport and Reaction in Microstructure” Max O. Bloomfield, Xiang-Yang Liu, Timothy S. Cale, World Congress on Computational Mechanics VI, September 5-10, 2004, Beijing, China.

“Atomistic Level Modeling of Semiconductor Processes and Nano-Interconnects”, X.-Y. Liu\*, W. Windl, D. Jovanovic, R. Stumpf, T. S. Cale, World Congress on Computational Mechanics VI, September 5-10, 2004, Beijing, China.

“Simulation of Microstructure Formation during Thin Film Deposition”, Max O. Bloomfield and Timothy S. Cale, 2004 IEEE Simulation of Semiconductor Processes and Devices conference (SISPAD), Sep. 1-3, 2004, Munich, Germany.

(invited) “Multiscale Process Modeling in Microelectronics”, Max O. Bloomfield and Timothy S. Cale, International Conference on Computational & Experimental Engineering and Science, July, 2004, Madiera, Portugal

(invited) “Grain-Continuum Methods for Microstructure Formation and Evolution”, Timothy S. Cale and Max O. Bloomfield, 4<sup>th</sup> European Congress on Computational Methods in Applied Science and Engineering (ECCOMAS 2004), July 24-28, 2004, Jyvaskyla, Finland.

“Back-End Compatibility of Bonding and Thinning Processes for a Wafer-Level 3D Interconnect Technology Platform”, S. Pozder, J.Q. Lu, Y. Kwon, S. Zollner, J. Yu, J.J. McMahon, T.S. Cale, K. Yu, and R.J. Gutmann, Paper 6.2, IITC, June 7-9, 2004, Burlingame, CA.

(invited) "Wafer-Level 3D Hyper-Integration Processing Technology", J.Q. Lu, T.S. Cale and R.J. Gutmann, 3D Technology, Modeling and Process Symposium, April 13, 2004, Burlingame, CA.

(invited) "Planarization Issues in Wafer-Level 3D Integration", Jian-Qiang Lu, Timothy S. Cale and Ronald J. Gutmann, Paper K7.7, Materials Research Society meeting, April 12-16, 2004, San Francisco, CA.

"Evaluation of Thin Dielectric-Glue Wafer-Bonding for Three-Dimensional Integrated Circuit-Applications", Yongchai Kwon, Jian Yu, Jay J McMahon, Jian-Qiang Lu, Timothy S Cale and Ronald J Gutmann, Paper F6.16, Materials Research Society meeting, April 12-16, 2004, San Francisco, CA.

"Fundamental Limits for 3D Wafer-to-Wafer Alignment Accuracy", Markus Wimplinger, Jian-Qiang (James) Lu, Jian Yu, Yongchai Kwon, Thorsten Matthias, Timothy S. Cale and Ronald J. Gutmann, Paper F6.10, Materials Research Society meeting, April 12-16, 2004, San Francisco, CA.

"Formation and Evolution of Grain Structure in Thin Films", Max O. Bloomfield and Timothy S.Cale, Materials for Advanced Metallization, March 8-10, 2004, Brussels, Belgium.

"A Kinetic Model for Chemical Vapor Deposition at the Feature Scale", Matthias K. Gobbert and Timothy S. Cale, AVS Fifth Int. Conf. on Microelectronics and Interfaces (ICMI), March 1-3, 2004, Santa Clara, CA.

"Thermal Cycling Effects on Bond Strength and Residual Stress in Wafer Pairs Bonded with Benzocyclobutene (BCB)", Y. Kwon, Jian-Qiang Lu, Timothy S. Cale and Ronald J. Gutmann, AVS Fifth Int. Conf. on Microelectronics and Interfaces (ICMI), March 1-3, 2004, Santa Clara, CA.

(invited) "Thermal Effects During Cu CMP", L. Borucki, A. Philipossian, J. Tichy and T. Cale, AVS Fifth Int. Conf. on Microelectronics and Interfaces (ICMI), March 1-3, 2004, Santa Clara, CA.

"Evolution of Interconnect Microstructures", Max O. Bloomfield and Timothy S. Cale, AVS Fifth Int. Conf. on Microelectronics and Interfaces (ICMI), March 1-3, 2004, Santa Clara, CA.

(invited) "Multiscale Modeling of Chemical Mechanical Planarization", T.S. Cale and J. A. Tichy and L.J. Borucki, Ninth International Chemical-Mechanical Planarization for ULSI Multilevel Interconnection Conference (CMP-MIC), Los Angeles, CA, Feb. 24-26, 2004.

"Experimental and Theoretical Analysis of Non-Rotating Copper Wafer Polishing", L.J. Borucki, A. Jindal, T.S. Cale, R.J. Gutmann, J.A. Tichy, S.H. Ng and S. Danyluk, Ninth International Chemical-Mechanical Planarization for ULSI Multilevel Interconnection Conference (CMP-MIC), Los Angeles, CA, Feb. 24-26, 2004.

(invited) "3D Hyper-Integration Technology Using Dielectric Adhesive Wafer Bonding and Cu Damascene Inter-Wafer Interconnects", J.-Q. Lu, Timothy S. Cale and Ronald J. Gutmann, International Workshop of 3D System Integration", December 16, 2003, Fraunhofer-Institute, Munich, Germany.

"Bonding Integrity of Oxidized Polydimethylsiloxane (PDMS) Using Four Point Bending", J.J. McMahon, Y. Kwon, J.-Q. Lu, T.S. Cale, R.J. Gutmann, Fall 2003 Meeting of the Materials Research Society, Dec. 1-5, 2003, Boston, MA.

"A Model Relating Process Variables to Film Properties for Reactively Sputtered Tantalum Oxide Thin Films", P. Jain, E. Rymaszewski, S. Borg, T.S. Cale, 2003 Annual Meeting of the AIChE, Nov. 17-22, 2003, San Francisco, CA.

"Formation and Evolution of Polycrystalline Microstructure", M.O. Bloomfield, Y.H. Im, T.S. Cale, 2003 Annual Meeting of the AIChE, Nov. 17-22, 2003, San Francisco, CA.

(invited) "Multiscale and Multistep Process Simulation", T.S. Cale, M.O. Bloomfield, Y.H. Im, J. Wang, H. Huang, 2003 Annual Meeting of the AIChE, Nov. 17-22, 2003, San Francisco, CA.

“Integrated Multiscale, Multistep Process Simulation for Damascene Structures”, Y.H. Im, M.O. Bloomfield, J. Seok, C.P. Sukam, J.A. Tichy, T. S. Cale, 2003 Annual Meeting of the AIChE, Nov. 17-22, 2003, San Francisco, CA.

(invited) “A Wafer-Level 3D IC Technology Platform”, R.J. Gutmann, J.-Q. Lu, S. Pozder, Y. Kwon, A. Jindal, M. Celik, J.J. McMahon, K. Yu and T.S. Cale, Advanced Metallization Conference 2003, Oct. 21-23, 2003, Montreal, Canada.

“Simulation of Etching and Sealing of Porous Dielectrics”, M.O. Bloomfield, Y.H. Im, and T.S. Cale, Advanced Metallization Conference 2003, Oct. 21-23, 2003, Montreal, Canada.

“Grain Boundary Migration in Metallic Interconnects”, M.O. Bloomfield and T.S. Cale, Advanced Metallization Conference 2003, Oct. 21-23, 2003, Montreal, Canada.

“Integrated Multistep Process Simulation with Chip-Scale Structures”, M.O. Bloomfield, L.J. Borucki, Y.H. Im, and T.S. Cale, Advanced Metallization Conference 2003, Oct. 21-23, 2003, Montreal, Canada.

“Three Dimensional Feature Profile Evolution during Etching of Porous Dielectric Materials”, Y.H. Im, M.O. Bloomfield, T.S. Cale, AVS 50<sup>th</sup> International Symp., Nov. 2-7, 2003, Baltimore, MD.

(invited) “Technology of Monolithic Wafer-Level 3D Hyperintegration”, J.-Q. Lu, T.S. Cale and R.J. Gutmann, Peaks Wafer Level Packaging International Symposium, Oct. 8-10, 2003; Whitefish, MT.

“Plasma Etching of Porous Dielectric Substrates”, M.O. Bloomfield, Y.H. Im, and T.S. Cale, 204<sup>th</sup> Meeting of the Electrochemical Society, Oct. 12-16, 2003, Orlando, FL.

“Microstructure Development and Evolution” M.O. Bloomfield, Y.H. Im, and T.S. Cale, 2003 IEEE International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), Sept. 3-5, 2003, Boston, MA.

“Developing the Structure of a Cu CMP Model” J. Seok, C.P. Sukam, L.J. Borucki, A. Jindal, J.A. Tichy, R.J. Gutmann, and T.S. Cale, 2003 IEEE International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), Sept. 3-5, 2003, Boston, MA.

“Integrated Multiscale Multistep Process Simulation” Y.H. Im, M.O. Bloomfield, J. Seok, C.P. Sukam, J.A. Tichy and T.S. Cale, 2003 IEEE International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), Sept. 3-5, 2003, Boston, MA.

(invited) “Thin Film Microstructure Simulation for Integrated Circuit Manufacturing”, T.S. Cale, M.O. Bloomfield and Y.H. Im, 5<sup>th</sup> EuroMech Solid Mechanics Conference (ESMC-5), Aug. 17-22, 2003, Thessaloniki, Greece.

(invited) “Development of Microstructure in Nanostructures and Thin Films”, Max O. Bloomfield, Yeon Ho Im, Jian Wang, Hanchen Huang, and Timothy S. Cale, SPIE First International Symposium on Microtechnologies for the New Millennium 2003, May 19-21, 2003, Gran Canaria, Canary Islands, Spain.

“Evaluation Procedures for Wafer Bonding and Thinning of Interconnect Test Structures for 3D ICs, J.-Q. Lu, A. Jindal, Y. Kwon, J.J. McMahon, T.S. Cale and R.J. Gutmann, 2003 International Interconnect Technology Conference (IITC), June 2-4, 2003, San Francisco, CA.

“Modeling of Thermal Dynamics and Mechanical Stress in 3D-IC Structure”, J. Zhang, J.-Q. Lu, R. Gutmann, and T. Cale, 203<sup>rd</sup> Meeting of The Electrochemical Society (ECS), Paris, France, April 27-May 2, 2003.

(invited) “3D System-on-a-Chip using Dielectric Glue Bonding and Cu Damascene Inter-Wafer Interconnects” J.-Q. Lu, T. Cale, and R. Gutmann, 203<sup>rd</sup> Meeting of The Electrochemical Society (ECS), Paris, France, April 27-May 2, 2003.

“Wafer Bonding and Thinning Integrity for 3D-IC Fabrication”, Y. Kwon, A. Jindal, J.J. McMahon, T.S. Cale, R.J. Gutmann, and J.-Q. Lu, 203<sup>rd</sup> Meeting of The Electrochemical Society (ECS), Paris, France, April 27-May 2, 2003.

“Effect of Plasma Sulfur Activation of SiLK on the Adhesion of Copper”, D.-L. Bae, J.J. Senkevich, Y. Kwon, and T.S. Cale, 203<sup>rd</sup> Meeting of The Electrochemical Society (ECS), Paris, France, April 27-May 2, 2003.

"A Multiscale Mechanical CMP Model for Patterned Wafers", C. P. Sukam, J. Seok, A. T. Kim, J. A. Tichy and T. S. Cale, 203<sup>rd</sup> Meeting of the Electrochemical Society (ECS), April 27-May 2, 2003, Paris, France.

"Integrated Multiscale Process Simulation of Damascene Structures", M. O. Bloomfield, Yeon Ho Im, J. Seok, C. P. Sukam, J. A. Tichy and T. S. Cale, 203<sup>rd</sup> Meeting of the Electrochemical Society (ECS), April 27-May 2, 2003, Paris, France.

“Wafer Level Assembly of Heterogeneous Technologies”, J.-Q. Lu, A. Jindal, P. D. Persans, T. S. Cale and R. J. Gutmann, MANTECH 2003, Scottsdale, AZ, May, 19-22, 2003.

“Dielectric-Glue Wafer-Bonding for 3-D ICs”, Y. Kwon, A. Jindal, J.J. McMahon, J.-Q. Lu, R.J. Gutmann, T.S. Cale, MRS Spring Meeting, April 22-25, 2003, San Francisco, CA,

“Wafer Thinning for Monolithic 3D Integration”, A. Jindal, J.-Q. Lu, Y. Kwon, G. Rajagopalan, J.J. McMahon, A.Y. Zeng, H.K. Flesher, T.S. Cale, R.J. Gutmann, MRS Spring Meeting, April 22-25, 2003, San Francisco, CA.

"Modeling of Surface Profile Evolution of Patterned Wafers during Chemical Mechanical Polishing", C.P. Sukam, J. Seok, A. T. Kim, J.A. Tichy and T.S. Cale, European Workshop on Materials for Advanced Metallization (MAM), Mar. 9-12, 2003, Aix-Marseille, France.

"Integrated Multiscale, Multistep Process Simulation for Damascene Structures", J. Seok, M.O. Bloomfield, Y.H. Im, C.P. Sukam, J. A. Tichy and T.S. Cale, European Workshop on Materials for Advanced Metallization (MAM), Mar. 9-12, 2003, Aix-Marseille, France.

"An Integrated Multiscale Chemical Mechanical Planarization Model for Patterned Wafers with Surface Evolution", C.P. Sukam, J. Seok, A.T. Kim, J.A. Tichy and T.S. Cale, 4<sup>th</sup> International Conference on Microelectronics and Interfaces (ICMI'03), March 3-6, 2003, Santa Clara CA.

“Coalescence of Nanoscale Islands During Polycrystalline Thin Film Growth”, M.O. Bloomfield, Y.H. Im, H. Huang and T.S. Cale, 4<sup>th</sup> International Conference on Microelectronics and Interfaces (ICMI'03), March 3-6, Santa Clara, CA.

“Characterization of Key Processing Steps for 3D-ICs using Dielectric Glue Bonding and Cu Damascene Inter-Wafer Interconnects”, J.-Q. Lu, A. Jindal, Y. Kwon, J. McMahon, B. Altemus, D. Cheng, E.T. Eisenbraun, T.S. Cale, and R.J. Gutmann, 4<sup>th</sup> International Conference on Microelectronics and Interfaces (ICMI'03), March 3-6, Santa Clara, CA.

“Feature Scale Modeling for Chip-Scale Models Of Pattern Density Effects During ECD”, Y.H. Im, M.O. Bloomfield and T.S. Cale, 4<sup>th</sup> International Conference on Microelectronics and Interfaces (ICMI'03), March 3-6, Santa Clara, CA.

“Evaluation of Wafer Bonding and Thinning for 3D-IC Fabrication”, Y. Kwon, A. Jindal, J. J. McMahon, J.-Q. Lu, T.S. Cale, and R.J. Gutmann, 4<sup>th</sup> International Conference on Microelectronics and Interfaces (ICMI'03), March 3-6, Santa Clara, CA.

“Direct Copper Metallization on Low-k SiLK Activated by Plasma Enhanced Chemical Vapor Deposition (PE-CVD) of Sulfur”, D.-L. Bae, J.J. Senkevich, Y. Kwon, and T.S. Cale, 4<sup>th</sup> International Conference on Microelectronics and Interfaces (ICMI'03), March 3-6, 2003, Santa Clara, CA.

(invited) "Integrated Multiscale and Multistep Process Simulation", M.O. Bloomfield, Y.H. Im, J. Seok, C.P. Sukam, J.A. Tichy, and T.S. Cale, Eighth international CMP-MIC Conference, Feb. 19-21, 2003, Marina Del Rey, CA.

(invited) "Planarization Issues for Three-Dimensional (3D) ICs and Wafer-Scale Packaging (WSP) Applications", R.J. Gutmann, A. Jindal, G. Rajagopalan, J.-Q. Lu, J.J. McMahon, Y. Kwon and T.S. Cale, Eighth international CMP-MIC Conference, Feb. 19-21, 2003, Marina Del Rey, CA.

"Wafer-Level High Density Multifunctional Integration (HDMI) for Low-Cost Micro/Nano/Electro Opto/Bio Heterogeneous Systems", R.J. Gutmann, J.-Q. Lu, J.J. McMahon, P.D. Persans, T.S. Cale, E.T. Eisenbraun, J. Castracane and A.E. Kaloyeros, Nanotech 2003, February 23-27, 2003, San Francisco, CA.

"Modeling of Material Removal for Fixed Abrasive CMP: Blanket Wafers," C. P. Sukam, J. Seok, A. T. Kim, J. A. Tichy and T. S. Cale, Walter Lincoln Hawkins Graduate Research Conference 2002, Oct. 17, 2002, Rensselaer Polytechnic Institute, Troy, NY.

"Reduction in Contact Resistance by Using a Modified Barrier Process and Understanding the Step Coverage Limitations Using the EVOLVE Simulation Program", Ardy Sidhwa, Todd Gandy, Michael Goulding, Chuck Spinner, Vinay Prasad, Timothy Cale, 19th International VLSI Multilevel Interconnection Conference (VMIC), Nov. 18-20, 2002, Singapore.

(invited) "Processing Technology for High Density Multifunctional Integration (HDMI) Using Wafer Bonding and Monolithic Inter-Wafer Interconnection, J.-Q. Lu, Y. Kwon, A. Jindal, K.-W. Lee, J.J. McMahon, G. Rajagopalan, A. Y. Zeng, R. P. Kraft, B. Altemus, B. Xu, E. Eisenbraun, J. Castracane, J. F. McDonald, T. S. Cale, A. E. Kaloyeros, R. J. Gutmann, 19th International VLSI Multilevel Interconnection Conference (VMIC), Nov. 18-20, 2002, Singapore.

(invited) "Integrated Multiscale Process Simulation," T. S. Cale, M. O. Bloomfield, J. Seok, C. P. Sukam, and J. A. Tichy, presented during the 19th International VLSI Multilevel Interconnection Conference (VMIC), Nov. 18-20, 2002, Singapore.

"Parallel Numerical Solution of the Boltzmann Equation for Atomic Layer Deposition", Samuel G. Webster, Matthias K. Gobbert, Jean-Francois Remacle and Timothy S. Cale, presented during Euro-Par 2002, Paderborn, Germany, August 29, 2002.

(invited) B. Melnick and T. S. Cale, "Summary of AMC 2002", presented during the Advanced Metallization Asia, Oct. 29-30, 2002, University of Tokyo, Tokyo, Japan.

(invited) M. O. Bloomfield, Y.-H. Im, H.Huang, and T.S. Cale, 'Coalescence of Nanoscale Islands into Polycrystalline Thin Films' International Union of Theoretical and Applied Mechanics Symposium on Multiscale Modeling and Characterization of Elastic-Inelastic Behavior of Engineering Materials (IUTAM), Oct. 20, 2002, Marrakech, Morocco.

"Feature Profile Evolution during Cl<sub>2</sub> and HBr Plasma Etching of Silicon", Y. H. Im, M. O. Bloomfield and Timothy S. Cale, presented during the AVS 47th International Symposium, Denver, CO, Nov. 3-8, 2002.

"Application of a global-local random-walk algorithm for thermal analysis of 3D integrated circuits", J. Kalyanasundharam, R. B. Iverson, E. T. Thompson, V. Prasad, T. S. Cale, R. J. Gutmann, Y. Le Coz, presented during the Advanced Metallization Conference 2002, Oct. 1-3, 2002, San Diego, CA.

"Improving ALD Pulse Protocols", V. Prasad, M. K. Gobbert, T. S. Cale, presented during the Advanced Metallization Conference 2002, Oct. 1-3, 2002, San Diego, CA.

"Grain Formation during Polycrystalline Thin Film Growth", M.O. Bloomfield, Y.H. Im, H. Huang, and T.S. Cale, presented during the Advanced Metallization Conference 2002, Oct. 1-3, 2002, San Diego, CA.

"Processing of inter-wafer vertical interconnects in 3D ICs", K. W. Lee, J. Q. Lu, Y. Kwon, G. Rajagopalan, M. Gupta, J. McMahon, A. Y. Zeng, R. P. Kraft, J. F. McDonald, T. S. Cale, R. J. Gutmann, B. Xu, B. Altemus, E. Eisenbraun, J. Castracane, A. Kaloyeros, presented during the Advanced Metallization Conference 2002, Oct. 1-3, 2002, San Diego, CA.

"Pattern density effects on film profile evolution in copper electrochemical deposition", Yeon Ho Im, Max O. Bloomfield, Timothy S. Cale, presented during the Advanced Metallization Conference 2002, Oct. 1-3, 2002, San Diego, CA.

“An Integrated Multiscale Mechanical Model for Chemical Mechanical Planarization,” J. Seok, C. P. Sukam, A. T. Kim, J. A. Tichy and T. S. Cale, presented during the Advanced Metallization Conference 2002, Oct. 1-3, 2002, San Diego, CA.

“Grain Formation During Polycrystalline Thin Film Growth”, Max O. Bloomfield, Yeon Ho Im, and Timothy S. Cale, presented during the Second ECS International Semiconductor Technology Conference (ISTC), Sept. 12-14, 2002, Tokyo, Japan.

“Pattern Density Effects on Film Profile Evolution During ECD”, Yeon Ho Im, Max O. Bloomfield, Suchira Sen, and Timothy S. Cale, presented during the Second ECS International Semiconductor Technology Conference (ISTC), Sept. 12-14, 2002, Tokyo, Japan.

“A Statistical Integrated Multiscale CMP Model with Surface Evolution,” C. P. Sukam, J. Seok, A. T. Kim, J. A. Tichy and T. S. Cale, presented during the Second ECS International Semiconductor Technology Conference (ISTC), Sept. 12-14, 2002, Tokyo, Japan.

“A Framework for Simulation of Materials Processing on the Island, Grain, And Reactor Scales”, M. O. Bloomfield, V. Prasad, O. Klaas, and T. S. Cale, International Conferences on Modern Materials and Technologies (CIMTEC 2002), July 14-18, 2002.

(invited) “Coalescence and Evolution of Nanoscale Islands into Polycrystalline Thin Films”, M. O. Bloomfield, D. F. Richards, D. Datta, O. Klaas, M. S. Shephard, and T. S. Cale, presented during the Fifth World Congress on Computational Mechanics (WCCM V), Vienna, Austria, July 7-12, 2002.

(Keynote) “Simulation of Materials Processing on the Island, Grain and Reactor Scales”, M.O. Bloomfield, V. Prasad, D. Datta, O. Klaas, M.S. Shephard, and T.S. Cale, presented during Multiscale Materials Modelling, London, England, June 17-20, 2002.

(invited) “Integrated Multiscale Process Simulation: Equipment to Microstructure”, Timothy S. Cale, Max O. Bloomfield, Yeon Ho Im, and Kenneth E. Jansen, presented during the 8<sup>th</sup> IUMRS International Conference on Electronic Materials, Xian, China, Jun 10-14, 2002.

"A Wafer-Scale 3D IC Technology Platform using Dielectric Bonding Glues and Copper Damascene Patterned Inter-Wafer Interconnects", J.-Q. Lu, Y. Kwon, G. Rajagopalan, M. Gupta, J. McMahan, K.-W. Lee, R.P. Kraft, J. F. McDonald, T.S. Cale, R.J. Gutmann, B. Xu, E. Eisenbraun, J. Castracane, and A. Kaloyeros, presented during the 2002 IEEE International Interconnect Technology Conference (IITC), San Francisco, CA, June 3-5, 2002.

“Prediction of Deposition Rates in Plasma-Enhanced Atomic Layer Deposition”, V. Prasad, S. C. Foster, M. K. Gobbert, and T. S. Cale, presented during the 201<sup>st</sup> Electrochemical Society Spring 2002 Meeting, Philadelphia, PA, May 12-17, 2002.

“Transient Multiscale Modeling of Electrochemical Deposition”, S. Sen, M. Bloomfield, K. Jansen, and T. Cale, presented during the 201<sup>st</sup> Electrochemical Society Spring 2002 Meeting, Philadelphia, PA, May 12-17, 2002.

“Transient Transport and Reactant-Wafer Interactions: Adsorption and Desorption”, S. G. Webster, M. K. Gobbert, V. Prasad, and T. S. Cale, presented during the 201<sup>st</sup> Electrochemical Society Spring 2002 Meeting, Philadelphia, PA, May 12-17, 2002.

(invited) “Multiscale Mechanical Modeling of CMP”, J. Seok, C. P. Sukam, J. A. Tichy, and T. S. Cale, presented during the 201<sup>st</sup> Electrochemical Society Spring 2002 Meeting, Philadelphia, PA, May 12-17, 2002.

“Multiscale Modeling of the Development Of 3-Dimensional Grain Structures”, M. O. Bloomfield, D. F. Richards, V. Prasad, O. Klaas, D. Datta, M. S. Shephard, and T.S. Cale, presented during the 2002 MRS Spring Meeting, San Francisco, CA, April 1-5, 2002.

“Modeling of Material Removal for Fixed Abrasive CMP”, C. P. Sukam, J. Seok, A. T. Kim, J. A. Tichy, and T. S. Cale, presented during the Seventh International CMP-MIC Conference, Feb. 27 – Mar. 1, 2002, Santa Clara, CA.

"Modeling of the Material Removal for Chemical Mechanical Planarization," C. P. Sukam, J. Seok, A. T. Kim, J. A. Tichy and T. S. Cale, presented during the AVS Third International Conference on Microelectronics and Interfaces, February 11-15, 2002, Santa Clara, California.

“Simulation of Materials Processing on the Island, Grain, and Reactor Scales”, M. O. Bloomfield, V. Prasad, D. Datta, O. Klaas, M. S. Shephard, and T. S. Cale, presented during the AVS Third International Conference on Microelectronics and Interfaces (ICMI), February 14, 2002.

“Prediction of Deposition Rates in Atomic Layer Deposition”, V. Prasad, M. K. Gobbert, and T. S. Cale, presented during the AVS Third International Conference on Microelectronics and Interfaces (ICMI), February 2002.

“Wafer Bonding Using Dielectric Polymer Glues in 3D Integration”, Yongchai Kwon, Jian-Qiang Lu, Russell P. Kraft, John F. McDonald, Ronald J. Gutmann and Timothy S. Cale, presented during the 2001 Materials Research Society (MRS) Fall Meeting, November 26-30, 2001, Boston, Massachusetts.

"Multiscale Simulation of the Development and Coalescence of 3-Dimensional Grain Structures", Max O. Bloomfield, Ottmar Klaas, Vinay Prasad, Jing Lu, Antoinette M. Maniatty and Timothy S. Cale, presented during the MRS Fall Meeting, November 26-30, 2001, Boston, Massachusetts.

(Invited) “Three-Dimensional (3D) ICs: A Technology Platform for Integrated Systems and Opportunities for New Polymeric Adhesives”, R.J. Gutmann, J.-Q. Lu, Y. Kwon, J.F. McDonald and T.S. Cale, presented during the 1<sup>st</sup> International IEEE Conference on Polymers and Adhesives in Microelectronics and Photonics (Polytronic 2001), Potsdam, Germany, October 21-24, 2001.

"A Multiscale Contact Mechanics and Hydrodynamics Model of Chemical Mechanical Polishing”, Andrew T. Kim, John A. Tichy and Timothy S. Cale, presented during the Eighteenth International VLSI Multilevel Interconnect Conference, Nov. 28 - 29, 2001, Santa Clara, CA

(Invited)“Design and Fabrication of Damascene Patterned Interconnections for “Face-to-Face” Wafer Bonded 3D-Stacked IC Via Chain Test Structures”, J.-Q. Lu, O. Ergodan, Y. Kwon, G. Rajagopalan, D.-L. Bae, C. K. Hong, M. Gupta, J. McMahan, R. P. Kraft, P. M. Belemjian, T. S. Cale, J. F. McDonald and R. J. Gutmann, B. Xu, E. Eisenbraun, and J. Castracane, presented during the Eighteenth International VLSI Multilevel Interconnection (VMIC) Conference, Nov. 28 - 29, 2001, Santa Clara, CA.

"Modeling and Simulation Opportunities for 3D Integrated Circuits", V. Prasad, M.O. Bloomfield, J. Lu, O. Klaas, A. Maniatty, M. S. Shephard and T. S. Cale, presented during the Eighteenth International VLSI Multilevel Interconnect Conference, Nov. 28 - 29, 2001, Santa Clara, CA.

(Invited) “Integrated Multiscale Simulation of Copper Electrochemical Deposition”, M. O. Bloomfield, S. Sen, K. E. Jansen, and T. S. Cale, presented during the Eighteenth International VLSI Multilevel Interconnect Conference, Nov. 28 - 29, 2001, Santa Clara, CA.

"A Feature Scale Model for Atomic Layer Deposition", M. K. Gobbert, V. Prasad, M. O. Bloomfield and T. S. Cale, presented during the Eighteenth International VLSI Multilevel Interconnect Conference, Nov. 28 - 29, 2001, Santa Clara, CA.

“Fabrication of Via-Chain Test Structures for 3D IC Technology using Dielectric Bonding of 200 mm Wafers”, J.-Q. Lu, Y. Kwon, G. Rajagopalan, M. Gupta, D.-L. Bae, J. McMahan, C.K. Hong, R. P. Kraft, O. Ergodan, P.M. Belemjian, , J. F. McDonald, T. S. Cale and R. J. Gutmann, B. Xu, E. Eisenbraun, J. Castrance and A. Kaloyeros, presented during the Advanced Metallization Conference, October 9-11, 2001, Montreal, Canada.

"A Transport and Reaction Model for Atomic Layer Deposition", M. K. Gobbert, V. Prasad, M. O. Bloomfield and T. S. Cale, presented during the Advanced Metallization Conference, October 9-11, 2001, Montreal, Canada.

"Modeling and Simulation Opportunities for 3D Integrated Circuits", Max O. Bloomfield, Vinay Prasad, Jing Lu, Ottmar Klaas, Antoinette M. Maniatty, Mark S. Shephard and Timothy S. Cale, presented during the Advanced Metallization Conference, October 9-11, 2001, Montreal, Canada.

"A Tool for the Representation, Evolution, and Coalescence of 3-Dimensional Grain Structures", M. O. Bloomfield, D. F. Richards and T. S. Cale, presented during the Sixth United States National Congress on Computational Mechanics, August 1-3, 2001, Dearborn, MI.

“Wafer Bonding Using Low-k Dielectrics as Bonding Glue in Three- Dimensional Integration”, Y. Kwon, J.-Q. Lu, R. J. Gutmann, R. P. Kraft, J. F. McDonald and T. S. Cale, presented during the 200th Meeting of The

Electrochemical Society, Inc. and the 52nd Meeting of The International Society of Electrochemistry (ECS/ISE), September 2-7, 2001, San Francisco, CA.

"Effectiveness of Pulsed Cu ECD in Void Reduction in Feature Fills", S. Sen, S. Soukane and T. S. Cale, presented during the 200th Meeting of The Electrochemical Society, Inc. and the 52nd Meeting of The International Society of Electrochemistry (ECS/ISE), September 2-7, 2001, San Francisco, CA.

"Connecting the Evolution and Coalescence of 3-Dimensional Grain Structures to Reactor-Scale Phenomena", Max O. Bloomfield, David F. Richards, Ottmar Klaas, Jing Lu, Antoinette M. Maniatty, and Timothy S. Cale, presented during the 200th Meeting of The Electrochemical Society, Inc. and the 52nd Meeting of The International Society of Electrochemistry (ECS/ISE), September 2-7, 2001, San Francisco, CA.

"A Multi-scale Elasto-Hydrodynamic Contact Model of Chemical Mechanical Planarization", Andrew T. Kim, John A. Tichy and Timothy S. Cale, presented during the 48<sup>th</sup> AVS Fall Meeting, Oct. 29- Nov. 2, San Francisco, CA.

"Connecting the Evolution and Coalescence of 3-Dimensional Grain Structures to Reactor-Scale Phenomena", Max O. Bloomfield, David F. Richards, Ottmar Klaas, Jing Lu, Antoinette M. Maniatty, Timothy S. Cale and Mark S. Shephard, presented during the 48<sup>th</sup> AVS Fall Meeting, Oct. 29- Nov. 2, San Francisco, CA.

"Plasma Processing in Multilevel Metallization Process Flows", Hong Liang, Max Bloomfield and Timothy S. Cale, presented during the 3<sup>rd</sup> International Symposium on Applied Plasma Science, held July 2-6 Fairbanks, Alaska.

"Modeling and Simulation of Plasma Enhanced Processing for Integrated Circuit Fabrication", Max O. Bloomfield, Vinay Prasad, David F. Richards and Timothy S. Cale, presented at the 3<sup>rd</sup> International Symposium on Applied Plasma Science, Fairbanks, Alaska, held July 2-6.

"Stacked Chip-to-Chip Interconnections Using Wafer Bonding Technology with Dielectric Bonding Glues", J.-Q. Lu, Y. Kwon, R. P. Kraft, R. J. Gutmann, J. F. McDonald, and T. S. Cale, presented during the 2001 IEEE International Interconnect Technology Conference (IITC 2001), held June 4-6, 2001, San Francisco, CA.

"Multi-Scale Finite element Model for CMP", A. T. Kim, J. A. Tichy, and T. S. Cale, presented during the First International Conference on Semiconductor Technology (ISTC 2001), held May 27-30, 2001, Shanghai, China.

"Microloading During Electrochemical Deposition: Integrated Multiscale Process Simulation", M. O. Bloomfield, S. Soukane, K. E. Jansen, and T. S. Cale, presented during the First International Conference on Semiconductor Technology (ISTC 2001), held May 27-30, 2001, Shanghai, China.

"Multiscale Modeling of Chemical Mechanical Planarization Processes", T. S. Cale, A. Kim and J. A. Tichy, presented during Society of Tribologists and Lubrication Engineers 2001, May 20-24, 2001, Orlando, FL.

"A Boltzmann Transport and Reaction Model for Atomic Layer Deposition" M. K. Gobbert and T. S. Cale, presented during the AVS Topical Conference on Atomic Layer Deposition, held May 14, 15, Monterey, CA.

"Integrated Multiscale Simulation of Copper Electrochemical Deposition Processes", M. Bloomfield, K. Jansen, and T. Cale, presented during the 199<sup>th</sup> Electrochemical Society Meeting, held March 25-29, 2001, Washington, DC.

"Mesoscale Modeling for LPCVD in the Transition Regime", M. K. Gobbert and T. S. Cale, presented during the 199<sup>th</sup> Electrochemical Society Meeting, held March 25-29, 2001, Washington, DC.

"CMP Wafer and Asperity Scale Models", A. T. Kim, J. A. Tichy, and T. S. Cale, presented during the 2001 Proceedings Sixth International Chemical-Mechanical Planarization for ULSI Multilevel Interconnection Conference (CMP-MIC) held March 7-9, 2001, Santa Clara, CA.

"200 mm Wafer Bonding for 3-D Interconnects Using Low-k Dielectrics as Bonding Glues", J.-Q. L, Y. Kwon, R.P. Kraft, R. J. Gutmann, J. F. McDonald, and T. S. Cale, presented during the Seventh International Conference on Dielectrics and Conductors for the ULSI Multilevel Interconnection, (DUMIC 2001), held March 6-7, 2001, Santa Clara, CA.

"Multiscale CMP Finite Element Contact Model: Wafer and Feature Scale", A. Kim, J. Tichy, T. S. Cale, Rensselaer Polytechnic Institute, presented during the AVS ICMI-Second International Conference on Microelectronics and Interfaces, held February 5-8, 2001, Santa Clara, CA.

"Multiscale Modeling of Pattern Loading Effects in Copper Electrochemical Deposition", M. O. Bloomfield, S. Soukane, K. E. Jansen, T. S. Cale, Rensselaer Polytechnic Institute, presented during the AVS ICMI-Second International Conference on Microelectronics and Interfaces, held February 5-8, 2001, Santa Clara, CA.

"Electrodeposition of Copper in Microstructures: Feature Scale Modeling of Pulse Plating", S. S. Sen, T. S. Cale, Rensselaer Polytechnic Institute, presented during the AVS ICMI-Second International Conference on Microelectronics and Interfaces, held February 5-8, 2001, Santa Clara, CA.

"Modeling of Feature Superfilling in Copper Electrochemical Deposition", S. Sen, S. Soukane, and T. S. Cale, presented during the 198<sup>th</sup> Meeting of the Electrochemical Society, held Oct. 22-27, 2000, Phoenix, AZ.

"Some Effects of Hydrogen on Cu (TMVS)(hfac) Sourced CVD of Cu Films", J. Hong, S. Shetty, D. Yang, T. S. Cale, presented during the 198<sup>th</sup> Meeting of the Electrochemical Society, held Oct. 22-27, 2000, Phoenix, AZ.

"CMP Finite Element Contact Model: Wafer and Feature Scale", A. T. Kim, J. A. Tichy and T. S. Cale, presented during the 198<sup>th</sup> Meeting of the Electrochemical Society, held Oct. 22-27, 2000, Phoenix, AZ.

"Multiscale Modeling of Electrochemical Deposition and Microloading Effects", M. O. Bloomfield, K. E. Jansen and T. S. Cale, presented during the 198<sup>th</sup> Meeting of the Electrochemical Society, held Oct. 22-27, 2000, Phoenix, AZ.

"3-D Integration Using Wafer Bonding Techniques", J.-Q. Lu, A. Kumar, Y. Kwon, E. Eisenbraun, R. P. Kraft, J. F. McDonald, R. Gutmann, T. Cale, P. Belemjian, O. Ergodan, A. Kaloyeros, J. Castracane and E. Eisenbraun, presented during the Advanced Metallization Conference, Sept. 28-30, 2000, San Diego, CA.

"Finite Element Analysis of CMP Pad Displacement and Slurry Flow Characteristics", A. T. Kim, J. A. Tichy and T. S. Cale, presented during the Advanced Metallization Conference, Sept. 28-30, 2000, San Diego, CA.

"Multiscale Modeling of Pattern Density Effects on Electrochemical Deposition with Leveling Agents", M. O. Bloomfield, K. E. Jansen and T. S. Cale, presented during the Advanced Metallization Conference, Sept. 28-30, 2000, San Diego, CA.

"Effects of Hydrogen on the Film Properties of Cu (TMVS)(hfac) Sourced CVD Copper", J. Hong, D. Yang, S. Shetty, and T. S. Cale, presented during the American Vacuum Society, 47<sup>th</sup> International Symposium, Oct. 2-6, 2000, Boston, MA.

"Extension Velocities for Level Set Based Surface Profile Evolution", D. F. Richards, S. Sen, M. O. Bloomfield, and T. S. Cale, presented during the American Vacuum Society, 47<sup>th</sup> International Symposium, Oct. 2-6, 2000, Boston, MA.

"Models of Electrochemical Deposition of Copper Thin Films", S. Soukane, S. Sen, T. S. Cale, presented during the American Vacuum Society, 47<sup>th</sup> International Symposium, Oct. 2-6, 2000, Boston, MA.

(Invited) "Multiscale Process Modeling for Integrated Circuit Fabrication", T. S. Cale, S. Soukane, D. F. Richards, M. O. Bloomfield and K. Jansen, Multiscale Materials Modeling Symposium of the International Union of Materials Research Societies – 6<sup>th</sup> International Conference in Asia, July 23-26, 2000, Hong Kong, China.

(Invited) "Integrated Multiscale Process Simulator for LPCVD", T.S. Cale, T.P. Merchant, L.J. Borucki, M.K. Gobbert, and A.H. Labun, presented during the Seventeenth International VLSI Multilevel Interconnections Conference (VMIC), June 26-30, 2000, Santa Clara, CA.

"Feature Superfilling Using Leveling Agents in Copper Plating", S. Soukane and T. S. Cale, presented during the Seventeenth International VLSI Multilevel Interconnections Conference (VMIC), June 26-30, 2000, Santa Clara, CA.

"Face to Face Wafer Bonding for 3D Chip Stack Fabrication to Shorten Wire Lengths", J.F. McDonald, R.P. Kraft, J.-Q. Lu, A. Kumar, T.S. Cale, T.-M. Lu, P. Belemjian, O. Erdogan, and Y. Kwon, presented during the Seventeenth International VLSI Multilevel Interconnections Conference (VMIC), June 26-30, 2000, Santa Clara, CA.

(Invited) "Multiscale Process Modeling for Integrated Circuit Fabrication", T. S. Cale, S. Soukane, D. F. Richards, M. O. Bloomfield and K. Jansen, presented during the "IMA Workshop on Multiscale Modeling", June 5-9, 2000, Minneapolis, MN.

"Modeling Ionized Magnetron Sputtering of Copper", M. Bloomfield, D. F. Richards and T. S. Cale, presented during the 197<sup>th</sup> Meeting of the Electrochemical Society, May 14-19, 2000, Toronto, Canada.

"Activation Energy Study for the Nucleation and Growth Stages of Cu(TMVS)(hfac) Sourced Copper CVD", D. Yang, J. Hong and T. S. Cale, presented during the 197<sup>th</sup> Meeting of the Electrochemical Society, May 14-19, 2000, Toronto, Canada.

"Modeling of Aspect Ratio Dependent Etching", Max Bloomfield, D. F. Richards, S. Soukane and T. S. Cale, presented during the 197<sup>th</sup> Meeting of the Electrochemical Society, May 14-19, 2000, Toronto, Canada.

"Evolution of Surface Morphology During Cu(TMVS)(hfac) Sourced Copper CVD", D. Yang, J. Hong and T. S. Cale, presented during the Spring 2000 MRS Meeting, April 24-28, 2000, San Francisco, CA.

"Some Opportunities for Materials Modeling in Microelectronics", D. F. Richards, T. S. Cale, presented during the Spring 2000 MRS Meeting, April 24-28, 2000, San Francisco, CA.

"Modeling of Ionized Magnetron Sputtering of Copper", M. Bloomfield, D. F. Richards and T. S. Cale, presented during the Spring 2000 MRS Meeting, April 24-28, 2000, San Francisco, CA.

"Activation Energy Study for the Nucleation and Growth Stages of Cu(TMVS)(hfac) Sourced Copper CVD", D. Yang, J. Hong and T.S. Cale, presented during the American Vacuum Society 2<sup>nd</sup> International Conference on Advanced Materials and Processes for Microelectronics, February 7 - 10, 1999, Santa Clara, CA.

"Effects of Water Vapor during the Nucleation and Growth Stages of Cu(TMVS)(hfac) Sourced Copper CVD", D. Yang, J. Hong and T.S. Cale, presented during the American Vacuum Society 2<sup>nd</sup> International Conference on Advanced Materials and Processes for Microelectronics, February 7 - 10, 1999, Santa Clara, CA.

(Invited) "Finite Element Analysis of CMP Pad and Slurry Behavior", J. A. Tichy, C. J. Clutz, T. S. Cale, L. Shan and S. Danyluk, presented during the American Vacuum Society 2<sup>nd</sup> International Conference on Advanced Materials and Processes for Microelectronics, February 7 - 10, 2000, Santa Clara, CA.

(Invited) "CMP Pad Displacement and Slurry Flow Characteristics" Finite Element Analysis", J. A. Tichy, C. J. Clutz and T. S. Cale, presented during the Fifth International Chemical Mechanical Polish for ULSI Multilevel Interconnection Conference, March 2-3, 2000, Santa Clara, CA.

"Aspect Ratio Dependent Etching", M. O. Bloomfield, S. Soukane and T. S. Cale, presented during the AIChE Fall 1999 Meeting, November 1-5, 1999, Dallas, TX.

"Aspect Ratio Dependent Etching", T. S. Cale, M. Bloomfield and S. Soukane, presented at the AVS International Symposium: Vacuum, Thin Films, Surfaces/Interfaces, and Processing, Oct 25-29, 1999, Seattle, Washington.

"Composition of Si/Ge Films in Structures", S. Soukane, T. S. Cale, C. Werner, A. Kersh and M. Bloomfield, presented at the AVS 46<sup>th</sup> International Symposium: Vacuum, Thin Films, Surfaces/Interfaces, and Processing, Oct 25-29, 1999, Seattle, Washington.

"Effects of Process Variables on Cu(TMVS)(hfac) Sourced Copper CVD Films", D. Yang, J. Hong and T. S. Cale, presented during the Advanced Metalization Conference, Sept 28-30, 1999, Orlando, Florida.

"Simulation of Ionized Magnetron Sputtering of Copper", M. Bloomfield and T. S. Cale, presented during the Advanced Metalization Conference, Sept 28-30, 1999, Orlando, Florida.

"Applications of Plasma Processes in Microelectronics", D. F. Richards, M. O. Bloomfield, S. Soukane and T. S. Cale, presented during the 2<sup>nd</sup> International Symposium of Applied Plasma Science, Sept. 20-24, 1999, Osaka, Japan.

(Invited) "Research at the NY State SIA Focus Center", T. S. Cale, presented during the 4<sup>th</sup> International Symposium on Chemical Mechanical Polishing, August 8-11, 1999, Lake Placid, New York.

“Recent Applications of EVOLVE”, M. O. Bloomfield, D. F. Richards, S. Soukane, and T. S. Cale, MRS Workshop on Advances in Thin Film Simulations and Experimental Verification, June 23-25, 1999, San Jose, CA.

(Invited) “Roles of Transport and Reaction Modeling for Topography Relevant Processes”, presented during the MRS Workshop on Advances in Thin Film Simulations and Experimental Verification, June 23-25, 1999, San Jose, CA.

(Keynote) “Opportunities for Materials Modeling in Microelectronics”, T. S. Cale, presented during the Multiscale Materials Modeling Symposium of the 1999 Meeting of the International Union of Materials Research Societies, June 1999, Beijing, China.

“Composition of Si/Ge Films in Structures”, S. Soukane, C. Werner, A. Kersch, M. Bloomfield, and T. S. Cale, presented at the American Vacuum Society 1<sup>st</sup> International Conference on Advanced Materials and Processes for Microelectronics, March 15-18, 1999, San Jose, CA.

“The Use of Topography Simulation in Process Integration”, T. S. Cale, T. P. Merchant, and L. J. Borucki, presented at the American Vacuum Society 1<sup>st</sup> International Conference on Advanced Materials and Processes for Microelectronics, March 15-18, 1999, San Jose, CA.

“Conformality of LPCVD Silicon Dioxide Films from TEOS: Mechanism Validation”, A. Labun, P. Ho, H. Moffat, M. E. Coltrin and T. S. Cale, presented during the American Vacuum Society 1<sup>st</sup> International Conference on Advanced Materials and Processes for Microelectronics, March 15-18, 1999, San Jose, CA.

“Improved Microstructure by Programmed Rate Chemical Vapor Deposition Processes”, D. Yang, R. Jonnalagadda, B. R. Rogers, J. T. Hillman, R. F. Foster and T. S. Cale, presented during the Fall 1998 meeting of the MRS, Nov 30 – Dec 4, 1998, Boston, MA.

“Nucleation of CVD Aluminum on Titanium Nitride, Tantalum Nitride, and Titanium – Tungsten Surfaces”, T. S. Cale and B. R. Rogers, presented during the MRS Fall 1998 Meeting, Nov 30 – Dec 4, 1998, Boston, MA.

“Effects of Process Variables on Film Morphology During TIBA Sourced Aluminum CVD”, R. Jonnalagadda, D. Yang, B. R. Rogers, T. S. Cale, R. F. Foster and J. T. Hillman, presented during the A.I.Ch.E 1998 Annual Meeting, Nov 15-20, 1998, Miama Beach, Florida.

“TEOS CVD Topography Simulation Using Surface CHEMKIN and EVOLVE”, A. H. Labun, T. S. Cale, P. Ho, H. K. Moffat, M. E. Coltrin, presented during the 45<sup>th</sup> International AVS Symposium, Nov 2-6, 1998, Baltimore, MD.

“Programmed Rate CVD Protocols”, D. Yang, J. J. Kristof, R. Jonnalagadda, B. R. Rogers, J. T. Hillman, R. F. Foster, and T. S. Cale, presented during the Symposium on Interconnect and Contact Metallization: Materials, Processes and Reliability, held during the 194<sup>th</sup> Meeting of the Electrochemical Society, November 1-6, 1998, Boston, MA.

“The Roles of “3d/2d” and “3d/2d” Topography Simulators in Process Development: Model Development and Process Integration”, T. S. Cale, T. P. Merchant, and L. J. Borucki, presented during the Advanced Metallization Conference in 1998, October 6 – 8, 1998, Colorado Springs, CO.

“Factor and Interaction Effects on Relative Median Time Between Electromigration Failure for CVD Aluminum”, D. Yang, R. Jonnalagadda, B. R. Rogers, J. T. Hillman, R. F. Foster, and T. S. Cale, presented during the Advanced Metallization Conference in 1998, October 6 – 8, 1998, Colorado Springs, CO.

“Mitigation of CMP Scratches on Polymer Coated Wafers”, L. Y. Wang, T. S. Cale, B. Wang, Z. Li, and J. F. McDonald, presented during the Fifteenth International VLSI Multilevel Interconnection Conference, June 16-18, 1998, Santa Clara, CA.

(Invited) “Deposition Process Fundamentals”, Timothy S. Cale, presented at the Arizona Chapter AVS 16<sup>th</sup> Annual Symposium, May 12, 1998, Phoenix, AZ.

“Texture and Surface Roughness of PRCVD Aluminum Films”, R. Jonnalagadda, D. Yang, T. Cale, J. Hillman and R. Foster, presented during the International Conference on Metallurgical Coatings and Thin Films, April 27 – May 1, 1998, San Diego, California.

“Optimal Programmed Rate Chemical Vapor Deposition of Tungsten”, J. J. Kristof, K. S. Tsakalis and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, April 27 – May 1, 1998, San Diego, California.

“Study of Factor and Interaction Effects During PRCVD of Al”, D. Yang, R. Jonnalagadda, T. S. Cale, B. R. Rogers, J. T. Hillman and R. F. Foster, presented during the MRS 1998 Spring Meeting, April 13-17, 1998, San Francisco, California.

(Invited) “The Roles of 3D/3D and 3D/2D Topography Simulators in Virtual Semiconductor Fabs”, T. S. Cale, presented during the MRS 1997 Fall Meeting, Dec. 1-5, 1997, Boston, Massachusetts.

“Substrate Dependence During Programmed Rate MOCVD of Al”, D. Yang, R. Jonnalagadda, T. S. Cale, J. T. Hillman and R. F. Foster, presented during the MRS 1997 Fall Meeting, Dec. 1-5, 1997, Boston, Massachusetts.

“Reaction Mechanisms for LPCVD of Silicon Dioxide from TEOS”, T. Cale, V. Mahadev, M. Coltrin, P. Ho and H. Moffat, presented during the A.I.Ch.E. 1997 Annual Meeting, Nov. 16-21, 1997, Los Angeles, California.

“Optimal Programmed Rate Chemical Vapor Deposition of Tungsten”, J. Kristof, L. Song, K. Tsakalis and T. Cale, presented during the A.I.Ch.E. 1997 Annual Meeting, Nov. 16-21, 1997, Los Angeles, California.

“Microstructural Evolution in Thin Films: Atomistic Simulations”, P. Zilaro, V. Mahadev, Z. Tang, J. Adams, and T. Cale, presented during the A.I.Ch.E. 1997 Annual Meeting, Nov. 16-21, 1997, Los Angeles, California.

“Modeling of Topography Evolution During Simultaneous Deposition and Etch Processes”, Z. Tang, V. Mahadev, and T. Cale, presented during the A.I.Ch.E. 1997 Annual Meeting, Nov. 16-21, 1997, Los Angeles, California.

“Vertical Integration of CVD Process Models”, M. Gobbert and T. Cale, presented during the A.I.Ch.E. 1997 Annual Meeting, Nov. 16-21, 1997, Los Angeles, California.

“The Effects of Substrate Temperature Ramping of CVD Aluminum Films”, D. Yang, R. Jonnalagadda, T. Cale, J. Hillman and R. Foster, presented during the A.I.Ch.E. 1997 Annual Meeting, Nov. 16-21, 1997, Los Angeles, California.

“Effects of Diluent and Carrier Gas Trajectories During PRCVD of Aluminum” R. Jonnalagadda, D. Yang, B. R. Rogers, J. T. Hillman, R. F. Foster and T. S. Cale, presented during the Advanced Metallization and Interconnect Systems for ULSI Applications in 1997, September 30 – October 2, 1997, San Diego, CA.

“Vertical Integration of CVD Process Models”, M. K. Gobbert, T. P. Merchant, L. J. Borucki and T. S. Cale, presented during the Fourteenth International Conference on Chemical Vapor Deposition and EUROCV D-11, September 5-9, 1997, Paris, France.

“Programmed Rate and Optimal Control Chemical Vapor Deposition of Tungsten”, J. J. Kristof, L. J. Song, P. E. Crouch, K. S. Tsakalis and T. S. Cale, presented during the Fourteenth International Conference on Chemical Vapor Deposition and EUROCV D-11, September 5-9, 1997, Paris, France.

“Microstructure Evolution in Thin Films: Atomistic Simulations”, V. Mahadev, A. Challa and T. S. Cale, presented during the Fourteenth International Conference on Chemical Vapor Deposition and EUROCV D-11, September 5-9, 1997, Paris, France.

“An Experimental Study of the Effects of Substrate Temperature Ramping on CVD-Al Film Properties”, R. Jonnalagadda, D. Yang, T. S. Cale, J.T. Hillman, R. F. Foster and B. R. Rogers, presented during the AVS 44<sup>th</sup> National Symposium, Oct. 20-24, 1997, San Jose, California.

“Nucleation of DMAH-Sourced CVD Aluminum on PVD and CVD TiN, and PVD Ti-W”, B. R. Rogers, D. Yang, R. Jonnalagadda and T. S. Cale, presented during the AVS 44<sup>th</sup> National Symposium, Oct. 20-24, 1997, San Jose, California.

(Invited) “Chemistry and Topography Evolution”, T. Cale and B. R. Rogers, presented during the AVS Surface Analysis '97 Symposium, May 20-22, 1997, Albuquerque, NM 87185.

“Bump Technologies For GaAs Interconnection”, C. L. Pillote, M. E. Grupen-Shemansky, S. P. Beaudoin and T. S. Cale, presented during the 1997 International Conference on Gallium Arsenide Manufacturing Technology, June 2-5, 1997, San Francisco, CA.

“Wafer Scale Stress Distributions in CMP”, C. Srinivasa-Murthy, D. Wang, S. P. Beaudoin, T. Bibby, K. Holland and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, April 21-25, 1997, San Diego, CA.

“The Effects of Temperature Ramping on MOCVD Al Film Properties”, D. Yang, R. Jonnalagadda, V. Mahadev, T. S. Cale, J. T. Hillman and R. F. Foster, presented during the International Conference on Metallurgical Coatings and Thin Films, April 21-25, 1997, San Diego, CA.

“Rapid Development of a 300 mm Substrate Heater Using Finite Element Analysis”, J. T. Hillman, A. Benmalik and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, April 21-25, 1997, San Diego, CA.

“Characterization of Electroplated Copper Solder Bumps for Flip Chip Applications”, S. Chungpaiboonpatana, S. P. Beaudoin, T. S. Cale, C. Pillote, G. Tam, M. Begay, B. Marlin, J. Molla and B. Lytle, presented during the International Conference on Metallurgical Coatings and Thin Films, April 21-25, 1997, San Diego, CA.

“Programmed Rate Chemical Vapor Deposition of Tungsten”, J. J. Kristof, L. J. Song, K. S. Tsakalis and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, April 21-25, 1997, San Diego, CA.

“Remote Microwave Plasma Enhanced CVD of Fluorinated Silicon Dioxide Using Fluorine-containing Organo-silicon Precursors”, Z. Jin, L. Xu, V. Mahadev, G. B. Raupp, T. S. Cale, R. Laxman and A. K. Hochberg, presented during the International Conference on Metallurgical Coatings and Thin Films, April 21-25, 1997, San Diego, CA.

“The Effects of Temperature Ramping on MOCVD Al Film Properties”, D. Yang, R. Jonnalagadda, V. Mahadev, T. S. Cale, J. T. Hillman and R. F. Foster, presented during the Spring 1997 meeting of the MRS, March 31-April 4, 1997, San Francisco, CA.

“Characterization of Electroplated Copper Solder Bump Processing for Flip-Chip Applications”, S. Chungpaiboonpatana, S. P. Beaudoin, T. S. Cale, C. L. Pillote, G. Tam, M. J. Begay, B. Martin, J. Molla and B. Lytle, presented during the Spring 1997 meeting of the MRS, March 31-April 4, 1997, San Francisco, CA.

“Microstructural Evolution in Thin Films Using an Atomistic Simulator”, V. Mahadev, A. Challa and T. S. Cale, presented during the Spring 1997 meeting of the MRS, March 31-April 4, 1997, San Francisco, CA.

(Invited) “Fundamentals of CMP”, C. Srinivasa-Murthy, D. Wang, J. Lee, K. Holland, T. Bibby, S. P. Beaudoin and T. S. Cale, presented during the 1997 Spring National AIChE meeting, March 9-13, 1997, Houston, TX.

“Remote Microwave Plasma Enhanced CVD of Fluorine Doped Films from FASi-4 and FTES”, Z. Jin, L. Xu, V. Mahadev, G. B. Raupp, T. S. Cale, R. Laxman and A. K. Hochberg, presented during the Third International Dielectrics for VLSI/ULSI Multilevel Interconnection Conference, Feb. 10-11, 1997, Santa Clara, CA.

“Nonuniformity in CMP Processes Due to Stress”, D. Wang, S. M. Chandrashekar, S. P. Beaudoin and T. S. Cale, presented during the Second International Conference on Chemical-Mechanical Polish Planarization for ULSI Multilevel Interconnection, Feb. 13-14, 1997, Santa Clara, CA.

“Optimal Control for Increasing Throughput in LPCVD”, L. Song, S. Shen, K. Tsakalis, P. E. Crouch and T. S. Cale, presented during the 35th IEEE Conference on Decision and Control, Dec. 11-13, 1996, Kobe, Japan.

“Combination of Statistical Design of Experiments Methods with Physically-based Modeling to Efficiently Characterize CVD Processes”, S. Bolnedi, T. S. Cale and G. B. Raupp, presented during the Fall 1996 National AIChE Meeting, Nov. 11-15, 1996, Chicago, IL.

“PFC-free Deposition of Fluorinated Silicon Oxide Thin Films”, Z. Jin, G. B. Raupp, T. S. Cale, R. Laxman, A. Hochberg, presented during the Fall 1996 MRS Meeting, Dec. 2-6, 1996, Boston, MA.

“DSMC Simulation of Reactor Feature Scale Flows” M. L. Hudson, T. J. Bartel, A. J. Russo and T. S. Cale, presented during the 43rd National AVS Symposium, Oct. 14-18, 1996, Philadelphia, PA.

(Invited) “Transport and Reaction Simulations on Multiple Scales”, T. S. Cale, V. Mahadev, M. K. Gobbert, D. Coronell, T. Merchant and L. J. Borucki, presented during the 43rd National AVS Symposium, Oct. 14-18, 1996, Philadelphia, PA.

“Remote Microwave Plasma Enhanced CVD of Low Dielectric Constant  $\text{SiO}_x\text{F}_y$  Films from FASi-4 and Oxygen”, Z. Jin, M. Virmani, G. J. Leusink, G. B. Raupp, T. S. Cale, presented during the 43rd National AVS Symposium, Oct. 14-18, 1996, Philadelphia, PA.

“Stress Distribution on Wafers during CMP Processing”, D. Wang, J. Lee, T. Bibby, K. Holland, S. P. Beaudoin and T. S. Cale, presented during the 43rd National AVS Symposium, Oct. 14-18, 1996, Philadelphia, PA.

“Von Mises Stresses in CMP”, D. Wang, S. P. Beaudoin, T. S. Cale, T. Bibby and K. Holland, presented during the 190th Meeting of the Electrochemical Society, October 6-11, 1996, San Antonio, TX.

“Control Aspects of Programmed Rate Chemical Vapor Deposition of Tungsten”, J. Kristof, L. Song, K. S. Tsakalis and T. S. Cale, presented during the conference on Advanced Metalization and Interconnect Systems for ULSI Applications, Oct. 1-3, 1996, Boston, MA.

“Chemical Vapor Deposition of Aluminum from Organometallic Compounds”, D. Yang, V. Mahadev, T. S. Cale, G. J. Leusink, J. Hillman and R. Foster, presented during the conference on Advanced Metalization and Interconnect Systems for ULSI Applications, Oct. 1-3, 1996, Boston, MA.

“Microloading in LPCVD: a Multi-Scale Simulation Approach”, M. Gobbert, T. Merchant, T. S. Cale and L. Borucki, presented during the conference on Advanced Metalization and Interconnect Systems for ULSI Applications, Oct. 1-3, 1996, Boston, MA.

“Characterization of an Electroplated Copper Solder Bump Process for Flip-Chip Applications”, S. Chungpaiboonpatana, S. Beaudoin, T. S. Cale, C. Pillote, G. Tam, M. Begay, B. Marlin, J. Molla and B. Lytle, presented during the conference on Advanced Metalization and Interconnect Systems for ULSI Applications, Oct. 1-3, 1996, Boston, MA.

“Von Mises Stress in CMP Processes”, D. Wang, S. Beaudoin, T. S. Cale, J. Lee, T. Bibby and K. Holland, presented during the conference on Advanced Metalization and Interconnect Systems for ULSI Applications, Oct. 1-3, 1996, Boston, MA.

“Chemical Vapor Deposition of Aluminum from Organometallic Compounds”, D. Yang, V. Mahadev, T. S. Cale, G. J. Leusink, J. Hillman and R. Foster, presented during TECHCON '96, Sept. 12-14, 1996, Phoenix, AZ.

“EVOLVE Simulations of Metal and Oxide Etch Processes”, V. Mahadev, Z. Tang, G. Sreedhar, T. S. Cale, R. Ma and R. Robinson, presented during TECHCON '96, Sept. 12-14, 1996, Phoenix, AZ.

“Remote Microwave PECVD of Low Dielectric Constant  $\text{F}_x\text{SiO}_y$  Films from FASi-4 and Oxygen”, Z. Jin, M. Virmani, G. J. Leusink, G. B. Raupp, T. S. Cale, R. Laxman and D. Roberts, presented during TECHCON '96, Sept. 12-14, 1996, Phoenix, AZ.

“A Methodology to Efficiently Characterize CVD Processes”, S. Bolnedi, G. B. Raupp and T. S. Cale, presented during TECHCON '96, Sept. 12-14, 1996, Phoenix, AZ.

“Programmed Rate LPCVD of Tungsten”, K. M. Tracy, J. Kristof, L. Song, K. Tsakalis, G. J. Leusink and T. S. Cale, presented during TECHCON '96, Sept. 12-14, 1996, Phoenix, AZ.

“Von Mises Stresses in CMP Processes”, D. Wang, S. P. Beaudoin, T. S. Cale, J. Lee, T. Bibby and K. Holland, presented during the Workshop on Chemical-Mechanical Polishing, August 18-21, 1996, Lake Placid, NY.

“Problems due to Nucleation in the Growth of Aluminum by CVD”, V. Mahadev, T. Kim, T. S. Cale, G. Leusink, J. Hillman and R. Foster, presented during the Thirteenth International VLSI Multilevel Interconnection Conference, June 18-20, 1996, Santa Clara, CA.

“Blanket Aluminum CVD Using TIBA and DMAH in a Cold-wall Single-wafer Reactor”, V. Mahadev, G. J. Leusink, T. S. Cale, J. T. Hillman and R. F. Foster, presented during the International Conference on Metallurgical Coatings and Thin Films, April, 22-26, 1996, San Diego, CA.

“Programmed Rate LPCVD: Improved Throughput for Single Wafer Reactors”, K. M. Tracy, S. Bolnedi, G. J. Leusink and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, April, 22-26, 1996, San Diego, CA.

“Remote Microwave PECVD of Low Dielectric Constant  $F_xSiO_y$  Films from FASi-4 and Oxygen”, M. Virmani, G. J. Leusink, G. B. Raupp, T. S. Cale, R. Laxman and A. K. Hochberg, presented during the International Conference on Metallurgical Coatings and Thin Films, April, 22-26, 1996, San Diego, CA.

“On the Origin of Topography Dependent Composition in Vapor Deposited Films”, T. S. Cale and S. K. Dey, presented during the International Symposium on Integrated Ferroelectrics, Tempe, AZ, March 18-20, 1996.

“Remote Microwave Plasma Enhanced CVD of Low Dielectric Constant  $SiO_xF_y$  Films from FASi-4 and Oxygen”, M. Virmani, Z. Jin, G. J. Leusink, G. B. Raupp and T. S. Cale, presented during the Second International Dielectrics for VLSI/ULSI Multilevel Interconnection Conference, Santa Clara, CA, February 20-21, 1996.

“Simulations of Simultaneous Deposition and Sputter Etching”, M. Virmani, V. Mahadev and T. S. Cale, presented during the Second International Dielectrics for VLSI/ULSI Multilevel Interconnection Conference, Santa Clara, CA, February 20-21, 1996.

“Morphology of Thin Films during the Initial Stages of Growth: Monte Carlo Simulations”, A. Challa and T. S. Cale, presented during the TMS 1996 Annual Meeting and Exhibition, Feb. 4-8, 1996, Anaheim, CA.

“Run-to-Run Adaptive Optimization of a Tungsten Silicide LPCVD Process”, T. S. Cale, P. E. Crouch, S. Shen and K. Tsakalis, presented during the 34th Conference on Decision and Control, New Orleans, LA, Dec. 13-15, 1995.

“Morphology of Ag Islands Grown on GaAs (110) at Low Coverage: Monte Carlo Simulations”, A. Challa, J. Drucker and T. S. Cale, presented during the 1995 Fall Meeting of the MRS, Boston, MA, Nov. 27 - Dec. 1, 1995.

“Optimal Control for LPCVD Processes”, P. E. Crouch, T. S. Cale, S. Shen, L. Song and K. S. Tsakalis, presented during the SEMATECH AEC/APC Workshop VII, New Orleans, LA, November, 5-8, 1995.

(Invited) “Computational Aspects of Topography Evolution During Low Pressure Deposition and Etch Processes”, G. Rajagopalan, V. Mahadev and T. S. Cale, presented during the International Workshop on Computational Electronics, Tempe, AZ, Oct. 30 - Nov. 2, 1995.

“The Combination of Equipment Scale and Feature Scale Models for Chemical Vapor Deposition via a Homogenization Technique”, M. Gobbert, T. S. Cale, C. Ringhofer, presented during the International Workshop on Computational Electronics, Tempe, AZ, Oct. 30 - Nov. 2, 1995.

“Experimental and Simulation Studies of TEOS Sourced Remote Microwave PECVD of Silicon Dioxide”, M. Virmani, D. A. Levedakis, G. B. Raupp and T. S. Cale, presented during the 42nd National AVS Meeting, Minneapolis, MN, Oct. 16-20, 1995.

“Process Optimization of Tungsten Chemical Mechanical Polishing”, V. Blaschke, T. S. Cale, R. Harwood, M. Hoffman, K. Holland, J. Lee, B. Tredinnick, presented during the 42nd National AVS Meeting, Minneapolis, MN, Oct. 16-20, 1995.

"PRCVD Blanket Tungsten Deposition", K. M. Tracy, S. Bolnedi, G. J. Leusink and T. S. Cale, presented during the 42nd National AVS Meeting, Minneapolis, MN, Oct. 16-20, 1995.

"Growth of CVD-Al Films using TIBA in a Single Wafer, Cold Wall LPCVD Reactor", S. S. Doad, G. J. Leusink, T. S. Cale, J. T. Hillman and R. F. Foster, presented during the 42nd National AVS Meeting, Minneapolis, MN, Oct. 16-20, 1995.

"Experimental and Simulation Study of Re-emission during Sputter Deposition of Ti-W Films", Y.-K. Chang, B. R. Rogers and T. S. Cale, presented during the 42nd National AVS Meeting, Minneapolis, MN, Oct. 16-20, 1995.

"Simulations of Al Thin Film Thermal Flow", H. Liao and T. S. Cale, presented during the 42nd National AVS Meeting, Minneapolis, MN, Oct. 16-20, 1995.

"A Methodology for Rapidly Optimizing Step Coverage for LPCVD Tungsten", S. Bolnedi, D. Wang, G. B. Raupp and T. S. Cale, presented during Advanced Metalization and Interconnect Systems for ULSI Applications, Portland, OR, Oct. 3-5, 1995.

"Blanket Tungsten Film Deposition Using Programmed Rate CVD", K. M. Tracy, S. Bolnedi, G. J. Leusink and T. S. Cale, presented during Advanced Metalization and Interconnect Systems for ULSI Applications, Portland, OR, Oct. 3-5, 1995.

"Temperature Dependence of Blanket Aluminum CVD on Si(100) using TIBA and DMAH", S. S. Doad, G. J. Leusink, B. Jin, T. S. Cale, J. T. Hillman and R. F. Foster, presented during Advanced Metalization and Interconnect Systems for ULSI Applications, Portland, OR, Oct. 3-5, 1995.

"Copper Reflow: Experiments and Simulations", T. S. Cale, D. S. Gardner, H. T. Vu and D. B. Fraser, presented during Advanced Metalization and Interconnect Systems for ULSI Applications, Portland, OR, Oct. 3-5, 1995.

"Optimal Control Processing to Increase Single wafer Reactor Throughput in LPCVD", P. E. Crouch, L. Song, K. S. Tsakalis and T. S. Cale, Presented during the Fourth IEEE/UCS/SEMI International Symposium on Semiconductor Manufacturing, Austin, TX, Sept. 17-19, 1995.

"Programmed Rate Chemical Vapor Deposition", T. S. Cale, B. R. Rogers, K. Tracy, P. E. Crouch, K. Tsakalis, S. Shen and L. Song, presented during the NATO ASI on Advances in Rapid Thermal and Integrated Processing, Maratea, Italy, July 3-14, 1995.

"Programmed Rate Chemical Vapor Deposition of Blanket Tungsten Thin Films", K. M. Tracy, S. Bolnedi, T. S. Cale, presented during the Twelfth International VLSI Multilevel Interconnection Conference, Santa Clara, CA, June 27-29, 1995.

"LPCVD of Aluminum Using TIBA in a Cold-Wall Single-Wafer Reactor", S. S. Doad, G. J. Leusink, T. S. Cale, J. T. Hillman and R. F. Foster, presented during the Twelfth International VLSI Multilevel Interconnection Conference, Santa Clara, CA, June 27-29, 1995.

"Removal Rate Behavior of Spin-on Dielectrics with Chemical Mechanical Polishing", L. Forester, D. K. Choi, R. Hosseini, B. Tredinnick, K. Holland, J. Lee and T. S. Cale, presented during the Twelfth International VLSI Multilevel Interconnection Conference, Santa Clara, CA, June 27-29, 1995.

"Increasing Throughput in Low Pressure Chemical Vapor Deposition: An Optimal Control Approach", T. S. Cale, P. E. Crouch, L. Song and K. S. Tsakalis, presented during the 1995 American Control Conference, Seattle, WA, June 21-23, 1995.

"A Simple Adaptive Optimization Algorithm for the Tungsten LPCVD Process", T. S. Cale, P. E. Crouch, S. Shen and K. S. Tsakalis, presented during the 1995 American Control Conference, Seattle, WA, June 21-23, 1995.

"Collimated Deposition of TiN: Experiments and Simulations", Z. Lin and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 24-28, 1995.

"Improving Electromigration Reliability in Al-alloy Lines", G. Rajagopalan, M. L. Dreyer, N. D. Theodore and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 24-28, 1995.

"Film Profile Predictions in Dual Frequency TEOS-Oxygen Plasma Systems", F. R. Myers and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 24-28, 1995.

"(Invited) Conformality and Composition of Films Deposited at Low Pressures", T. S. Cale, presented during the 1995 Spring MRS Meeting, San Francisco, CA, April 17-21, 1995.

"The Effects of Collimator Life Time on the Ti and TiN Film Growth Rates and Conformalities in Sputter Deposition Processes: Experiments and Simulations", H. Liao, H. Stippel, K. Reddy, S. Geha, K. Brown, P. Lindorfer, S. Saha, Z. Lin and T. Cale, presented during the 1995 Spring MRS Meeting, San Francisco, CA, April 17-21, 1995.

"Optimal Control for LPCVD", T. S. Cale, P. E. Crouch, L. Song and K. S. Tsakalis, presented during the 187-th Meeting of the Electrochemical Society, Reno, NV, May 21-26, 1995.

"One Approach to Combining Equipment Scale and Feature Scale Models", M. K. Gobbert, T. S. Cale and C. A. Ringhofer, presented during the 187-th Meeting of the Electrochemical Society, Reno, NV, May 21-26, 1995.

"Step Coverage Prediction in TEOS-Oxygen Plasma Systems", F. R. Myers and T. S. Cale, presented during the First International Dielectrics for VLSI/ULSI Multilevel Interconnection Conference, Santa Clara, CA, Feb. 21-22, 1995.

"Experimental and Simulation Studies of Thermal Flow of Borophosphosilicate and Phosphosilicate Glasses", H. Liao, G. Thallikar, F. R. Myers and T. S. Cale, presented during the First International Dielectrics for VLSI/ULSI Multilevel Interconnection Conference, Santa Clara, CA, Feb. 21-22, 1995.

"Growth Morphology of Ag Islands on GaAs(110) at Low Coverage: Monte Carlo Simulations", A. Challa, T. S. Cale and J. Drucker, presented during the 1994 Fall Meeting of the MRS, Boston, MA, Nov. 28 - Dec. 2, 1994.

"Experiments and Simulations of Collimated and Uncollimated TiN PVD Using a Combined Specular-Diffuse Formulation", A. J. Toprac, B. P. Jones, J. Schlueter, Z. Lin and T. S. Cale, presented during the 1994 Fall Meeting of the MRS, Boston, MA, Nov. 28 - Dec. 2, 1994.

"Conformality of SiO<sub>2</sub> Film Deposition Using Remote Microwave Plasmas", D. A. Levedakis, X. P. Jin, T. S. Cale and G. B. Raupp, during the 1994 Annual AIChE Meeting, San Francisco, CA, Nov. 13-18, 1994.

"Prediction of SiO<sub>2</sub> Step Coverage in Dual Frequency TEOS-Oxygen Plasma Systems", F. R. Myers and T. S. Cale, presented during the 1994 Annual AIChE Meeting, San Francisco, CA, Nov. 13-18, 1994.

"Spatial Dependence of Ti-W Film Composition in Features on Patterned Wafers", B. R. Rogers, C. J. Tracy and T. S. Cale, presented during the 1994 Annual AIChE Meeting, San Francisco, CA, Nov. 13-18, 1994.

"Experiments and Simulations of Thermal Flow of BPSG and PSG Glasses", G. Thallikar, H. Liao, F. Myers and T. S. Cale, presented during the 1994 Annual AIChE Meeting, San Francisco, CA, Nov. 13-18, 1994.

"Experiments and Simulations of High Pressure Chemical Vapor Deposition of TiN from Tetrakis-dimethylamino-titanium and Ammonia in Vias", H. Liao, T. S. Cale, J. J. Hsieh, A. J. Toprac, J. N. Musher, R. G. Gordon and B. H. Weiller, presented during the 1994 Annual AIChE Meeting, San Francisco, CA, Nov. 13-18, 1994.

"Uncollimated and Collimated Sputter Deposition of TiN: Experiments and Simulations", Z. Lin, T. S. Cale, A. J. Toprac, S.-Q. Wang and J. Schlueter, presented during the 1994 Annual AIChE Meeting, San Francisco, CA, Nov. 13-18, 1994.

"Experimental and Simulation Studies of Thermal Flow of BPSG and PSG Glasses", G. Thallikar, H. Liao, F. R. Myers and T. S. Cale, presented during the 41st National Symposium of the American Vacuum Society, Denver, CO, Oct. 24-28, 1994.

"Step Coverage of Silicon Dioxide Films Deposited in Dual Frequency TEOS-Oxygen Plasma Systems", F. R. Myers and T. S. Cale, presented during the 41st National Symposium of the American Vacuum Society, Denver, CO, Oct. 24-28, 1994.

"Experimental and Simulation Study of APCVD TiN from TDMAT and Ammonia", H. Liao, T. S. Cale, J. J. Hsieh, A. J. Toprac, J. N. Musher, R. G. Gordon and B. H. Weiller, presented during the 41st National Symposium of the American Vacuum Society, Denver, CO, Oct. 24-28, 1994.

"Conformality of SiO<sub>2</sub> Films from TEOS-sourced Remote Microwave Plasma-Enhanced Chemical Vapor Deposition", D. A. Levedakis, T. S. Cale and G. B. Raupp, presented during the 41st National Symposium of the American Vacuum Society, Denver, CO, Oct. 24-28, 1994.

"Uncollimated and Collimated TiN PVD: Experiments and Simulations", Z. Lin and T. S. Cale, A. J. Toprac, S.-Q. Wang and J. Schlueter, presented during the 41st National Symposium of the American Vacuum Society, Denver, CO, Oct. 24-28, 1994.

"Kinetic Model Testing and Extraction of Wafer Surface Conditions and Parameters from Film Profiles in LPCVD W from SiH<sub>4</sub> and WF<sub>6</sub>", S. Bolnedi, M. Virmani, G. B. Raupp and T. S. Cale, presented during Advanced Metallization for ULSI Applications 1994, Austin, TX, Oct. 4-6, 1994.

"Experimental and Simulation Studies of PECVD Titanium", S. S. Doad, T. S. Cale, M. S. Ameen, J. T. Hillman and R. F. Foster, presented during Advanced Metallization for ULSI Applications 1994, Austin, TX, Oct. 4-6, 1994.

"Uncollimated and Collimated TiN Depositions: Experiments and Simulations", Z. Lin, T. S. Cale, A. J. Toprac, S.-Q. Wang and J. Schlueter, presented during Advanced Metallization for ULSI Applications 1994, Austin, TX, Oct. 4-6, 1994.

"Experimental and Simulation Studies of Atmospheric Chemical Vapor Deposition of Titanium Nitride from Tetrakis-dimethylaminotitanium and Ammonia", H. Liao, J. J. Hsieh, A. J. Toprac, J. N. Musher, R. G. Gordon, B. H. Weiller and T. S. Cale, presented during Advanced Metallization for ULSI Applications 1994, Austin, TX, Oct. 4-6, 1994.

"Simulation of Collimated Titanium Nitride Physical Vapor Deposition using EVOLVE", A. J. Toprac, S.-Q. Wang, J. Schlueter, and T. S. Cale, presented during the Spring 1994 MRS Meeting, San Francisco, CA, April, 1994.

"Development of a Gate Metal Etch Process for Gallium Arsenide Wafers", R. Bammi, T. S. Cale and G. Grivna, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 25-29, 1994.

"Transport Through Multicomponent Dual Frequency Plasma Sheaths", F. R. Myers, M. W. Peters, M. Ramaswami and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 25-29, 1994.

"Numerical Simulations of Thin Film Thermal Reflow", H. Liao and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 25-29, 1994.

"Flux Distributions and Growth Rate Uniformities From Hexagonal Collimators", Z. Lin and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 25-29, 1994.

"Estimating Effective Diffusivities and Flux Distributions for Sputter Deposited Al-(1.5%)Cu Films Using Film Profiles", D. S. Taylor, M. B. Chacara, and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 25-29, 1994.

"Computer Simulations of Borophosphosilicate Film Thermal Flow, H. Liao and T. S. Cale, during the Eleventh International VLSI Multilevel Interconnect Conference, Santa Clara, CA, June, 1994..

"Ion Energy and Angular Distributions in TEOS-Oxygen Dual Frequency Plasma Sheaths, F. R. Myers, M. W. Peters, M. Ramaswami and T. S. Cale, during the Eleventh International VLSI Multilevel Interconnect Conference, Santa Clara, CA, June, 1994..

"Flux Distributions and Growth Rate Uniformities From Hexagonal Collimators", Z. Lin and T. S. Cale, during the Eleventh International VLSI Multilevel Interconnect Conference, Santa Clara, CA, June, 1994.

"Kinetics and Conformality of MOCVD TiN Films, T. S. Cale and G. B. Raupp, presented during the 1993 Fall Meeting of the Materials Research Society, Nov. 29-Dec. 3, 1993, Boston, MA

"The Impact of Gas Phase and Surface Chemical Reactions on Step Coverage in LPCVD", G. B. Raupp and T. S. Cale, invited paper presented during the 1993 Fall Meeting of the Materials Research Society, Nov. 29-Dec. 3, 1993, Boston, MA

"Low Knudsen Number Transport and Deposition", H. Liao and T. S. Cale, presented during the 40th National AVS Symposium, November 15-19, 1993, Orlando, FL.

"Experimental and Modeling Studies of Ti-W Composition Variations in Features on Patterned Wafers", B. R. Rogers and T. S. Cale, presented during the 40th National AVS Symposium, November 15-19, 1993, Orlando, FL.

"Experimental and Simulation Studies of Hot Sputter Deposited Aluminum-Copper Alloys", D. S. Taylor, M. B. Chaara and T. S. Cale, presented during the 40th National AVS Symposium, November 15-19, 1993, Orlando, FL.

"Simulation of Low Pressure Deposition Processes on Three Dimensional Evolving Surfaces", H. Liao and T. S. Cale, presented during the 40th National AVS Symposium, November 15-19, 1993, Orlando, FL.

"Oxygen Ion Angular and Energy Distribution Functions in Single and Dual Frequency PETEOS of SiO<sub>2</sub>", F. R. Myers, M. Ramaswami and T. S. Cale, presented during the 40th National AVS Symposium, November 15-19, 1993, Orlando, FL.

"Surface Reaction Mechanism for Tungsten Deposition through Silane Reduction of Tungsten Hexafluoride", S. Bolnedi, G. B. Raupp and T. S. Cale, presented during the A.I.Ch.E. 1993 Annual Meeting, November 7-12, 1993, St. Louis, MO.

"Curvature Driven Surface Diffusion of Aluminum-Copper Films", D. S. Taylor, M. K. Jain, M. B. Chaara and T. S. Cale, presented during the A.I.Ch.E. 1993 Annual Meeting, November 7-12, 1993, St. Louis, MO.

"Kinetic Parameter Estimation for MOCVD TiN Using Film Profiles", M. B. Chaara, G. B. Raupp and T. S. Cale, presented during the A.I.Ch.E. 1993 Annual Meeting, November 7-12, 1993, St. Louis, MO.

"Ballistic Transport and Reaction on Three Dimensional Evolving Surfaces", H. Liao and T. S. Cale, presented during the A.I.Ch.E. 1993 Annual Meeting, November 7-12, 1993, St. Louis, MO.

"Modeling and Experimental Studies of SiO<sub>2</sub> Film Deposition Using Remote Microwave Plasmas", D. a. Levedakis, M. B. Chaara, T. S. Cale and G. B. Raupp, presented during the A.I.Ch.E. 1993 Annual Meeting, November 7-12, 1993, St. Louis, MO.

"Ion Energy and Angular Distributions in Multicomponent Dual Frequency Plasma Sheaths", F. R. Myers, M. Ramaswami and T. S. Cale, presented during the A.I.Ch.E. 1993 Annual Meeting, November 7-12, 1993, St. Louis, MO.

"Origin of the Apparent Reaction order Shifts in Silane Reduction of WF<sub>6</sub>", S. Bolnedi, G. B. Raupp T. S. Cale, presented at Advanced Metallization for ULSI Applications in 1993, Oct. 5-7, 1993, San Diego, CA.

"MOCVD TiN from TDEAT and Ammonia: Experiments and Simulations", T. S. Cale, M. B. Chaara, H. Liao and G. B. Raupp, presented at Advanced Metallization for ULSI Applications 1993, Oct. 5-7, 1993, San Diego, CA.

"Applications of EVOLVE for Deposition Simulations on Patterned Wafers", T. E. Zirkle and T. S. Cale, presented at TECHCON'93, Sept. 28-30, 1993, Atlanta, GA.

"Modeling and Experimental Studies of Silicon Oxide Film Deposition Using Remote Microwave Plasmas", D. A. Levedakis, M. B. Chaara, T. S. Cale and G. B. Raupp, presented at TECHCON'93, Sept. 28-30, 1993, Atlanta, GA.

"Low Pressure Depositions on Three Dimensional Surfaces", H. Liao and T. S. Cale, presented at TECHCON'93, Sept. 28-30, 1993, Atlanta, GA.

"Kinetic Parameter Estimates Using Film Profiles in Features", M. B. Chaara, G. B. Raupp and T. S. Cale, presented at TECHCON'93, Sept. 28-30, 1993, Atlanta, GA.

"Dual Frequency Plasma Sheath Model", F. R. Myers, M. Ramaswami and T. S. Cale, presented at TECHCON'93, Sept. 28-30, 1993, Atlanta, GA.

"Reactor Scale and Feature Scale Simulations of Programmed Rate CVD", J.-H. Park and T. S. Cale, presented at the First International RTP Conference, Sept. 7-9, 1993, Phoenix, AZ.

"Ion Distribution Functions in Dual Frequency Plasma Sheaths", F. R. Myers, M. Ramaswami and T. S. Cale, presented during the Tenth International VLSI Multilevel Interconnect Conference, 1993, Santa Clara, CA.

"Low Pressure Deposition Simulations on Three Dimensional Surfaces", H. Liao and T. S. Cale, presented during the Tenth International VLSI Multilevel Interconnect Conference, June 8-9, 1993, Santa Clara, CA.

"Spatial Composition Variations in Sputter Deposited Ti-W Films", B. R. Rogers and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, April 19-23, 1993, San Diego, CA.

"Conformality of MOCVD TiN Films from TDEAT and NH<sub>3</sub>", T. S. Cale, M. B. Chaara, G. B. Raupp and I. J. Raaijmakers, presented during the International Conference on Metallurgical Coatings and Thin Films, April 19-23, 1993, San Diego, CA.

"Three Dimensional Simulation of an Isolation Trench Refill Process", H. Liao and T. S. Cale, presented during the International Conference on Metallurgical Coatings and Thin Films, April 19-23, 1993, San Diego, CA.

"Characterization of PSG Films Deposited From PECVD TEOS and TMP", C. L. Pillote, F. A. Shemansky, T. S. Cale and G. B. Raupp, presented during the International Conference on Metallurgical Coatings and Thin Films, April 19-23, 1993, San Diego, CA.

"TEOS Sourced Remote Microwave Plasma Deposition of Silicon Dioxide", G. B. Raupp, D. A. Levedakis, K. W.-K. Tsui and T. S. Cale, presented during the 39th National AVS Symposium, Nov. 19-23, 1992, Chicago, Ill.

"Sequential Deposition of SiO<sub>2</sub> and Poly-Si in Isolation Trenches", T. E. Zirkle, S. R. Wilson, S. Sundaram, T. S. Cale and G. B. Raupp, presented during the 39th National AVS Symposium, Nov. 19-23, 1992, Chicago, Ill.

"Combined Reactor and Feature Scale Model for Tungsten Silicide LPCVD", J. H. Park, M. K. Jain and T. S. Cale, presented during the National AIChE Meeting, Nov. 1-6, 1992, Miami Beach, Fl.

"Estimating Kinetic Parameters for LPCVD Tungsten Using Film Profiles in Features", M. B. Chaara, T. S. Cale and G. B. Raupp, presented during the National AIChE Meeting, Nov. 1-6, 1992, Miami Beach, Fl.

"TEOS Sourced Remote Microwave Plasma Deposition of Silicon Dioxide", G. B. Raupp, D. A. Levedakis, K. W.-K. Tsui and T. S. Cale, presented during the National AIChE Meeting, Nov. 1-6, 1992, Miami Beach, Fl.

"Ion Energy and Angular Distributions in Dual Frequency PECVD", F. R. Myers, M. Ramaswami and T. S. Cale, presented during the National AIChE Meeting, Nov. 1-6, 1992, Miami Beach, Fl.

"Spatial Composition Variation in Sputtered Ti-W Films", B. R. Rogers, C. J. Tracy and T. S. Cale, presented during Advanced Metalization for ULSI Applications in 1992, October, 20-22, 1992, Tempe, AZ.

"Kinetics and Conformality of TiN Films from TDMAT and NH<sub>3</sub>", T. S. Cale, G. B. Raupp, J. T. Hillman and M. J. Rice, presented during Advanced Metalization for ULSI Applications in 1992, October, 20-22, 1992, Tempe, AZ.

"Corrosion Film Model for the Hydrogen Reduction of WF<sub>6</sub>: Implications for Feature Scale Simulation", G. B. Raupp and T. S. Cale, presented during Advanced Metalization for ULSI Applications in 1992, October, 20-22, 1992, Tempe, AZ.

"Conformality of Collimated Sputter Deposited Films", D. S. Taylor, M. K. Jain, T. S. Cale, M. G. Fissel and I. J. Raaijmakers, presented during Advanced Metalization for ULSI Applications in 1992, October, 20-22, 1992, Tempe, AZ.

"Sequential Deposition of SiO<sub>2</sub> and Poly-Si for Trench Isolation", T. S. Cale, G. B. Raupp, T. E. Zirkle, S. R. Wilson and S. Sundaram, presented during the National Meeting of The Electrochemical Society, October 11-16, 1992, Toronto, Canada.

"Surface Diffusion of Aluminum-Copper Alloys During Sputter Deposition", M. K. Jain, T. S. Cale, R. L. Duffin and C. J. Tracy, presented during the Ninth International VLSI Multilevel Interconnection Conference, June 9-10, 1992.

"PETEOS: Experiment and Simulation", T. E. Zirkle, C. I. Drowley, W. G. Cowden, T. S. Cale and G. B. Raupp, presented during the Ninth International IEEE VLSI Multilevel Interconnection Conference, June 9-10, 1992.

"Estimating Deposition Conditions and Kinetic Parameters Using Film Profiles", T. S. Cale, M. B. Chaara, G. B. Raupp and A. Hasper, presented at the MRS Spring Meeting, April 27 - May 1, 1992.

"Reaction Mechanism Discrimination Using Experimental Film Profiles in Features", T. S. Cale, G. B. Raupp, M. B. Chaara and F. A. Shemansky, presented at the International Conference on Metallurgical Coatings and Thin Films, April 6-10, 1992.

"PETEOS Simulation Using Evolve, A Deposition Simulator", T. E. Zirkle, C. Drowley, W. G. Cowden and T. S. Cale, presented at the International Conference on Metallurgical Coatings and Thin Films, April 6-10, 1992.

"Estimating Local Deposition Conditions During Blanket Tungsten Deposition", M. B. Chaara and T. S. Cale, presented at the International Conference on Metallurgical Coatings and Thin Films, April 6-10, 1992.

"Factorial Study of Wear Characteristics of PECVD Carbon Films", C. L. Pillote and T. S. Cale, presented at the International Conference on Metallurgical Coatings and Thin Films, April 6-10, 1992.

"The Inherently Transient Nature of Deposition Processes", T. S. Cale, G. B. Raupp, J.-H. Park, M. K. Jain and B. R. Rogers, presented at the First International Conference on Transport Phenomena in Processing, March 22-26, 1992.

"Flux Distributions on Low Pressure Deposition and Etch Processes", T. S. Cale, presented at the Forty-Fourth Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, November 24-26, 1991.

"Ballistic Transport and Surface Diffusion in Features during Low Pressure Deposition Processes", T. S. Cale, G. B. Raupp and M. K. Jain, presented at the AIChE Annual Meeting, November 17-22, 1991.

"Feature Scale Transport Processes and Surface Reactions in LPCVD", T. S. Cale, G. B. Raupp, M. K. Jain and F. A. Shemansky, presented at the AIChE Annual Meeting, November 17-22, 1991.

"Dual Frequency Plasma Sheath Model", F. M. Myers and T. S. Cale, presented at the AIChE Annual Meeting, November 17-22, 1991.

"Magnetic Determination of Average Catalyst Temperature in Fluidized Bed Catalytic Reactors", T. S. Cale and J. A. Merson, presented at the AIChE Annual Meeting, November 17-22, 1991.

"Ballistic Transport - Reaction Model Prediction of Film Conformality in TEOS/O<sub>2</sub> Plasma Enhanced Deposition of Silicon Dioxide", T. S. Cale, G. B. Raupp and T. H. Gandy, presented during the 38th National AVS Symposium, November 11-15, 1991.

"Kinetics and Mechanism of Deposition of SiO<sub>2</sub> from Thermal Pyrolysis of TEOS", G. B. Raupp, T. S. Cale and F. A. Shemansky, presented during the 38th National AVS Symposium, November 11-15, 1991.

"The Effects of Temperature and Flow Rate Transients on Thickness and Composition Uniformity of LPCVD Tungsten Silicide Films", T. S. Cale, G. B. Raupp and J.-H. Park, presented during the 38th National AVS Symposium, November 11-15, 1991.

"Free Molecular Transport and Deposition for Blanket and Selective Tungsten in Features of Circular Cross Section", M. Govil, T. S. Cale and G. B. Raupp, presented at the 180th Meeting of the Electrochemical Society, October 13-18, 1991.

"Comparison of Calculated and Experimental Conformality for Blanket Tungsten LPCVD", T. S. Cale, T. H. Gandy, M. K. Jain, G. B. Raupp, M. Govil and A. Hasper, presented during the Advanced Metallizations for ULSI Applications Workshop in 1991, October 8-10, 1991.

"The Inherently Transient Nature of Deposition Processes", T. S. Cale, J. H. Park, G. B. Raupp, M. K. Jain and B. R. Rogers, presented during the Advanced Metallizations for ULSI Applications Workshop in 1991, October 8-10, 1991.

"A General Model for Aluminum PVD", T. S. Cale, T. H. Gandy, M. K. Jain, M. Ramaswami and G. B. Raupp, presented at the Eighth International IEEE VLSI Multilevel Interconnection Conference, June 10-13, 1991

"Impacts of Temperature and Reactant Flow Rate Transients on LPCVD Tungsten Silicide Film Properties", T. S. Cale, G. B. Raupp and J.-H. Park, presented at the 1991 Spring Meeting of the MRS, April 29-May 3, 1991.

"Step Coverage Predictions Using Combined Reactor Scale and Feature Scale Models for Blanket Tungsten LPCVD", T. S. Cale, J.-H. Park, T. H. Gandy, G. B. Raupp and M. K. Jain, presented at the International Conference on Metallurgical Coatings and Thin Films, April 22-26, 1991.

"Model Predictions of Feature Size Dependent Step Coverages by PVD, LPCVD and PECVD Films", T. S. Cale, T. H. Gandy, G. B. Raupp and M. Ramaswami, presented at the International Conference on Metallurgical Coatings and Thin Films, April 22-26, 1991.

"Predictions of LPCVD Film Properties Using a Combined Reactor Scale and Feature Scale Model", T. S. Cale, G. B. Raupp and J.-H. Park, presented at Materials In Washington, February 28-March 1, 1991.

"Discrimination Between Deposition Reaction Mechanisms Through Step Coverage Measurements and Fundamental Feature Scale Modeling", G. B. Raupp and T. S. Cale, presented at Materials In Washington, February 28-March 1, 1991.

"Unified Model for LPCVD and PVD Processes", T. S. Cale, T. H. Gandy, M. Ramaswami and G. B. Raupp, presented at the 9th Annual Symposium of the Arizona Chapter of the AVS, February 26-27, 1991.

"Discrimination Between Deposition Reaction Mechanisms Through Step Coverage Measurements and Fundamental Feature Scale Modeling", G. B. Raupp, F. A. Shemansky and T. S. Cale, presented at the 9th Annual Symposium of the Arizona Chapter of the AVS, February 26-27, 1991.

"Localized Corrosion of Al-1.5% Cu Thin Films Exposed to Photoresist Developing Solutions", B. R. Rogers, S. R. Wilson and T. S. Cale, presented at the 9th Annual Symposium of the Arizona Chapter of the AVS, February 26-27, 1991.

"Mechanism of Plasma-Enhanced Deposition of Silicon Dioxide from TEOS/O<sub>2</sub> Mixtures", G. B. Raupp, T. S. Cale and Peter W. Hey, presented at the Fall 1990 MRS Meeting, November 26 - December 1, 1990.

"Unified Model for Ballistic Transport and Gas-Solid Reactions in Features", T. S. Cale, G. B. Raupp and T. H. Gandy, presented at the Fall 1990 MRS Meeting, November 26 - December 1, 1990.

"Comparison of Step Coverage Predictions for LPCVD: Boltzmann Equation Based Model vs. Continuum Diffusion-Reaction Model", T. S. Cale, G. B. Raupp, T. H. Gandy and M. K. Jain, presented at the Fall National AIChE Meeting, November 11-16, 1990.

"Step Coverage of LPCVD Silicon Dioxide from TEOS", T. S. Cale, G. B. Raupp and F. A. Shemansky, presented at the Fall National AIChE Meeting, November 11-16, 1990.

"Step Coverage Prediction in TEOS Plasma-Enhanced Deposition of Silicon Dioxide from the Boltzmann Equation, G. B. Raupp, T. S. Cale, T. H. Gandy and P. W. Hey, presented at the Fall National AIChE Meeting, November 11-16, 1990.

"Kinetics of Silicon Dioxide Deposition Through Low Pressure TEOS Pyrolysis", F. A. Shemansky, T. S. Cale and G. B. Raupp, presented at the Fall National AIChE Meeting, November 11-16, 1990.

"A Fundamental Model for Transport and Deposition of Blanket Tungsten Films", T. S. Cale, T. H. Gandy and G. B. Raupp, presented at the Workshop on Tungsten and Other Advanced Metals for ULSI Applications VII, October 22-24, 1990.

"Comparison of Continuum Diffusion-Reaction and Fundamental Particle Flux Based Models for LPCVD", T. S. Cale, G. B. Raupp, T. H. Gandy and M. K. Jain, presented at the Workshop on Tungsten and Other Advanced Metals for ULSI Applications VII, October 22-24, 1990.

"A Fundamental Feature Scale Model for Low Pressure Deposition Processes", T. S. Cale, T. H. Gandy and G. B. Raupp, presented at the Fall 1990 AVS Meeting, October 8-12, 1990.

"Localized Corrosion of Al-1.5%Cu Thin Films Exposed to Photoresist Developing Solutions", B. R. Rogers, S. R. Wilson and T. S. Cale, presented at the Fall 1990 AVS Meeting, October 8-12, 1990.

"Process Development Tools for Single Wafer LPCVD Reactors", G. B. Raupp and T. S. Cale, presented at the SRC Stanford Joint Contract Review, August 22-23, 1990.

"Unifying Model for Step Coverage in Deposition Processes for Multilevel Interconnection", G. B. Raupp, T. S. Cale, presented at the IEEE VLSI Multilevel Interconnection Conference, 1990.

"Comparison of a Method for Inverting Fredholm Equations of the First Kind with the Method of Regularization", J. A. Merson and T. S. Cale, presented at IMSE 90, Arlington, TX, May, 15-18, 1990.

"LPCVD of Tungsten Silicide Barriers and Tungsten in Rectangular Trenches", T. S. Cale, G. B. Raupp and M. K. Jain, presented at the Spring Meeting of the Materials Research Society, Symposium B: Advanced Metallizations in Microelectronics, San Francisco, CA, April 1990.

"Modified Line-of-Sight Model for LPCVD Tungsten Silicide Barrier Layers in Rectangular Trenches", T. S. Cale, G. B. Raupp, presented at the Spring Meeting of the Materials Research Society, Symposium B: Advanced Metallizations in Microelectronics, San Francisco, CA, April 1990.

"Step Coverage of Tungsten Silicide Films Deposited by Low Pressure Dichlorosilane Reduction of Tungsten Hexafluoride", G. B. Raupp, T. S. Cale, M. K. Jain, D. Srivinas and B. Rogers, presented at the Eighth International Conference on Thin Films, San Diego, CA, April 1990.

"Maximizing Step Coverage in Tungsten LPCVD", T. S. Cale, G. B. Raupp and M. K. Jain, presented at the Eighth International Conference on Thin Films, San Diego, CA, April 1990.

#### **Selected Invited Seminars:**

"Grain-Focused Models: Materials and Processes", T. S. Cale, University of Florida, Gainesville, FL, March 25, 2007.

"Towards a Virtual Wafer Fab", T. S. Cale, IBM, Fishkill, NY, Dec. 15, 2006.

"Grain Focused Simulations in Microelectronics", NIST, Gaithersburg, Md, May 15, 2006.

"Towards a Virtual Wafer Fab: BEOL Process and Materials Modeling and Simulation", IBM Research, Yorktown Heights, NY, April 5, 2006.

"Towards the Virtual Wafer Fab: Process and Materials Modeling", IBM/RPI CCNI Meeting, RPI, January 20, 2006.

"Topography and Materials Modeling", TEL, ANT, Albany, NY, Dec. 7, 2005.

- “Multiscale Modeling and Simulation: Meters to Nanometers”, Dept. of Chemical Engineering, University of Louisville, Louisville, KY, June 9, 2005.
- “Materials Oriented Process Simulation”, AMD, Dresden, Germany, March 9, 2005.
- “Multiscale Modeling: A Grain Focus”, Dept. of Materials Science, Queen Mary, University of London, London, UK, February 4, 2005.
- “Multiscale Modeling: A Grain Focus”, Vanderbilt Institute for Nanoscale Science and Engineering, Vanderbilt University, Nashville, TN Jan. 31, 2005.
- “Multiscale Process Modeling in Microelectronics”, Institute of Physics, Chinese Academy of Sciences, Beijing, China, September 9, 2004.
- “Some ALD and Thin Film Modeling Capabilities”, Benet Laboratories, Watervilet, NY, April 8, 2004
- “Property-Oriented Multiscale Process Simulation”, Synopsis Advisory Board Meeting, Washinton, DC, Dec. 9, 2003.
- “A Parallel Level-set Environment for Nanoscale Topography Evolution”, Synopsis, Sunnyvale, CA, Nov. 18, 2003.
- ”Parallel Level-set Environment for Nanoscale Topography Evolution”, Infineon, Munich, Germany, Aug., 2003.
- “Multiscale Process and Materials Modeling in Microelectronics”, Univ. of Limerick, Limerick, Ireland, July, 2003.
- “Multiscale Process and Materials Simulation in Microelectronics”, Univ. of Maryland, April, 2003.
- “Integrated Multiscale, Multistep Process Simulation: ECD and CMP”, LSI Logic, Milpitas, CA, Dec. 2002.
- “Thoughts on Process Simulation in Microelectronics”, LSI Logic, Gresham, Oregon, Nov. 2002.
- “Integrated Multiscale Process Simulation in Microelectronics”, Wavefront, Yokohama, Japan.
- “Integrated Multiscale Process Simulation in Microelectronics”, Fluent, Lebanon, NH, Sept, 2002.
- “Focus Center – New York, Rensselaer: Interconnections for Gigascale Integration”, EV Group, Scharding, Austria, July, 2002.
- “Integrated Multiscale Process Simulation in Microelectronics: Grain Scale to Equipment Scale”, University of Glasgow, Glasgow, Scotland, June, 2002.
- “Multiscale Simulation: 3D Grain Formation and Evolution”, Jiaotong University, Xian, China, June, 2002.
- “EVOLVE, etc.”, CFDRC, Hunstville, Alabama, March, 2002.
- “Integrated Multiscale Process Simulation in Microelectronics & Misc. Thoughts”, Dept. of Chemical Engineering, University of South Carolina, Columbia, South Carolina, March, 2002.
- “Integrated Multiscale Process Simulation in Microelectronics: Grain Scale to Equipment Scale”, Foundation for Research & Technology-Hellas (FORTH), Heraklion, Crete, Greece, March, 2002.
- “Integrated Multiscale Process Simulation in Microelectronics: Grain Scale to Equipment Scale”, Foundation for Research & Technology-Hellas (FORTH), Patras, Greece, March, 2002.
- “Technology Transfer of EVOLVE”, ASML, Santa Cruz, CA, Feb., 2002.
- “EVOLVE, etc.”, Avant!, Fremont, CA, Feb., 2002.
- “Process Simulation: Atomic to Reator Scales”, Intel, Santa Clara, Nov. 30, 2001.
- “Integrated Multiscale Process Simulation in Microelectronics: Equipment to Atomic Scales”, Hoseo Univeristy, Korea, November, 2001.
- “Process Simulation: Feature Scale to Equipment Scale”, Samsung Corp., Korea, November, 2001.
- “3D Platforms for ICs and Heterogeneous Systems”, IBM, Yorktown, August 2001

- “Integrated Multiscale Process Simulation in Microelectronics”, Department of Chemical Engineering, University of Pennsylvania, September 2001.
- “Focus Center – New York, Rensselaer: Interconnections for Gigascale Integration” and “Integrated Multiscale Process Simulation for Microelectronics: Equipment to Atomic Scales”, Chartered Semiconductor Manufacturing, Singapore, June 2001.
- “Integrated Multiscale Process Simulation for Microelectronics: Equipment to Atomic Scales”, National University of Singapore, Singapore, June 2001
- “Focus Center – New York, Rensselaer: Interconnections for Gigascale Integration” and “Integrated Multiscale Process Simulation for Microelectronics: Equipment to Atomic Scales”, IMEC, Leuven, Belgium, April 2001.
- “Integrated Multiscale Process Simulation for Microelectronics: Equipment to Atomic Scales”, Vanderbilt University, Nashville, TN, March 2001.
- “Integrated Multiscale Process Simulation”, Argonne National Lab, Argonne, IL, February 2001.
- “Semiconductor Materials Processing”, Air Liquide, Chicago, IL, February 2001.
- “Process Simulation in Microelectronics”, Chemnitz University, Chemnitz, Germany, September 2000.
- “Integrated Multiscale Process Simulation in Microelectronics”, Delft University, July 2000.
- “Integrated Multiscale Process Simulation”, Multi-scale Modeling Workshop, Institute for Mathematics and its Applications, University of Minnesota, June 2000.
- “Predictive Process, Property, Performance Modeling for Microelectronics”, Gigascale Integration Research Center Workshop”, Stanford, March, 2000.
- “Transport and Reaction Process Modeling: Examples in Semiconductor Materials Processing”, Department of Mechanical Engineering, Hong Kong Polytechnic University, September 1999.
- “Transport and Reaction Process Modeling: Examples in Semiconductor Materials Processing”, Department of Chemical Engineering, Clarkson University, May 1999.
- “Transport and Reaction Process Modeling: Examples in IC Fabrication”, Department of Chemical Engineering, Vanderbilt University, January 1999.
- “Opportunities for Chemical Engineers in Microelectronics Research”, Advisory Council, Rensselaer Polytechnic Institute, May 1998.
- “Topography Relevant Process Simulations”, Physics Department, State University of New York, Albany, April 1998.
- “Topography Relevant Process Simulations”, Center for Advanced Interconnect Science and Technology, Rensselaer Polytechnic Institute, April 1998.
- “Topography Relevant Process Simulations”, Department of Chemical Engineering, North Carolina State University, October 1997.
- “Transport and Reaction Examples in Semiconductor Materials Processing”, Department of Chemical Engineering, Rensselaer Polytechnic Institute, August 1997.
- “The Status of Multi-Scale Transport and Reaction Simulations”, DARPA Workshop on GMR Materials, University of Virginia, December 3, 1996.
- “Transport and Reaction Simulation in Microelectronics”, University of Missouri, Rolla, October 23, 1996.
- “The Status of Multi-Scale Transport and Reaction Simulations in Microelectronic Process Fabrication”, Michigan Technological Institute, October 4, 1996,
- “Transport and Reaction during Deposition and Etch Processes”, Stanford TCAD Review, August 7-8, 1996.
- “Transport and Reaction during Deposition, Etch and Thin Film Flow Processes”, Center for Solid State Electronics Research, Arizona State University, July 25, 1996.

- "Topography Evolution During Deposition and Etch Processes", NATO ASI on "Plasma Processing of Semiconductors", at Chateau de Bonas, France, June 17-28, 1996.
- "Introduction to Plasma Enhanced CVD", NATO ASI on "Plasma Processing of Semiconductors", at Chateau de Bonas, France, June 17-28, 1996.
- "Applications of EVOLVE", LSI Logic, Santa Clara, CA, February 12, 1996.
- "Topography Evolution & Applications, NSF/DARPA Workshop on Computational Materials Science, held at the Institute for Mathematics and its Applications, Minneapolis, MN, January 23-26, 1996.
- "Low Pressure Transport and Reaction in Features", Workshop on Modeling, Simulation and Database Needs in Plasma Processing", sponsored by the National Research Council, Washington, D.C., April 1-2, 1995.
- "EVOLVE: Theory and Applications", Intel, Santa Clara, CA, March 19, 1995.
- "Applications of EVOLVE to PVD Processes: Conformality and Composition", Meeting of the Northern California Thin Films Users Group of the American Vacuum Society, Palo Alto, CA, August 18, 1994.
- "Physically Based Deposition and Etch Process Simulation", Korea-US IC Design Automation and Manufacturing Workshop, Taejon, South Korea, November 17-20, 1993.
- "EVOLVE: A Tool for Process Development", LSI Logic, Santa Clara, CA, September 17, 1993.
- "EVOLVE: Applications in PVD", Varian, Palo Alto, CA, June, 1993.
- "EVOLVE: A Tool for Kinetic Model Development", SEMATECH, Dallas, TX, May, 1993.
- "Transport and Reaction at High Knudsen Numbers", University of Notre Dame, Department of Chemical Engineering, March, 1993
- "Understanding Conformality: The Ballistic Transport and Reaction Model", AZ AVS Chapter's 10th Annual Symposium and Short Course Program, March, 1993.
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- "Transport and Reaction at High Knudsen Numbers", University of Texas, Department of Chemical Engineering, February, 1993
- Research summary on "Process Development Tools for Single Wafer Reactors", Semiconductor Research Corporation Research Review, Rensselaer Polytechnic Institute, Nov. 10-11, 1992.
- "Semiconductor Materials Processing Research in Chemical Engineering", Third Annual Industrial Relations Meeting of the Center for Solid State Electronics Research at ASU, October 29-30, 1992.
- "EVOLVE, A Low Pressure Deposition Process Simulator", Advanced Micro Devices, Santa Clara, CA, September, 23, 1992.
- "Applications of EVOLVE", Sandia National Laboratory, Albuquerque, NM, August 21, 1992.
- "TCAD at Arizona State University", SEMATECH, Austin, TX, April 16, 1992.
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- "EVOLVE, a Simulator for Low Pressure Chemical Vapor Deposition and Etch Processes", Motorola, Advanced Technology Center, August 26, 1991.
- "Demonstration of a Simulator for Low Pressure Chemical Vapor Deposition Processes", SILVACO Data Systems, Santa Clara, CA, June 10, 1991.
- "A Simulator for Low Pressure Deposition Processes", National Semiconductor, Santa Clara, CA, June 10, 1991.
- "Insights into the Control of Semiconductor Processes", D. E. Rivera and T. S. Cale, Technology '90, Dec. 5-6, 1990.

- "Unified Feature Scale Model for Deposition and Etch Processes (with Reference to Reactor Scale Models)", Intel Corp., Santa Clara, CA, Nov., 1990.
- "Feature Scale Model for Ballistic Transport and Gas-Solid Reactions", Novellus Systems, Inc., San Jose, CA, Nov. 1990.
- "Unified Feature Scale Model for Deposition and Etch Processes", Fall 1990 Industrial Relations Meeting of the Center for Solid State Electronics Research at ASU, Nov. 1990.
- "A Modified Line-of-sight Model for Low Pressure Chemical Vapor Deposition", Motorola, Mesa, AZ, May, 1990.
- "Desiccant Characterization Research at Arizona State University", Gas Research Institute, Chicago, IL, May, 1989.
- "The Influence of Operating Conditions on Keyhole Formation in Plasma Silicon Oxynitride Passivation Layers", Intel, Chandler AZ, July, 1986.
- "Applications of Catalytic Crystallite Thermometry", Chemical Engineering Department of the University of California at Los Angeles, January, 1986.
- "Magnetic Crystallite Thermometry and its Applications", presented at Dow Chemical Co., Sept. 24, 1985.
- "Nickel Crystallite Thermometry", BYU Catalysis Laboratory, Brigham Young University, May, 1984.
- "Catalytic Crystallite Thermometry", Chemical Engineering Department of the University of Arizona, December, 1984.
- "*In-Situ* Magnetic Characterization of Catalysts", Center for Solid State Sciences at ASU Fall 1982 Symposium Series.

**Advisees:**

In addition to the listed students below, I have mentored a number of post-doctoral research associates; including, Sang-Hwui Lee, Daniel N. Bentz, Jing Zhang, Jian Zhang, Yeon Ho Im, Jongwon Seok, Vinay Prasad, Daewon Yang, David Richards, Sofiane Soukane, Vadali Mahadev, Zongwu Tang, Rao Annapragada, Yu-Kwang Chang and Gerrit Leusink.

**Student Theses and Dissertations:**

Max Bloomfield, "Multiscale Microstructure Modeling and Simulation", Ph.D., Chemical Engineering, RPI, expected May 2007.

Ameet Kulkarni, "Adhesion of Ta to Porous MSQ", M.S., Chemical Engineering, RPI, December 2005.

Dae-lok Bae, "Copper Electrochemical Deposition on Modified Surfaces", Ph.D., Chemical Engineering, RPI, August 2004. (Co-advisor with J. Senkevich)

Yongchai Kwon, "Bonding for Hyperintegration through Wafer Stacking", Ph.D., Chemical Engineering, RPI, August 2003. (Co-advisor with R. Gutmann)

Pushkar Jain, "Pulsed DC Reactively Coupled Tantalum Oxide Thin Films for Embedded Capacitors", Ph.D., Chemical Engineering, RPI, May 2003. (Co-advisor with G. Rymaszewski.)

Vinay Bhagwat, "Comparison of High Frequency and DC Characteristics of Different Dielectrics Based Thin Films for Embedded Capacitor Applications", M.S., Chemical Engineering, RPI, December 2002. (Co-advisor with G. Rymaszewski.)

Jasbir Juneja, "Effect of Substrate Temperature on the Dielectric Properties of Tantalum Oxide Films Deposited by Reactive Pulsed Magnetron Sputtering", M.S., Chemical Engineering, RPI, December 2002. (Co-advisor with G. Rymaszewski.)

Andrew Kim, "Multiscale CMP Modeling", Ph.D., Mechanical Engineering, RPI, May 2002. (Co-advisor with J. Tichy)

Shrinivas Shetty, "Lowering CVD Copper Film Resistivities By Using Hydrogen", Chemical Engineering, M.S. RPI, August 2000.

John Kristof, "Optimal Programmed Rate Chemical Vapor Deposition of Tungsten", Electrical Engineering, M.S. ASU, May 2000. (Co-advisor with K. Tsakalis.)

Daewon Yang, "Nucleation Studies of Aluminum CVD", Chemical Engineering, Ph.D., RPI, December, 1999.

Rexford Brian Clevinger, "Lead-Tin Oxide Surface Removal From C4 Bumps", Chemical Engineering, M.S., ASU, May 1999.

Veera Mohan K. Gunturu, "Installation and Characterization of a Dual Frequency Plasma Etcher", Chemical Engineering, M. S., ASU, May 1999.

Lei Xu, "Kinetics and Conformality of Films Deposited from FTES", Chemical Engineering, M.S., ASU, May, 1998.

Chandrashekar Srinivasa-Murthy, "Non-Uniformity in Chemical Mechanical Polishing Processes: An Effect of Stress", Chemical Engineering, M.S., ASU, December 1997. (Co-advisor is S. Beaudoin)

Patrick Zilaro, "EVOLVE for Solid State Transport and Reaction", Chemical Engineering, M.S., ASU, May, 1999.

Raj Jonnalagadda, "Aluminum CVD in a Rotating Disc Reactor", Chemical Engineering, M.S., ASU, December 1997.

Surasit Chungpaiboonpatana, "Characterization of Bump Processing", Chemical Engineering, M.S., ASU, August 1997. (Co-advisor is S. Beaudoin)

Frank Myers, "Step Coverage of Silicon Dioxide Films Using Dual Frequency PETEOS", Chemical Engineering, Ph.D., ASU, May, 1997.

Dapeng Wang, "Von Mises Stresses in CMP Processes", Chemical Engineering, M.S., ASU, May, 1997. (Co-advisor is S. Beaudoin)

Moneth Virmani, "Remote Microwave Plasma Enhanced Chemical Vapor Deposition of Fluorine Doped Silicon Dioxide from FASi-4", Chemical Engineering, M.S., ASU, May, 1996.

Kathryn Tracy, "Programmed Rate Chemical Vapor Deposition of Tungsten", Materials Science and Engineering, M.S., ASU, May, 1996.

Ashok Challa, "Microstructure Evolution During the Early Stages of Deposition: Monte Carlo Simulations", Science and Engineering of Materials, Ph.D. ASU, May, 1996.

Hung Liao, "Simulation of Deposition and Reflow Processes", Chemical Engineering, Ph.D., ASU, December, 1995.

Gaddam Sreedhar, "Integration Studies of Via Etch and Aluminum Sputter Deposition Steps", Chemical Engineering, M. S., ASU, December, 1995.

Satnam S. Doad, "Evaluation of TIBA as an Al CVD Source", Chemical Engineering, M.S., ASU, December, 1995.

Ganesh Rajagopalan, "Novel Structure for Evaluating the Electromigration Reliability of Aluminum-Copper Interconnects", Chemical Engineering, M. S., ASU, August, 1995.

Zhou Lin, "Transport Through Collimators", Chemical Engineering, M. S., ASU, December, 1995.

Rahul Bammi, "Development of a Gate Metal Etch Process for GaAs Wafers", Chemical Engineering, M. S., ASU, May, 1994.

Manjula Ramaswami, "Dual Frequency Plasma Sheath Models", Chemical Engineering, M. S., ASU, May, 1994.

Donald S. Taylor, "Simulation and Experimental Studies of Sputter Deposited Films", Electrical Engineering, M.S., ASU, May, 1994.

Robert H. Cavett, "A New Approach to the Solution of Nonlinear Equations", Chemical Engineering, Ph.D., ASU, August, 1993.

Manoj K. Jain, "Maximizing Step Coverage at High Throughput During Low Pressure Deposition Processes", Chemical Engineering, Ph.D., ASU, December, 1992.

Jung-Hwan Park, "Combined LPCVD Single Wafer Reactor and Feature Scale Model", Chemical Engineering, Ph.D., ASU, August, 1992.

T.-Q. Phan, "Ballistic Transport-Reaction Model for Rectangular Vias", Chemical Engineering, M.S., ASU, May, 1992.

Kenneth W.-K. Tsui, "Design, Construction and Testing of a Remote Microwave Plasma Deposition System", Chemical Engineering, M.S., ASU, May, 1992 (Co-advisor with G. B. Raupp).

Cynthia Pillote, "Deposition of Hard Carbon Films for Hard Disk Protection Layers", Materials Science and Engineering, M.S., ASU, December, 1991.

Meenakshi Govil, "Fundamental Feature Scale Model for LPCVD in Features of Circular Cross-section", Chemical Engineering, M.S., ASU, August 1991.

Todd H. Gandy, "Fundamental Feature Scale Model for Deposition and Etchback in Trenches of Symmetric Cross-section", Chemical Engineering, M.S., ASU, May 1991.

Chul-Kun Cho, "Catalytic Reactor Control Using Nickel Crystallite Thermometry", Chemical Engineering, Ph.D., ASU, 1990.

Sherif Aly Mohamed, "A Fundamental Model for Transport and Reaction in a Single Catalyst Pore", Chemical Engineering, M.S., ASU, 1990.

Bridget R. Rogers, "Localized Corrosion of Al-1.5%Cu Thin Films Exposed to Photoresist Developing Solutions", Chemical Engineering, M.S., ASU, 1990.

John A. Merson, "Magnetically Determined Axial Solid Temperature Profiles in Packed Bed Catalytic Reactors", Chemical Engineering, Ph.D., ASU, 1990

P. K. Sinha, "Internal Gettering of Iron and Nickel in Silicon", Chemical Engineering, Ph.D., ASU, 1988.

Hepburn Ingham. "Catalytic Cracking Detector for Gas Chromatography, Chemical Engineering, M.S., ASU, 1989. (Co-advisor with V. E. Sater)

Douglas K. Ludlow, "The Application of Nickel Crystallite Thermometry to Low Reynolds Number Interphase Heat Transfer", Chemical Engineering, Ph.D., ASU, 1986.

Janet M. Lawson, "The Model Dependency of the Apparent Nusselt Number in Packed Beds at Low Reynolds Numbers", Chemical Engineering, M.S., ASU, 1986.

Philip H. Williams, "The Effect of Rapid Calcination on a Cobalt-Thoria/Alumina Fischer-Tropsch Catalyst", Chemical Engineering, M.S., ASU, 1985.