

ALBERT K. HENNING

Curriculum vita

199 Heather Lane
Palo Alto, CA 94303
650-380-5309 (Mobile)
henning@aquarianmicro.com

EDUCATION

Department of Electrical Engineering, Stanford University, Stanford, CA 94305

1987 **Doctor of Philosophy.**
Dissertation: “Hot Carrier Effects in CMOS Field Effect Transistors at Cryogenic Temperatures.”
Thesis Advisor: James D. Plummer, Professor and former Dean of Engineering, Stanford University

Department of Physics and Astronomy, Dartmouth College, Hanover, NH 03755

1979 **Master of Arts.**
Thesis: “DC Conductivity in Compensated p-Ge Between .35K and 4.2K.”
Thesis Advisor: P. Bruce Pipes, Provost Emeritus, Franklin & Marshall College

1977 **Bachelor of Arts.** Received *magna cum laude*, with Distinction in Physics.

EXPERIENCE

MEMS Technologies Dresden

Fraunhofer Institute for Photonic Microsystems, Dresden, Germany

7/13-Present **US Business Development MEMS.** Responsible for: business development in the US for MEMS product development, product manufacturing, and technology development, for the foundry services organization within FhG-IPMS; intellectual property development based upon FhG-IPMS technologies; business plan related to spin-off MEMS technologies company; market evaluation and analysis, tailored to technological strengths, present and future, of FhG-IPMS.

MonolithIC3D, Inc., San Jose, CA 95124

3/13-Present **Chief Scientist.** Responsible for: technology assessment of advanced integrated circuit process technologies; development of qualitative and quantitative concepts for integration of three-dimensional integrated circuit devices and processes with existing planar technologies, including FinFET; thermal analysis of rapid thermal and laser annealing processes in the context of three-dimensional process and device technology; generation of new intellectual property centered on three-dimensional integration of nanoscale logic circuits, memory devices, and related process technology; synthesis of three-dimensional integrated circuit technology with MEMS devices and Internet-of-Things (IoT)sensors.

Aquarian Microsystems, Inc., Palo Alto, CA 94303

1/06-Present **Principal.** Microfabrication, MEMS, and microfluidics consulting, R&D, product development, process design and development, and manufacturing services (especially mask layout and thin-film metrology) firm. Focused on standalone and integrated microfabricated valves, pressure sensors, flow sensors, biosensors, microfluidics, microfluidic logic, and related systems; with applications to

energy efficient refrigeration, micro fuel cells, medical devices (e.g. insulin delivery), and electrical power distribution systems. Finalist in 2006 and 2007 California Clean Tech Open competitions in Energy Efficiency category (<http://www.cleantechopen.com>), writing, editing, and defending start-up company business plans. Co-Investigator on NSF and NASA SBIR grants related to micromachined pressure sensor, and NSF SBIR grant related to refrigeration microvalve.

SmallTech Consulting, Menlo Park, CA 94025

10/14-Present **Consultant.** Responsible for: application analysis, technology design and development, device design and development, focused on MEMS in general and microfluidics in particular; generation of detailed device/product engineering specifications; interface with prototype engineering firms.

NanoInk, Inc., Campbell, CA 95008

4/07-2/13 **Director of MEMS Technology.** Responsible for: MEMS operations relative to NanoEncryption technology as applied to Brand Protection applications for high-value pharmaceuticals; conception and development of new nanotechnologies related to NanoEncryption tagging and identification; microfabrication process characterization and metrology, including metrology for surface tension-driven capillary flows; process and device development (including yield analysis, reliability analysis, SDOE, and transfer to production), related to MEMS-based dip pen nanolithography applied to semiconductor mask repair, bioassay micro-arrays, active and passive (surface tension-driven) microfluidics and nanofluidics, general DPN/AFM cantilever structures, and related applications; technical support for sales and marketing, including development of new customers; generation and management of IP as member of corporate IP Committee.

Redwood Microsystems, Inc., Menlo Park, CA 94025

4/98-1/06 **Director of Technology.** Responsible for advanced process and systems research and development, driven both internally and in response to new customer specifications, with particular emphasis on microfabricated microfluidic components and systems, embedded systems (DeviceNet-related hardware and software) design and manufacture, product reliability and yield, and product qualifications (pressure controller, flow controller, and integrated panel flow system) for key customer (Applied Materials). Manager of project to develop high-sensitivity micromachined pressure sensor; key technical contributor to this project (operation modes, structural design and modeling, and microfabrication process design). Manage engineering staff in micromachined shut-off valve development. Manage corporate patent portfolio and intellectual property development. Develop models of microvalve-based flow systems. Perform FEA of microvalve membrane mechanical stress and reliability. Corporate officer. Safety officer. Member of executive staff.

6/97-4/98 **Manager, Wafer and Die Process Engineering.** Responsible for process engineering and development in the wafer fabrication facility. Corporate officer. Member of executive staff. Corporate safety officer. Manager for project to develop a high-performance, high-reliability MFC for the semiconductor process equipment industry, including meeting qualification specifications for Applied Materials. Developer of models for multi-component microflow systems. Developed and distributed design tools for mass flow controllers and integrated gas control systems.

1/96-6/97 **Program Manager.** Engineer, and engineering manager, for third-party-funded R&D project to extend Redwood's microvalve MEMS technology to low-cost, high-volume refrigeration and air conditioning applications. Technical point of contact and principal investigator for Federal research contracts. Responsible to third-party funders for progress and reporting. Lead participant in six-month Conceptual Engineering effort to develop product specification for refrigeration microvalve. Utilized direct-report as well as matrix-management techniques. Developer of physical models for thermopneumatic microvalves: low-power behavior; liquid distribution and control; two-phase phenomena in confined microcavities; compressible gas models for low-flow behavior; resolution and sensitivity analyses for low-flow mass flow controller.

Thayer School of Engineering, Dartmouth College, Hanover, NH 03755

- 1/96-6/98 **Adjunct Associate Professor.** Principal interests: scanning probe microscopy of semiconductor dopants, defects, and electronic materials and device failure analysis; micro-turbine design and fabrication; silicon germanium MOSFET device physics and fabrication.
- 7/93-12/95 **Associate Professor.** Principal interests: scanning probe microscopy of semiconductor dopants, defects, and electronic materials and device failure analysis; MOSFET device physics and fabrication; novel applications of micro-fabrication science, especially to micro-machines and microfluidic devices and structures. Director and Founder of Solid State Microengineering Lab.
- 9/93-6/94 **Visiting Scientist.** Sabbatical leave at the Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, hosted by Prof. Dimitri Antoniadis. Principal interests: Scanning probe microscopy applied to dopant profiling; hot carrier transport and heavy doping in silicon devices.
- 9/87- 6/93 **Assistant Professor.** Principal interests: MOSFET device physics, fabrication, reliability, and modeling; thin-film high-temperature superconducting materials and field-effect devices; novel applications of micro-fabrication science. Responsible for planning, design, construction, capital equipment fundraising and procurement, and direction of the Solid State Microengineering Laboratory, a Class 100/1000 clean room. [See <http://engineering.dartmouth.edu/microeng/>]

Integrated Circuits Laboratory, Stanford University, Stanford, CA 94305

- 10/82- 8/87 **Research Assistant.** Instructor for laboratory course in integrated circuit fabrication. Researched hot carrier transport and device reliability in MOS transistors at room and low temperatures, including device design, layout, fabrication, measurement, and physical modeling. Directed undergraduates in independent research activities.

Intel Corporation, Santa Clara, CA 95051

- 8/79- 10/82 **Device Physicist.** Participated in NMOS process development for SRAM and microcontroller applications. Initial device physicist for CMOS microprocessor (80386) process development. Responsible for test chip generation, electrical device characterization, process experiment design, MOSFET design and optimization, design rule definition and analysis, technician supervision.

Department of Physics and Astronomy, Dartmouth College, Hanover, NH 03755

- 9/77- 6/79 **Research Assistant.** Characterized hopping conduction mechanisms in doped semiconductors for cryogenic device application (bolometer). Instructor for undergraduate laboratory courses.

U.S. PATENTS and PATENT APPLICATIONS

1. J. J. Deacutis and A. K. Henning, "Switchable Thermoelectric Element and Array." U.S. Patent Application, filed June 1992. Granted November 1993 (#5,261,747). Assigned to Board of Trustees, Dartmouth College.
2. A. K. Henning, M. Zdeblick, J. S. Fitch, D. A. Hopkins, Jr., and L. J. Lilly, "Low-power themopneumatic microvalve." U.S. Patent Application, filed June 1997. Granted October 2000 (#6,129,331). Assigned to Redwood Microsystems, Inc.
3. A. Zias, P. Mauger, S. Cahill, N. Nystrom, and A. K. Henning, "Micro-electromechanical Sensor." U.S. Patent Application, filed July 2002. Issued May 2006 (#7,047,814). Assigned to Redwood Microsystems, Inc.
4. A. K. Henning, M. Selser, and B. A. Cozad, "High-flow microvalve." U.S. Patent Application 20050067029, filed April 2004. Issued January 2006 (#6,986,365). Assigned to SMC KK.

5. A. Zias, P. Mauger, S. Cahill, N. Nystrom, and A. K. Henning, "Micro-electromechanical Sensor." U.S. Patent Application, filed July 2001. Issued December 2007 (#7,305,890). Assigned to SMC KK.
 6. J. M. Harris, M. Selser, B. A. Cozad and A. K. Henning, "Dual pedestal shut-off valve." U.S. Patent Application, filed March, 2004. Issued December 2007 (#7,309,056). Assigned to SMC KK.
 8. A. K. Henning, "Micro-pneumatic logic." U.S. Patent Application, filed November, 2006.
 9. A. K. Henning, "Micro-hydraulic logic." U.S. Patent Application, filed January, 2008.
 10. A. K. Henning, "Methods and apparatuses for complementary micro-pneumatic devices and circuits." U.S. Patent Application 20100269920, filed January, 2010.
 11. C. A. Mirkin, *et al.*, "Scanning probe epitaxy." U.S. Patent Application 20100071098, filed 13 May 2009.
 12. J. E. Bussan, M. R. Nelson, J. S. Fragala, A. K. Henning, and J. R. Rendlen, "Nanomanufacturing devices and methods." U.S. Patent Application 20100089869, filed 13 May 2009. Issued September, 2012 (#8,261,368). Assigned to NanoInk.
 13. J. S. Fragala, A. K. Henning, and R. R. Shile, "Piezoresistor height sensing cantilever." U.S. Patent Application 20100100989, filed 13 May 2009. Issued March 2013 (#8,393,011). Assigned to NanoInk.
 14. J. S. Fragala, A. K. Henning, and R. R. Shile, "Heated cantilever." U.S. Patent Application 20100147820, filed 13 May 2009.
 15. A. K. Henning, J. S. Fragala, and R. R. Shile, "Dual-tip cantilever." U.S. Patent Application 20100235954, filed 13 May 2009.
 16. A. K. Henning, R. R. Shile, J. S. Fragala, N. A. Amro, and J. R. Haaheim, "High density, hard tip arrays." U.S. Patent Application 20120295030, filed 12 May 2012.
 17. Z. Or-Bach, B. Cronquist, and A. K. Henning, "Method of processing a semiconductor device." U.S. Patent 9,023,688, issued May 5, 2015. Assigned to MonolithIC3D.
- Other patent applications in process. Related foreign patents and applications not listed.

PUBLICATIONS

h-index = 17; i10-index = 24; total citations = 1179 (13 April 2016)

Refereed Journal Articles

1. A. K. Henning, N. N. Chan, J. T. Watt and J. D. Plummer, "Substrate current at cryogenic temperatures: Measurements, and a 2-D model for CMOS technology." *IEEE Transactions on Electronic Devices* **ED-34**, pp. 64-74 (1987).
2. A. K. Henning and J. D. Plummer, "Thermionic emission probability for semiconductor-insulator interfaces." *IEEE Transactions on Electronic Devices* **ED-34**, pp. 2211-2212 (1987).
3. A. K. Henning and J. L. Dimauro, "Calculation of lateral distribution of interface traps along MIS channel." *Electronics Letters* **27**, pp. 1445-1447 (1991).
4. E. Fisch, A. K. Henning, and J. Walsh, "A Cerenkov microlaser." *IEEE J. Quantum Electronics* **27**, pp. 753-759 (1991).
5. E. E. Fisch, J. E. Walsh, A. K. Henning, and M. F. Kimmitt, "The semiconductor Cherenkov laser." *Nuclear Instruments and Methods in Physics Research* **A304**, pp. 679-682 (1991).
6. F. Rodriguez, A. Filimonov, A. Henning, C. Coughlin, M. Greenberg, "Radiation-induced effects in multiprogrammable pacemakers and implantable defibrillators." *Pacing and Clinical Electrophysiology* **14**, pp. 2143-2153 (1991).

7. H. F. Wei, A. K. Henning, J. Slinkman, and W. R. Hunter, "A graphical ellipsometric data reduction algorithm and its application in thin SiO₂ film measurement." *Journal of the Electrochemical Society* **139**, pp. 1783-1790 (1992).
8. X. Tian, F. E. Kennedy, Jr., J. J. Deacutis, and A. K. Henning, "The development and use of thin film thermocouples for contact temperature measurement." *Tribology Transactions* **35**, pp. 491-499 (1992).
9. A. K. Henning, T. Hochwitz, J. Slinkman, J. Never, S. Hoffman, P. Kaszuba, and C. Daghljan, "Two-dimensional surface dopant profiling in silicon using scanning Kelvin probe microscopy." *Journal of Applied Physics* **77**, pp. 1888-1896 (1995).
10. T. Hochwitz, A. K. Henning, C. G. Levey, C. P. Daghljan, J. Slinkman, "Capacitive Effects on Quantitative Dopant Profiling with Scanned Electrostatic Force Microscopes." *Journal of Vacuum Science and Technology B* **14**, pp. 457-462 (1996).
11. T. Hochwitz, A. K. Henning, C. G. Levey, C. P. Daghljan, J. Slinkman, James Never, Phil Kaszuba, Randy Wells, John Pekarik, Bob Gluck, "Imaging Dopant Profiles of Integrated Circuit Devices with the Force-Based Scanning Kelvin Probe Microscope." *Journal of Vacuum Science and Technology B* **14**, pp. 440-446 (1996).
12. A. K. Henning and T. Hochwitz, "Scanning Probe Microscopy for 2-D Semiconductor Dopant Profiling and Device Failure Analysis." *Materials Science and Engineering* **B42**, pp. 88-98 (1996).
13. A. K. Henning, J. S. Fitch, J. M. Harris, E. B. Dehan, B. A. Cozad, L. Christel, Y. Fathi, D. A. Hopkins, Jr., L. J. Lilly, W. McCulley, W. A. Weber, and M. Zdeblick, "Microfluidic MEMS for semiconductor processing." *IEEE Transactions on Components, Packaging, and Manufacturing Technology* **B21**, pp. 329-337 (1998).
14. A. K. Henning, "Improvements to a compact, pressure- and structure-based compressible gas flow model for microvalves." Submitted to *IEEE/ASME Journal of Microelectromechanical Systems*, February, 2004. Revised April, 2005.
15. A. K. Henning, "Comprehensive model for thermopneumatic actuators and microvalves." *IEEE/ASME Journal of Microelectromechanical Systems* **15**(5), pp. 1308-1318 (2006).

Refereed Conference Proceedings Articles

1. J. P. Dishaw, K. R. Kokkonen, J. A. Matthews and A. K. Henning, "Current characterization of SCR latch-up in CMOS circuits." *IEEE Transactions on Electronic Devices* **ED-30**, p. 1582 (1983).
2. A. K. Henning, N. Chan and J. D. Plummer, "Characterization and 2-D simulation of impact ionization current in MOSFETs between 77 and 300K." *IEEE Transactions on Electronic Devices* **ED-32**, p. 2543 (1985).
3. A. K. Henning, N. Chan and J. D. Plummer, "Substrate current in N-channel and P-channel MOSFETs between 77 and 300K: Characterization and simulation." *IEEE International Electron Devices Meeting, Digest of Technical Papers*, pp. 573-576 (IEEE, Piscataway, NJ, 1985).
4. A. K. Henning and J. D. Plummer, "NMOS FET gate current effects for realistic biases at 80K and 300K." *Proceedings, Symposium Low Temperature Electronics and High Temperature Superconductors* (Electrochemical Society Proceedings, Vol. **88-9**), pp. 130-135 (Electrochemical Society, Pennington, NJ, 1988).
5. A. K. Henning, "Si-SiO₂ interface degradation measurement using the floating gate technique." *Proceedings, Symposium Silicon Nitride and Silicon Dioxide Thin Insulating Films* (Electrochemical Society Proceedings, Vol. **89-7**), pp. 385-400 (Electrochemical Society, Pennington, NJ, 1989).
6. A. K. Henning, "Low temperature gate current and 'channel' hot carriers in MOS transistors." *IEEE Proceedings of the Workshop on Low Temperature Semiconductor Electronics*, pp. 109-113 (IEEE, Piscataway, NJ, 1989).

7. J. L. Dimauro and A. K. Henning, "Lateral distribution of interface states in PMOSFETs." *IEEE International Electron Devices Meeting, Digest of Technical Papers*, pp. 81-84 (IEEE, Piscataway, NJ, 1990).
8. A. Filimonov, F. Rodriguez, A. Henning, C. Coughlin, and M. Greenberg, "Effects of high-energy radiation on automatic implantable cardioverter defibrillators." *Medical Physics* **17**, p. 210 (1990)
9. A. Filimonov, F. Rodriguez, A. Henning, C. Coughlin, and M. Greenberg, "Pacemaker response to photon and electron high energy radiation." *Medical Physics* **17**, p. 210 (1990)
10. F. Rodriguez, A. Filimonov, A. K. Henning, C. Coughlin, and M. Greenberg, "Effects of high-energy radiation on AICDs and programmable pacemakers." *Proceedings, Third IEEE Symposium on Computer-Based Medical Systems*, pp. 182-189 (IEEE, Piscataway, NJ, 1990).
11. C. Hitchcock, T. Cooley, B. Fagin, and A. K. Henning, "Extension and enhancement of a small microsystem program: The Dartmouth/IBM interaction." *Proceedings, Microelectronic Systems Education Conference*, p. 233 (1990).
12. A. K. Henning, "Extraction of barrier heights in Si/Si_{1-x}Ge_x heterojunctions with MIS gates." *Electrochemical Society Extended Abstracts* **1**, p. 404 (Electrochemical Society, Pennington, NJ, 1991).
13. A. K. Henning, K. Olander, and M. J. Franklin, "A unified data acquisition and analysis environment for UNIX workstations: Northcalc." Presented at the joint ASEE-NSF technical sessions, ASEE annual meeting, Toledo, OH, June 1992.
14. H. F. Wei, A. K. Henning, J. Slinkman, and J. L. Rogers, "Modeling process-dependent thermal silicon dioxide (SiO₂) films on silicon," in *The Physics and Chemistry of SiO₂ and the Si-SiO₂ Interface 2*, eds. C. R. Helms and B. E. Deal, pp. 31-41 (Plenum, New York, 1993).
15. T. Hochwitz, A. K. Henning, C. G. Levey, C. P. Daghlian, J. Slinkman, J. Never, P. Kaszuba, R. Gluck, S. Hoffman, and M. O'Boyle, "Failure analysis using scanning Kelvin probe microscopy." *1994 IBM Failure Analysis Worldwide Technical Exchange*, Session O-5 (IBM Microelectronics, Burlington, VT, 1994).
16. A. K. Henning, T. Hochwitz, C. P. Daghlian, J. Slinkman, J. Never, P. Kaszuba, and S. Hoffman, "2D dopant profiling using scanning Kelvin probe microscopy." *1994 IBM Failure Analysis Worldwide Technical Exchange*, Session O-7 (IBM Microelectronics, Burlington, VT, 1994).
17. M. Hargrove, A. K. Henning, J. Slinkman, and J. C. Bean, "Quantum mechanical modeling of the charge distribution in a Si/Si_{1-x}Ge_x/Si p-channel FET." *IEEE International Electron Devices Meeting, Digest of Technical Papers*, pp. 735-738, (IEEE, Piscataway, NJ, 1994).
18. A. K. Henning and C. G. Levey, "Undergraduate research in micro-fabrication science and technology at Dartmouth College." *ASEE 1994 Annual Conf. Proc.*, pp. 2599-2606 (American Society for Engineering Education, Washington, DC, 1994).
19. T. Hochwitz, A. K. Henning, C. P. Daghlian, R. Gluck, R. Bolam, P. Coutu, and J. Slinkman, "DRAM failure analysis with the force-based Kelvin probe." *Int'l. Reliability Physics Symposium*, pp. 217-222 (IEEE, Piscataway, NJ, 1995).
20. T. Hochwitz, A. K. Henning, C. G. Levey, C. P. Daghlian, J. Slinkman, "Capacitive Effects on Quantitative Dopant Profiling with Scanned Electrostatic Force Microscopes." *Proceedings, Third Intl. Workshop on the Measurement and Characterization of Ultra-Shallow Doping Profiles in Semiconductors*, pp. 51.1-51.9 (American Vacuum Society, 1995).
21. T. Hochwitz, A. K. Henning, C. G. Levey, C. P. Daghlian, J. Slinkman, James Never, Phil Kaszuba, Randy Wells, John Pekarik, Bob Gluck, "Imaging Dopant Profiles of Integrated Circuit Devices with the Force-Based Scanning Kelvin Probe Microscope." *Proceedings, Third International Workshop on the Measurement and*

Characterization of Ultra-Shallow Doping Profiles in Semiconductors, pp. 47.1-47.8 (American Vacuum Society, 1995).

22. F. E. Kennedy, A. K. Henning, D. Frusescu, L. M. Caballero, X. Tian, and T. M. Cook, "Temperature sensors for detecting failure of tribological components." *Proceedings, 49th Meeting, Society for Machinery Failure Prevention Technology* (Vibration Institute, Willowbrook, IL, 1995), pp. 281-292.

23. A. K. Henning, "Effects of doping on the dynamic mechanical response of semiconductor cantilevers to electrostatic forces." In *Proceedings, Microlithography and Metrology in Micromachining* (International Society for Optical Engineering, Bellingham, WA, 1995; M. T. Postek, ed.), volume 2640, pp. 236-245.

24. J. Monberg and A. K. Henning, "Microfabricated sensors for the measurement of electromagnetic fields in biological tissues." In *Proceedings, Micromachined Devices and Components* (International Society for Optical Engineering, Bellingham, WA, 1995; R. Roop and K. Chau, eds.), volume 2642, pp. 138-148.

25. C.-L. Tsai and A. K. Henning, "Out-of-plane microstructures using stress engineering of thin films." In *Proceedings, Microlithography and Metrology in Micromachining* (International Society for Optical Engineering, Bellingham, WA, 1995; K. W. Markus, ed.), volume 2639, pp. 124-132.

26. A. K. Henning and C. G. Levey, "The Science and Technology of Micro-machines: Development of an Undergraduate Course." *Proc. Eleventh Biennial University/Government/Industry Microelectronics Symposium*, pp. 230-236 (IEEE, Piscataway, NJ, 1995).

27. A. K. Henning and M. Jett, "Dynamic Authoring and Retrieval of Textual Information: DARTEXT." *Proceedings, Dartmouth Institute for Advanced Graduate Studies (DAGS '95)*, pp. 280-290 (Birkhäuser, Boston, 1995).

28. M. J. Hargrove, C. E. Hembree, A. K. Henning, J. Slinkman, and Y. Zhang, "Calculation of carrier confinement in buried SiGe layers." Paper B3.04, presented (by M. J. Hargrove) at the *International Conference on Computational Physics: PC '97* (annual meeting of the Computational Physics Division of the American Physical Society, Aug. 25-28, 1997).

29. C.-L. Tsai and A. K. Henning, "Surface micromachined turbines." In *Proceedings, TRANSDUCERS '97: 1997 International Solid State Sensors and Actuators Conference*, pp. 829-832 (IEEE Press, Piscataway, NJ, 1997).

30. A. K. Henning, J. Fitch, E. Falsken, D. Hopkins, L. Lilly, R. Faeth, and M. Zdeblick, "A thermopneumatically actuated microvalve for liquid expansion and proportional control." In *Proceedings, TRANSDUCERS '97: 1997 International Solid State Sensors and Actuators Conference*, pp. 825-828 (IEEE Press, Piscataway, NJ, 1997).

31. A. K. Henning, "Microfluidic MEMS for semiconductor processing." In *Proceedings, 2nd Annual International Conference on Innovative Systems in Silicon*, pp. 340-349 (IEEE Press, Piscataway, NJ, 1997).

32. A. K. Henning, "Effect of semiconductor surface band pinning on scanning electrostatic force microscopy." In *Proceedings, Materials and Device Characterization in Micromachining* (International Society for Optical Engineering, Bellingham, WA, 1998; C. R. Friedrich and Y. Vladimirovsky, eds.), volume 3512, pp. 54-65.

33. A. K. Henning, "Microfluidic MEMS." In *Proceedings, IEEE Aerospace Conference*, Paper 4.906 (IEEE Press, Piscataway, NJ, 1998).

34. J. S. Fitch, A. K. Henning, E. B. Arkilic, J. M. Harris, "Pressure-based mass-flow control using thermopneumatically-actuated microvalves." In *Proceedings, Solid-State Sensor and Actuator Workshop*, pp. 162-165 (Transducers Research Foundation, Cleveland, OH, 1998).

35. A. K. Henning, J. S. Fitch, J. M. Harris, E. B. Arkilic, B. Cozad, and E. B. Dehan, "Performance of MEMS-based gas distribution and control systems for semiconductor processing." In *Proceedings, SEMICON West Workshop on Gas Distribution* (SEMI, Mountain View, CA, 1998).

36. A. K. Henning, J. M. Harris, R. Pearlstein and B. Hertzler, "Contamination reduction using MEMS-based, high-precision mass flow controllers." In *Proceedings, SEMICON West Symposium on Contamination Free Manufacturing for Semiconductor Processing* (SEMI, Mountain View, CA, 1998).
37. A. K. Henning, "Liquid and gas-liquid phase behavior in thermopneumatically actuated microvalves." In *Proceedings, Micro Fluidic Devices and Systems* (International Society for Optical Engineering, Bellingham, WA, 1998; A. B. Frazier and C. H. Ahn, eds.), volume 3515, pp. 53-63.
38. A. K. Henning, J. Fitch, J. M. Harris, E. B. Arkilic, B. Cozad, and B. Dehan, "MEMS-based gas distribution and control systems for semiconductor processing." In *Proceedings, Micromachined Devices and Components* (International Society for Optical Engineering, Bellingham, WA, 1998; P. J. French and K. Chau, eds.), volume 3514, pp. 159-170.
39. A. K. Henning, "Compact pressure- and structure-based gas flow model for microvalves." In *Proceedings, Materials and Device Characterization in Micromachining* (International Society for Optical Engineering, Bellingham, WA, 2000; Y. Vladimirsky and P. J. Coane, eds.), volume 4175, pp. 74-81.
40. A. K. Henning, B. A. Cozad, E. Lawrence, E. B. Arkilic, and J. M. Harris, "Practical aspects of micromachined gas distribution systems for semiconductor processing." In *Proceedings, Microfluidic Devices and Systems* (International Society for Optical Engineering, Bellingham, WA, 2000; C. H. Mastrangelo and H. Becker, eds.), volume 4177, pp. 251-262.
41. A. K. Henning, "Performance and Reliability of MEMS-Based Gas Distribution Devices." In *Proceedings, Gas Delivery and Analysis Symposium* (SEMI, San Jose, CA, 2001).
42. A. K. Henning, A. Zias, N. Mourlas, and S. Metz, "A MEMS-based, high-sensitivity pressure sensor for ultraclean semiconductor applications." In *Proceedings, 13th IEEE/SEMI Advanced Semiconductor Manufacturing Conference and Workshop (ASMC)*, pp. 165-168 (IEEE, Piscataway, NJ, 2002).
43. A. K. Henning, "General yield and reliability considerations for MEMS-based flow control systems." In *Proceedings, 2002 IEEE Microelectronics Reliability and Qualification Workshop (MRQW)* (The Aerospace Corp., El Segundo, CA, 2002).
44. E. Lawrence and A. K. Henning, "Long-term drift measurements in MEMS-based mass flow controllers." In *Proceedings, Reliability, Testing, and Characterization of MEMS/MOEMS II* (International Society for Optical Engineering, Bellingham, WA, 2003; R. Ramesham and D. M. Tanner, eds.), volume 4980, pp. 41-50.
45. E. D. Lawrence and A. K. Henning, "Reliability of MEMS-based mass-flow controllers for semiconductor processing." In *Proceedings, Int'l. Reliability Physics Symposium*, pp. 478-483 (IEEE, Piscataway, NJ, 2003).
46. A. K. Henning, "Improved gas flow model for microvalves." In *Proceedings, TRANSDUCERS 2003: 2003 International Solid State Sensors and Actuators Conference*, pp. 1550-1553 (IEEE Press, Piscataway, NJ, 2003).
47. A. K. Henning, S. Patel, M. Selser, and B. A. Cozad, "Factors affecting silicon membrane burst strength." In *Proceedings, Reliability, Testing, and Characterization of MEMS/MOEMS III* (International Society for Optical Engineering, Bellingham, WA, 2004; D. M. Tanner and R. Ramesham, eds.), volume 5343, pp. 145-153.
48. A. K. Henning, "Confirmation of large-periphery compressible gas flow model for microvalves." In *Proceedings, MEMS/MOEMS Components and Their Applications* (International Society for Optical Engineering, Bellingham, WA, 2004; S. W. Janson and A. K. Henning, eds.), volume 5344, pp. 155-162.
49. A. K. Henning, "Micro-pneumatic logic." In *Proceedings, ASME IMECE 2004*, Paper IMECE2004-61334 (ASME, New York, 2004).
50. A. K. Henning, "Concepts for micropneumatic and microhydraulic logic gates." In *Proceedings, Microfluidic Devices and Systems* (International Society for Optical Engineering, Bellingham, WA, 2007; I. Papautsky, ed.), volume 6465.

51. A. K. Henning, "On the reliability of thermopneumatic actuators with silicon membranes." In *Proceedings, Reliability, Testing, and Characterization of MEMS/MOEMS* (International Society for Optical Engineering, Bellingham, WA, 2007; A. Hartzell, ed.), volume 6463.
52. A. K. Henning, "Application concepts for complementary micro-pneumatic devices and circuits." In *Proceedings, Microfluidics, BioMEMS, and Medical Microsystems VI* (International Society for Optical Engineering, Bellingham, WA, 2008; W. Wang, C. Vauchier, eds.), volume 6886.
53. N. A. Amro, J. Haaheim, M. Nelson, J. Fragala, A. Henning, and J. Bussan, "Fully automated nanoscale scanning probe lithography." In *Proceedings, Technologies for Future Micro Nano Manufacturing*, Paper P24.B (Transducers Research Foundation, San Diego, CA, 2011; T. Kenny and M. A. Schmidt, eds.)
54. J. S. Fragala, A. K. Henning, R. R. Shile, N. Amro, and J. Haaheim, "High-performance, high-density tip arrays for reliable manufacturing." In *Proceedings, Technologies for Future Micro Nano Manufacturing*, Paper P29.A (Transducers Research Foundation, San Diego, CA, 2011; T. Kenny and M. A. Schmidt, eds.)
55. A. K. Henning, S. Rozhok, J. Fragala, R. Shile, and K. Ouyang, "An all-at-once factorial method to optimize dip-pen deposition of liquid protein inks." In *Proceedings, Microfluidics, BioMEMS, and Medical Microsystems XI* (International Society for Optical Engineering, Bellingham, WA, 2013; H. Becker, ed.)
56. A. K. Henning, J. Fragala, R. Shile, and P. Simao, "Piezoresistive pens for dip-pen nanolithography." In *Proceedings, Microfluidics, BioMEMS, and Medical Microsystems XI* (International Society for Optical Engineering, Bellingham, WA, 2013; H. Becker, ed.)
57. Albert K. Henning, Joseph S. Fragala, R. Roger Shile, Pam Simao, and Sergey Rozhok, "Advances in piezoresistive pens for dip-pen nanolithography." In *Proceedings of 2013 Nanomechanical Sensing Workshop (NMC2013)*, pp. 165-166 (The Printing House, Stoughton, WI, 2013).
58. B. Rajendran, A. K. Henning, B. Cronquist, and Z. Or-Bach, "Pulsed Laser Annealing: A scalable and practical technology for monolithic 3D IC." In *Proceedings, IEEE International Conference on 3D System Integration (3D IC)* (IEEE, Washington, DC, 2013).
59. A. K. Henning, B. Rajendran, B. Cronquist, and Z. Or-Bach, "Thermal Considerations for Monolithic Integration of Three-Dimensional Integrated Circuits." In *Proceedings, IEEE SOI-3D-Subthreshold Microelectronics Technology Unified Conference (S3S)*, pp. 1-2 (IEEE, Washington, DC, 2013).
60. Z. Or-Bach, B. Cronquist, Z. Wurman, I. Beinglass, and A. Henning, "Precision bonders - a game changer for monolithic 3D." In *Proceedings, IEEE SOI-3D-Subthreshold Microelectronics Technology Unified Conference (S3S)*, pp. 1-3 (IEEE, Washington, DC, 2014).
61. Z. Or-Bach, B. Cronquist, Z. Wurman, I. Beinglass, and A. K. Henning, "Modified ELTRAN®—A game changer for Monolithic 3D." In *Proceedings, IEEE SOI-3D-Subthreshold Microelectronics Technology Unified Conference (S3S)*, pp. 1-3 (IEEE, Washington, DC, 2015).

Other Publications

1. A. K. Henning, E. B. Dehan, E. B. Arkilic, and J. M. Harris, "Evaluating the use of MEMS-based gas and fluid delivery systems." *MICRO* **16**(7), pp. 117-131 (Canon Communications, Santa Monica, CA, 1998).
2. A. K. Henning, "Superconductivity and the future of electronics - The heat is on." *Directions* (Magazine of Thayer School of Engineering), Fall 1988.

INVITED CONFERENCE and WORKSHOP PRESENTATIONS

1. T. Hochwitz, A. K. Henning, C. P. Daghljan, and J. Slinkman, "Failure analysis with a Kelvin probe microscope." Presented (by T. Hochwitz) at the 20th International Symposium for Testing and Failure Analysis, November 1994.
2. A. K. Henning (Dartmouth College), M. Jett (Electronic Technical Publishing, Inc.), T. Rich (Bucknell University), and R. Lynch (DelMar), "Electronic 'Texts' for Engineering Education and Technical Training: Issues and Progress." A panel discussion for the Dartmouth Institute for Advanced Graduate Studies (DAGS '95) conference on "Electronic Publishing and the Information Superhighway", 30 May-2 June 1995, Boston, MA.
3. A. K. Henning and C. G. Levey, "The Science and Technology of Micro-machines." Presented (by A. Henning) as part of the NSF-sponsored *Project Showcase* at the ASEE Annual Conference (June 1995), Anaheim, CA.
4. A. K. Henning, "The Science and Technology of Micro-machines: Development of an Undergraduate Course and Summer Workshop. I. Overview and Curricular Details." Presented at *Intensive Short Workshop in Micro-Electro-Mechanical Systems (MEMS) Curriculum Development* (August 1995), Chicago, IL. Sponsored by NSF and the U. of Illinois at Chicago.
5. A. K. Henning and T. Hochwitz, "Scanning Probe Microscopy for 2-D Semiconductor Dopant Profiling and Device Failure Analysis." Presented (by A. K. Henning) at the *4th International Workshop on Beam Injection Assessment of Defects in Semiconductors*, June 3-6, 1996, El Escorial, Spain.
6. A. K. Henning, "Scanning Probe Microscopy for 2-D Dopant Profiling and Device Failure Analysis." Presented at the *22nd International Symposium for Testing and Failure Analysis*, November 21, 1996, Los Angeles, CA.
7. A. K. Henning, J. Fitch, J. Harris, and B. Dehan, "MEMS-based gas control for ESG distribution." Presented (by A. Henning) at the 1997 Meeting of the Institute for Environmental Science, Los Angeles, CA.
8. A. K. Henning, "Microfluidic devices for semiconductor processing." Presented at the 1997 National Symposium of the American Vacuum Society.
9. A. K. Henning, "Microfluidic MEMS." Presented at the 1997 Rocky Mountain Chapter Symposium of the American Vacuum Society.
10. A. K. Henning, "Microfluidic MEMS for semiconductor processing." Presented at the *2nd Annual IEEE International Conference on Innovative Systems in Silicon*, Austin, TX, 1997.
11. A. K. Henning, "Microfluidic MEMS." Presented at the *IEEE Aerospace Conference*, Snowmass, CO, 1998.
12. A. K. Henning, "General yield and reliability considerations for MEMS-based flow control systems." Presented at the *2002 IEEE Microelectronics Reliability and Qualification Workshop (MRQW)*, The Aerospace Corp., El Segundo, CA, 2002.
13. A. K. Henning, "Physics, technology, applications, and reliability of microvalves." Presented at *Air Force Research Laboratory Microfluidics Workshop*, University of Southern California, May 2003.
14. A. K. Henning, "Introduction to MEMS (Microelectromechanical Systems)." Day-long seminar as part of the *Society of Manufacturing Engineers Micro-Manufacturing Conference*, Boston, MA, 22 April 2008.
15. A. K. Henning, "Reliability of Microflow Devices and Systems." Presented at *2nd Annual Workshop on MEMS Testing and Reliability*, co-produced by MEMS Investor Journal and MEPTEC, San Jose, CA, 21 October 2009.
16. A. K. Henning, "The Economics of Clean Tech Startups." Presented at *California State University – East Bay, Department of Economics, Research Seminar Series*, Hayward, CA, 4 November 2009.

OTHER PRESENTATIONS

Hot carriers in silicon (device physics, measurements, and TCAD model development)

General Electric, Corporate Research Center, July 1984, Schenectady, NY.
Stanford University, Computer-Aided Design of IC Fabrication Processes conference, August 1985.
General Motors, Corporate Research Center, October 1985, Troy, MI.
Stanford University, Computer-Aided Design of IC Fabrication Processes conference, August 1986.
U. of Utah, Department of Electrical Engineering, Salt Lake City, November 1986
U. of Minnesota, Department of Electrical Engineering, Minneapolis, MN, January 1987
IBM, T. J. Watson Research Center, Yorktown Heights, NY, January 1987
Dartmouth College, Thayer School of Engineering, Hanover, NH, February 1987
U. of Massachusetts, Department of Electrical Engineering, Amherst, February 1987
U. of Vermont, Department of Electrical and Computer Engineering, Burlington, February 1987
Varian, Palo Alto, CA, March 1987
Intel, Components Research, Santa Clara, CA, March 1987
Dartmouth College, Physics Colloquium, 21 October 1988.
IBM, General Technology Division, Essex Junction, VT, 4 November 1988.
Analog Devices, Wilmington, MA, 20 September 1989.
IBM, General Technology Division, Essex Junction, VT, 8 November 1989.
Digital Equipment, Hudson, MA, 17 September 1990.
Analog Devices, Wilmington, MA, 22 August 1992.
AT&T Bell Laboratories, Murray Hill, NJ, 28 September 1992 (Host: Dr. Mark Pinto).
MIT, Dept. of EECS, VLSI Seminar, Cambridge, MA, 5 October 1993 (Organizer: Prof. James Chung).
Dartmouth College, Physics Colloquium, Hanover, NH, 27 May 1994 (Organizer: Prof. Mary Hudson).

Scanning probe microscopy applied to materials measurement, dopant profiling, and failure analysis

Sematech, Analytical Lab Managers' Working Group, Austin, TX, 10 February 1994 (Organizer: Dr. Alain Diebold).
Motorola Corporation, Advanced Process and Device Research Lab, Austin, TX, 11 February 1994 (Host: Dr. Jack Higman).
Dartmouth College, Thayer School Faculty Seminar series, Hanover, NH, May 1994 (Organizer: Dean Charles Hutchinson).
U. Vermont, Materials Science Seminar, Burlington, VT, May 1994 (Organizer: Prof. Walter Varhue).
IBM Microelectronics, Essex Junction, VT, June 7, 1994 (Host: Mr. Pepi Cadrecha).
Analog Devices, Norwood, MA, July 1994 (Host: Dr. Richie Payne).
Intel, Aloha, OR, 16 December 1994 (Host: Dr. Sean Corcoran).
Texas Instruments, Central Research Lab, Dallas, TX, 9 March 1995 (Host: Dr. Leigh Ann Files).
Sematech, Failure Analysis Forum, Phoenix, AZ, 30 March 1995. (Host: Dr. Dave Vallett, IBM).
Hewlett-Packard, Corvallis, OR, 12 June 1995 (Host: Mr. Bob Shreeve).
Dartmouth College, Thayer School Faculty Lecture Series, Hanover, NH, 9 November 1995.
University of Pennsylvania, Dept. of Electrical Engineering, Philadelphia, PA, 25 January 1996 (Host: Prof. Jay Zemel).
Stanford University, Center for Integrated Systems, Stanford, CA, 24 April 1996 (Host: Dr. Peter Griffin).

Micro-machine science, materials and fabrication technology

Creare, Inc., Hanover, NH, 20 November 1991 (Host: Dr. Javier Valenzuela).
Analog Devices, Norwood, MA, 16 June 1993 (Host: Dr. Brad Scharf).
Spelman College, Atlanta, GA, October 1994 (Host: Prof. Etta Falconer).

Morehouse College, Atlanta, GA, October 1994 (Host: Prof. Robert Dixon).
 Dartmouth Hitchcock Medical Center, October 1994 (Host: Dr. Jack Hoopes)
 Materials Science Seminar series at U. Vermont, Burlington, VT, November 1994 (Organizer: Prof. Walter Varhue).
 Raytheon Appliances Technology Center Series #10 at Amana, Iowa, 12 February 1996 (Host: Joe Adamski).
 Bay Area MEMS Journal Club, Mountain View, CA, 4 June 1997 (Host: Dr. Rolfe Anderson).
 Xerox Palo Alto Research Center, Palo Alto, CA, 9 September 1998 (Host: Dr. Chris Van de Walle).
 Eidgenössische Technische Hochschule – Zürich, Switzerland, 14 August 2002 (Host: Prof. Dr. Henry Baltes).
 Berkeley Sensors and Actuators Center, 15 March 2006 (Host: Prof. Al Pisano).
 Bay Area MEMS Journal Club, Mountain View, CA, 13 April 2006 (Host: Dr. Rolfe Anderson).
 Berkeley Sensors and Actuators Center, 3 February 2015 (Host: John Huggins).

RESEARCH GRANTS and CONTRACTS

1. “Analog Devices Career Development Professorship.” Granted October 28, 1987. PI. Funding: \$60,000 per year for four years.
2. “Thermal and Thermomechanical Behavior of Thin Solid Films in Sliding Contacts.” Office of Naval Research. Co-PI with F. Kennedy. \$68,900 for the period 1 October 1988-30 September 1989.
3. “Physical Modeling of Hot Carrier Transport Processes in CMOSFETs.” IBM General Products Division, Essex Junction, VT. PI. \$98,800 for the period 1 July 1989-30 June 1990.
4. “Surface and Interface Properties of High-Temperature Superconductors.” National Science Foundation, Division of Materials Research. PI. \$127,600 for the period 1 July 1989-30 June 1992.
5. “Physical Modeling of Hot Carrier Transport Processes in CMOSFETs-Contract Extension.” IBM General Products Division, Essex Junction, VT. PI. \$100,000 for the period 1 July 1990-30 June 1991.
6. “IBM Faculty Development Award.” PI. \$60,000 for the period 1 July 1990-30 June 1992.
7. “Physical Modeling of Hot Carrier Transport Processes in CMOSFETs”-Contract Extension. IBM General Products Division, Essex Junction, VT. PI. \$98,000 for the period 1 July 1991-30 June 1992.
8. “Support for Solid State Laboratory.” Analog Devices, Norwood, MA. PI. \$120,000 for the period 1 October 1991-30 September 1993.
9. “Supplement to Grant DMR-8914240, ‘Surface and Interface Properties of High-Temperature Superconductors’.” National Science Foundation, Research Experiences for Undergraduates Program. PI. \$10,000 for the period 1 July 1991-30 June 1992.
10. “Process-Dependent Defects and Disorder Densities in Thermal SiO₂ Films.” General User Grant, National Synchrotron Light Source, Brookhaven National Labs, Long Island, NY. PI. Free access to NSLS Beamline x24c for two weeks during October 1991. Dr. Jack Rife, Office of Naval Research, Sponsor.
11. “Laser Scanning Fluorescent Microscope.” National Institutes of Health. Co-Investigator with E. Hansen (PI). 1 October 1992 to 30 June 1993.
12. “In-situ measurement of surface temperature and contact area during sliding.” Office of Naval Research. Co-PI with F. Kennedy. \$195,036 for period 1 January 1993-31 December 1994.
13. “Biaxially Aligned YBCO Thin Films on Non-Lattice Matched Substrates.” Department of Defense, Strategic Defense Initiative Office, SBIR Program. PI, K. Goeking of Creare, Inc., Hanover, NH. Co-PI on sub-contract portion (\$80,000) with C. Levey for period 1 July 1994-30 June 1995.

14. "Three-Dimensional Microstructures by Stress Engineering of Thin Films: Formation and Characterization." Analog Devices. PI. \$20,000 for period 1 July 1993-30 June 1994.
15. "Temperature probes for detecting incipient failure of tribological components." Office of Naval Research. Co-Investigator with F. Kennedy. \$90,000 for period 1 April 1995-31 March 1996.
16. "Three-Dimensional Microstructures by Stress Engineering of Thin Films: Construction and evaluation of an electro-fluid mechanical transducer (micro-turbine)." Analog Devices, Inc. PI. \$25,000 for period 1 January 1995-30 December 1995.
17. "Fabrication of Thermocouple MOSFET Arrays." National Nanofabrication Facility (Stanford University-NSF). PI. \$10,000 for period 1 September 1995-30 June 1996.
18. "Development of Simulation Tools for Via, Contact, and Interconnect Structures and Reliability." Semiconductor Research Corporation. Co-PI with H. Frost. \$60,000 for the period 1 October 1995-30 September 1996.
19. "Three-Dimensional Microstructures by Stress Engineering of Thin Films: Construction and evaluation of an electro-fluid mechanical transducer (micro-turbine)." Analog Devices, Inc. PI. \$25,000 for period 1 January 1996-30 December 1996.
20. "Microfabricated Thermopneumatic Actuators for Use in Fluid Regulation Systems and Other Integrated Electrofluidic Circuits." Electronics Technology Office of the Defense Advanced Research Projects Agency. \$680,000 for the period 1 January 1994-30 September 1997. Lead scientist and TPOC for the period 1 January 1996-31 December 1996. PI for the period 1 January 1997 to 30 September 1997.
21. "Thermopneumatic Microvalves for Control of Refrigerant Liquids." Read-Rite Corporation. PI. \$1,000,000 for the period 1 January 1996-31 December 1996.
22. "Mesocooler." Defense Science Office of the Defense Advanced Research Projects Agency. M. Philpott, University of Illinois at Urbana-Champaign, PI. Redwood Microsystems portion: \$309,696 for the period 1 October 1997-30 September 2000. [Note: Redwood ultimately did not participate actively in this project.]
23. "An Active Combustion Control System Using Micro-Sensors and Actuators." Phase I SBIR-NASA contract. Subcontractor to Physical Sciences, Inc. (M. Miller, PI). \$19,731 for the period 7 May 1999-11 September 1999.
24. "Biomolecule Nanoarray Fabrication Methods and Apparatus." Phase II NIH-NHGRI contract 2R44HG002978-02. Co-investigator with NanoInk, Inc. (Nabil Amro, PI). Responsible for piezoresistive and thermo-active probe design, process design, processing, test, and characterization.
25. "Novel MEMS Pressure Sensor." Phase I SBIR-NSF contract. Subcontractor to Wyoming Silicon, LLC (Z. Gray and T. Hochwitz, PI). \$8,000 for the period 1 January 2008 to 31 December 2008.
26. "Scanning Probe Epitaxy." Phase I DARPA-MTO contract. Subcontractor to Northwestern University (Chad A. Mirkin, PI). Responsible for probe design, process design, processing, test, and characterization of Tip Based Nanofabrication program devices (T. Kenny, program manager).
27. "Novel MEMS Pressure Sensor." Phase I SBIR-NSF award #IIP-0740424. Subcontractor to Wyoming Silicon, LLC (T. Hochwitz, PI). \$8,000 for the period 1 January 2008 to 31 December 2008.
28. "Cryogenic MEMS Pressure Sensor." Phase I SBIR-NASA award #08-1 X7.03-9931. Subcontractor to Wyoming Silicon, LLC (Z. Gray, PI). \$15,000 for the period 1 January 2009 to 30 June 2009.
29. "Refrigeration Microvalve." Phase I SBIR-NSF award #IIP-0945983. Subcontractor to Wyoming Silicon, LLC (Z. Gray, PI). \$15,000 for the period 1 January 2010 to 30 December 2010.

EQUIPMENT GRANTS

1. “An Interdisciplinary Measurement and Computational Laboratory Environment.” Hewlett Packard Foundation, 1 June 1988. PI. \$140,000.
2. Awarded electronic and materials fabrication equipment through the IBM (Essex Junction, VT) Technical Gifts Program. PI. Approximate value, \$50,000, 30 June 1989.
3. “Completion of a Rapid Prototyping Facility.” National Science Foundation, CISE Program in Research Instrumentation NSF 89-48. Co-PI with B. Fagin and C. Hitchcock. \$104,625.
4. “Electronic Materials Measurement and Simulation Laboratory Improvement.” National Science Foundation, Instrumentation and Laboratory Improvement Program, NSF 88-90. PI. \$47,000 for the period 1 April 1990-31 March 1992.
5. Awarded equipment from Eaton Corporation (MA). PI. Approximate value, \$5,000, Spring 1990.
6. “Acquisition of a Scanning Electron Microscope for Imaging, Analysis, and E-beam Lithography.” PI, with C. Daghlian. National Science Foundation, Engineering Research Equipment Grant Program. \$75,000.
7. Awarded integrated circuits from National Semiconductor Corporation (CA). PI. \$5,000, Summer 1990.
8. Awarded an atomic force microscope from IBM-Essex Junction, VT, for silicon dislocation, defect, and doping profile studies. PI, with C. Daghlian. Approximate value, \$200,000. Fall 1995 (On loan beginning Fall 1992).
9. Awarded polysilicon and TEOS oxide CVD deposition systems for the Solid State Lab, by Analog Devices. PI. Approximate value, \$57,000. Fall 1992.
10. “Interdisciplinary instruction with HP 700 Series workstations: Data acquisition, visualization, and distributed supercomputing.” PI. Hewlett Packard Company. \$400,000 for period 1 September 1992-31 August 1993.

INSTRUCTIONAL GRANTS

1. “Undergraduate Curriculum Development in Micro-machine Science and Fabrication Technology.” National Science Foundation. PI. \$130,000 for period 1 April 1994 -30 September 1995.
2. “Support for the Summer Undergraduate Workshop in Micro-machine Science and Fabrication Technology.” AT&T Foundation. PI. \$20,000 for the period 1 April 1994-31 October 1995.

RESEARCH SUPERVISION

Doctoral Degree Students

Huafeng Wei Ph.D. June 1992. “Modeling process-dependent gate dielectrics for silicon devices.”

Todd Hochwitz Ph.D. September 1995. “Measurement of surface dopant densities with the force-based scanning Kelvin probe.”

Chia-Lun Tsai Ph.D. September 1997. “Formation of three-dimensional microstructures by stress engineering of thin films.”

Michael Hargrove Ph.D. June 1999. “Characterization and modeling of the charge distribution in Si/Si_{1-x}Ge_x/Si P-channel MOSFETs.”

Master's Degree Students

Andrew B. Nye III M.S. 1989. “Development of processes to deposit thin films of a buffer layer, superconductor, insulator, and metal to make superconductive electronic devices on silicon substrates.”

Judith L. Dimauro (now Judith L. Sarkis) M.S. 1989. "A study of interface state generation in PMOSFETs using the charge-pumping technique."

Eric D. Overton M.E. 1989. "Software and hardware Monte Carlo simulations of electron flow in bulk silicon."

David J. Carter M.S. 1990. "A vacuum deposition system for laser ablation and ion beam processing of superconducting and insulating thin films."

Bin Liu M.S. 1990. "Simulation of electron flow in bulk silicon: The convolution approach."

Haroon Chaudhri M.S. 1991. "Physical modeling of the hot carrier effects in MOSFETs."

Fabio Rodriguez M.S. 1991. "Effects of high-energy radiation on automatic, implantable cardioverter defibrillators (AICDs) and programmable pacemakers."

Jian-Qi Tan M.S. 1993. "Superconductor thin film deposition and FET device fabrication."

Sumit Dhanda M.S. 1993. "Convolution approach to the simulation of charge transport in silicon."

Craig Hill M.S. 1995. "Analysis and improvements of integrated circuit yields limited by gate conductor etch defects."

Michael Hargrove M.S. 1994. "Self-consistent solution of the coupled Schrödinger and Poisson equations applied to quantum well heterostructures."

Louis Caballero M.S. 1994. "Development of a thin film thermocouple array."

Baccalaureate Students

Andrew Wells A.B. '89. "Semiconductor measurement software."

Jian-Qi Tan A.B. '90. "Capacitance measurement software," and "Linear voltage ramp hardware for quasi-static capacitance measurements."

James Di Carlo A.B. '91. "Raster scanning electronics for laser ablation of high- T_c thin films," and "SiGe Poisson-Schrödinger numerical equation solver."

Edward Truex A.B. '91. "Raster scanning electronics for laser ablation of high- T_c thin films."

Rachel Batto A.B. '90. "Lock and entry accounting system for Solid State Laboratory."

Peter Caress A.B. '91. "Interactive mesh manipulation for finite element mesh generator."

Arif Irfanullah A.B. '91. "Parallel architectures and Monte Carlo simulation of electron flow in silicon."

Peter Caress A.B. '91. "Parallel architectures and finite element simulation of electron flow in silicon."

Herbert Anderson A.B. '91. "Design and construction of a resist spinner for photolithography."

Adam Payne, Yale B.S. '91. "High-temperature superconducting thin-film deposition and characterization."

Amina Rage B.E. '90. "Mass-flow control of atmospheric oxidation and diffusion furnaces."

Steve Kovacs A.B. '92. "Parallel architectures and convolution simulation of electron flow in silicon."

Karen Daniels A.B. '94. "Carousel target holder for in situ multi-layer deposition of thin-film high-temperature superconductor, and characterization of films using SEM."

Luis Paz-Galindo A.B. '93. "Examination of fluid flow in micro-channels."

Mulumba Kiwanuka-Natigo A.B. '92. "Computer modeling of fluid flow through microchannels."

Sohan de Mel, Vassar College A.B. '92. "Modifications and characterization of a vacuum leak detector."

Navaid Farooqi, Vassar College A.B. '92. "IEEE-488 control for capacitance vs. voltage measurements."

Michelle Maurer, Smith College A.B. '93. "Laser ablation temperature monitor software."

Alison Spencer, Amherst College A.B. '92. "Automated resistance vs. temperature measurement," and "Improvements to laser ablation raster control."

Teressa Trusty, Stanford University B.S. '95. "Studies of thin-film, high-temperature superconductors."

R. Jed Buchanan A.B. '93. "High-temperature superconductor deposition closed-loop temperature control."

Joseph Lin A.B. '93. "Capacitance measurements in thin-film high- T_c superconducting capacitors."

Sanjeev Dugar A.B. '93. "Capacitance measurements in thin-film high- T_c superconducting capacitors."

Wayne Bantner A.B. '92. "Fabrication of a laminar fluidic amplifier on silicon."

Nicholas Mourlas A.B. '92. "Fabrication of micron size Rayleigh jets through micro-machining."

Todd Cook A.B. '93. "Switchable thermocouple array."

Ian Czaja A.B. '94. "Design, construction, and characterization of a liquid phase oxide deposition system."

Noble Ekajeh A.B. '93. "Growth and measurement of thin oxides."

Erika Graham A.B. '93. "Effect of rapid thermal processes on growth of thin oxides on silicon."

Jing Yan, Yale B.S. '93. "High- T_C devices and film deposition."
April Whitescarver '96. "Studies of silicon wafer bonding."
Geoff Zawtock A.B. '94. "Scanning Kelvin probe microscopy."
Krista Plaisted '97. "Development of WWW tools and documents for MEMS-related work at Dartmouth."
Geoff Dolan A.B. '95. "Micro-fluidic devices and logic."
James Monberg A.B. '95. "Micro-antenna design and fabrication."
Kara Relyea A.B. '98. "Micro-fluidic ring oscillators."
Susanna Leng A.B. '98. "Micro-fluidic ring oscillators."

COURSES TAUGHT

Thayer School of Engineering, Dartmouth College

Engineering Sciences 22 - Systems. Core class in the undergraduate major. Linear systems course directed primarily at advanced sophomores. Introduced end-of-course group project and presentation. Introduced concepts of chaos and neural networks. Developed fluids demonstration, including transition from linear to turbulent flow. Developed fluids lab (water drop as a chaotic system). Introduced journal method for homework evaluation, including verbal examination based on journal work. Upgraded laboratory equipment and laboratories to digitally-controlled HPIB instruments. Migrated course materials for accessibility using WWW. Introduced use of Matlab and DT-VEE (HP's LabView-equivalent environment).

Engineering Sciences 184 - Semiconductor Theory and Devices. Advanced undergraduate and graduate elective course.

Engineering Sciences 194 - Semiconductor Device and Materials Fabrication. Advanced undergraduate and graduate elective course. Designed process flow and mask set for four-mask NMOSFET process. Led lab exercise fabrication of NMOSFETs and related devices. Introduced principles of statistical design of experiments.

Engineering Sciences 65 - Science and Technology of Micro-machines. Development funded by NSF, Division of Undergraduate Education, Course and Curriculum Development Program. Course materials available using WWW. Combination of in-house laboratory exercises and out-of-house design projects (fabrication at the Microelectronics Center of North Carolina using the MUMPs process).

Engineering Sciences 87/88 - Undergraduate Investigations/Honors Thesis. Supervised ten undergraduates in for-credit research activities.

Additional Teaching Responsibilities. *Engineering Sciences 63 - Science of Materials.* Core class in the undergraduate major. Taught undergraduate laboratories in microfabrication materials and characterization related to this course. *Engineering Sciences 21 - Introduction to Engineering.* Project advisor for five undergraduate groups. *Engineering 196/295 - Engineering Design Methodology/B.E. Project.* Advised B.E. candidates on a variety of industrially-driven research projects. *Technology 7 - Freshman Seminar.* Led guest lectures related to microfabrication materials and devices for sections on "The Materials Revolution", and "Artificial People from Clay to Computers."

Beyond Dartmouth College: SemiZone (<http://www.semizone.com>)

Microflow Devices. (Completed June, 2002) *From the 2002 Course Description:* This 40-hour online course covers the device physics, underlying technology, and applications of Microflow Devices. These devices represent a subset of MEMS, lying at the intersection of Fluid Mechanics and Microfabrication Science and Technology. In the broadest sense, they encompass the more sharply-defined field of Microfluidics. Microfluidics represents the intersection of Microflow Devices, and Biology, wherein biologically significant fluids are sensed and manipulated.

Because of the sharp growth in Microfluidics over the past ten years, however, that subfield has grown beyond the scope of what can comfortably be covered through a single Semizone course. As a consequence, this course will provide foundations for Microfluidics, through presentation of fluid mechanics and microstructures topics. However, topics specific to microfluidics, such as the behavior of biological fluids, or motive forces such as electro-osmosis or electro-phoresis, will not be discussed. Since the lead time for MEMS technology to reach the marketplace appears to be between 5 and 15 years, and given the acceleration in Microflow Device development starting around 1990, we expect to see many new products hitting the market in the next five years. Such devices include gas distribution and control products for use in the manufacture of semiconductor integrated circuits. The course will have significant emphasis on this important aspect of Microflow Device Technology. Examples of other applications will be drawn from the automotive (pressure sensors), printing (inkjet printheads), battery, aerospace (microsatellite thrusters), and chemical engineering fields.

HONORS AND AWARDS

Analog Devices (Inc.) Career Development Professor, 1987-1991
IBM Faculty Development Award, 1990-1992
Senior Member, IEEE, 2007

CONSULTING (Before 2013)

Intel Corporation, Santa Clara, CA 95051: Characterized integrated circuit latch-up and capacitance phenomena (10/82- 4/83).
Spectra, Inc., Hanover, NH 03755: Microdynamic device process integration (1990).
Dean Technology, Inc., Lebanon, NH 03766: Microfabrication of fluid systems (1990).
Creare, Inc., Hanover, NH 03755: Thin film etching and ferroelectrics (10/94-12/94).
Hewlett-Packard Corporation, Corvallis, OR 97330-4299: Application of scanning probe microscopy to semiconductor dopant profiling and failure analysis (6/95).
Skyline Ventures, Palo Alto, CA 94303-3002: MEMS-related technology assessment (9/09).

COMMITTEES

Thayer School Professional Fellows Program (April 1988)
Thayer School Phasing (Summer 1988)
Department of Engineering Sciences Undergraduate Curriculum (October 1988-90)
Graduate Admissions (August 1989-91)
Faculty Advisory, Project NORTHSTAR (September 1989-1993)
Graduate Core Curriculum, Chair. Solicited broad inputs from faculty and students in an attempt to develop a consensus for graduate curriculum change, over a two year period (1/90-9/92).
Electron Microscope Facility Advisory (July 1992-1995)
E.E. Just Fellowship Program Faculty Advisory (July 1992-June 1993)
Thayer School Faculty External Relations Advisory (Summer 1992-1995)

PROFESSIONAL MEMBERSHIPS AND ACTIVITIES

Member, Sigma Xi (not current)
Member, IEEE (Senior Member, 2007)
Member, ASEE (not current)
Member, Electrochemical Society (not current)
Journal Article Reviewer: *IEEE Transactions on Electron Devices*, *Electron Device Letters*, *Transactions on Components, Packaging, and Manufacturing Technology*, and *Journal of Microelectromechanical Systems*; *ASEE Journal of Engineering Education*; Elsevier *Applied Surface Science*, and *Sensors and Actuators A*; Springer *Microfluidics and Nanofluidics*; Institute of Physics *Journal of Micromechanics and Microengineering*, *Semiconductor Science and Technology*, and *Smart Materials and Structures*.

Proposals Reviewer, NSF Division of Undergraduate Education, NSF Division of Materials Research, DOE Laboratory Technology Research Program, NSF Division of Engineering Centers and Education, NSF Division of Engineering/SBIR Reviews (including 2007 Microfluidics Panel).

Book Reviewer, Ronald A. Rohrer and Michael L. Reed, Introductory Applied Circuit Analysis for Electrical and Computer Engineers. (Prentice Hall, Upper Saddle River, NJ: 1997)

Book Reviewer, Richard M. Reis, Tomorrow's Professor: Preparing for Academic Careers in Science and Engineering. (IEEE Press, Piscataway, NJ: 1997)

Book Contributor, Sheila Tobias and Jacqueline Raphael, The Hidden Curriculum: Faculty-Made Tests in College Science. (Plenum Press, New York: 1997)

Session Chair, Electrochemical Society Meeting, Chicago, IL (October 13, 1988)

Program Committee and Session Chair, IEEE Workshop on Low Temperature Electronics (U. of Vermont, August 1989)

Program Committee and Session Chair, Dartmouth Institute for Advanced Graduate Studies conference on 'Electronic Publishing and the Information Superhighway' (Boston, MA, 30 May-2 June 1995).

Member, Industrial Advisory Board, Air Conditioning and Refrigeration Center (An NSF Industry-University Cooperative Research Program), Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign, 1 January 1996-31 December 1997.

Attendee, NIST-ATP Workshop on Microsystems and Nanosystems. Albuquerque, NM, January 1998.

Program Committee, SPIE Micromachining and Microfabrication Symposium, Materials and Device Characterization in Micromachining (Santa Clara, CA, September 1998, 1999 and 2000).

Program Committee, SPIE Micromachining and Microfabrication Symposium, Reliability, Testing, and Characterization of MEMS/MOEMS (Santa Clara, CA, September 2001; San Jose, CA, January 2003-2005).

Session Co-Chair (replacement), Transducers 2003, Boston, MA (June 2003).

Conference Co-Chair and Chair, SPIE Micromachining and Microfabrication Symposium, MEMS/MOEMS Components and their Applications (San Jose, CA, January 2004-2013).

Symposium Co-Chair, SPIE MOEMS-MEMS Micro & Nanofabrication Symposium, (San Jose, CA, January 2006-2007). Member of Symposium Steering Committee (2006-2007).

Symposium Chair, SPIE MOEMS-MEMS Micro & Nanofabrication Symposium, (San Jose, CA, January 2008-2009). Member of Symposium Steering Committee (2008-2013).

Invited Participant, NSF Workshop on Control and System Integration of Micro- and Nano-Scale Systems (Prof. Ben Shapiro, U. Maryland; NSF, Arlington, VA, March 2004).

Guest Editor, Sensors and Materials, Special Issue on Microvalves (MY, Tokyo, Japan, 2006).

Participant, MEMS Summit (Stanford, CA, 2010).

Member, Dartmouth College Physics and Astronomy Alumni Advisory Board (2012-Present).

ADVISING

Academic advisor to thirty-two freshmen, 1987-1995

Academic advisor to eight entering graduate students, 1988-1991

Cluster Associate, Independent Residences, Fall 1989-Fall 1990

Class of '95 Engineering Sciences advisor

Faculty advisor, Society of Black Engineers, July 1992-September 1993

COMMUNITY SERVICE AND ACTIVITIES

Singing. Member, Dartmouth Glee Club, 1973-77. Member, Dartmouth Aires, 1973-77. Lead (Sir Joseph Porter), *HMS Pinafore*, Dartmouth Repertory Production, 1979. Member, Stanford Mendicants, 1979-1981. Member, San Francisco Symphony Chorus, 1981-82. Member, Handel Society Chorus, 1987-1994. Member, Full Circle Chorale, 1994-1995. Member, Oratorio Society (Palo Alto, CA), Winter 1997, Fall 2006-Present.

Volunteer. Loma Prieta (CA) Chapter, Sierra Club: Executive Committee, Member (1983-85), Chair (1985-87). Mentor, MentorNet [<http://www.mentornet.net>] (1997-2007). Treasurer (1999-2001) and Board member (2001-

2002), Friends of the Palo Alto High School Choirs. Treasurer and Board member (2003-2005), Palo Alto High School Theatre Boosters. Dartmouth Alumni Association of Silicon Valley: Board member (2005-2009); Monthly meeting organizer (2006); President (2007-2009). Invited talk: "The Ludington Dunes: A Personal History"; given before A Few Friends for the Environment of the World, Ludington, MI, March 2016.

Volunteer science teacher. Marion Cross School, Norwich, VT: Kindergarten (AY 1989-1990), two visits; 1st grade (AY 1990-1991), two visits; 1st, 2nd, grades AY 1992-1993), six visits [through December 31, 1992 -- led four-week, eight-hour unit on levers]. Led two science units, four weeks each (one hour each week), on sound and electricity, February-March 1993. Led 4th grade group on number theory and simple geometry, using ancient Babylonian and Greek approaches as examples, April-May 1994. Led three sessions in each of two 5th classes, on algebra and the relation between simple systems and the equation of a straight line, November 1994. Computer consultant, Walter Hays Elementary School, Palo Alto [CA] Unified School District, (1996-97). Advanced high school physics tutor, October 2005-2006.

Sports instruction. Cross-country ski instructor, Ford Sayre (Hanover, NH) Ski Program, Winter 1991, 1992. Norwich (VT) Recreation Council: Assistant coach, 1st grade boys'-girls' soccer, Fall 1993. Head coach, 3rd/4th grade girls' basketball, Fall-Winter 1993-94. Head coach, 2nd grade boys'-girls' soccer, Fall 1994. Referee, soccer, Fall 1994. Head coach, 5th grade girls' basketball, Fall-Winter 1994-95. Assistant coach, 3rd-4th grade boy's soccer, Fall 1995. Assistant coach, 3rd-4th grade boy's basketball, Fall-Winter 1995-96. Palo Alto (CA) YMCA: Coach, 4th-5th boys' basketball, Winter 1997. Palo Alto (CA) Little League: Assistant Coach, SF Chronicle baseball team, Spring 1997. Palo Alto (CA) YMCA: Coach, 4th-5th boys' basketball, Winter 1998. Palo Alto (CA) Little League: Assistant Coach, Townshend & Townshend baseball team, Spring 1998. Palo Alto (CA) YMCA: Coach, 6th-8th boys' basketball, Winter 1999.