

Benjamin Shapiro

PERSONAL INFORMATION

General Information

Benjamin Shapiro, Ph.D.

Associate Professor (as of 2006)

Fischell Department of Bioengineering (50%) and the Institute for Systems Research (50%)

Member of the Maryland Nano Center, the Greenebaum Cancer Center, and the Applied Math and Scientific Computation (AMSC) program

University of Maryland at College Park, MD 20742, benshap@umd.edu, (301) 405-4191

Education

Ph.D. in Control and Dynamical Systems, **California Institute of Technology** (June 1999).

Thesis Advisor: Dr. Richard Murray.

Bachelor of Science in Aerospace Engineering (with highest honors),

Georgia Institute of Technology (September 1995).

Employment Background

Associate Professor	Fischell Department of Bioengineering , University of MD Institute for Systems Research (ISR) , University of MD	50% 50%	present – Jan 2010
Sabbatical	Center for Nanoscale Science and Technology (CNST), at National Institute for Standard and Technology (NIST) Advanced Technology Center (ATC), at National Institutes of Health (NIH)	50% 50%	Jan 2010 – Jan 2009
Associate Professor	Aerospace Engineering , University of Maryland Institute for Systems Research (ISR) , University of MD	50% 50%	Jan 2009 – April 2006
Assistant Professor	Aerospace Engineering , University of Maryland Institute for Systems Research (ISR) , University of MD	50% 50%	April 2006 – June 2000
Instructor [#]	Control and Dynamical Systems, California Institute of Technology	100%	Aug – Dec 1999
Visiting Instructor [#]	Aerospace and Mechanical Engineering, Cornell University	100%	Aug – Dec 1997
Visiting Researcher	United Technologies Research Center and Pratt & Whitney, United Technologies Corporation	100%	Summers of 1996/7

[#] Taught an introductory controls course for senior undergraduates and first year graduate students

RESEARCH INTERESTS

My group's research combines advanced control theory with micro/nanoscale science. My group was the first to demonstrate feedback control methods for microfluidic systems, and this topic has now become a new field of research with ongoing contributions from my group and from others.

Likewise, we have developed and experimentally validated control methods, as well as *in-vivo* modeling and optimal design techniques, for the field of magnetic drug targeting. In magnetic drug targeting, magnets are used to focus magnetized therapy (chemotherapy, nano-therapeutics,

magnetized stem cells, etc) to patient disease locations – to tumors, infections, blood clots, or diabetic wounds. We have shown that smart control can dramatically improve magnetic targeting.

For both research thrusts above, my group has carried out the whole research spectrum from initial application ideas to basic-science theory (modeling, simulations, design, and optimization) and experimental validation (including validation in animal and human autopsy experiments with collaborators). I also have results in modeling and control of lab-on-a-chip electrowetting, model-reduction of heat-transfer in micro-chip electronics, modeling and measurement of micro-friction, modeling and optimization of microscale conjugated polymer ('conducting plastics') actuation, and measuring spatial-distribution of genes (DNA) and gene expression (mRNA) across animal and human tissue samples. Further details are available at: www.controlofmicrobio.umd.edu .

My prior PhD work at Caltech and United Technologies was on optimal control of jet engines.

HONORS AND AWARDS

The most prestigious awards are **bolded**.

- HA1. Image/video of the month for the magnetic drug targeting community (demonstrating our invention that a simple magnetic system can push/inject magnetic materials), featured online (<http://www.magneticmicrosphere.com/>) June 2012.
- HA2. **Cover of IEEE Control Systems Magazine**, twice (April 2012 and June 2012).
- HA3. **Plenary talk** (and program committee member) for the International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale: 3M-NANO 2012, Xi'an, China, Aug/Sept 2012.
- HA4. **Scientific Advisory Board** for Pulse Therapeutics, a magnetic drug targeting start-up company, 2011 – present.
- HA5. Advisor for 1st place (tie) Capstone team. Team lead by John Lin (a former undergrad student in my group). 2010.
- HA6. Won 3rd place for poster in 8th International Conference on the Scientific and Clinical Applications of Magnetic Carriers, Rostok Germany, 2010.
- HA7. **Fulbright Scholar (to Germany)**. 2009.
- HA8. Member **Japan-America Frontiers of Engineering Symposium**, organized by the **National Academy of Engineers** and the **Japan Science and Technology Agency**, "that brings together 100 outstanding engineers (ages 30-45) from U.S. companies, universities, and government labs to discuss leading-edge research and technical work across a range of engineering fields". At symposium, won 2nd place for best research presentation.
- HA9. Outstanding Professor AIAA award. Each year students in the Aerospace department vote for the "... *professor deemed to be the best teacher in courses over the past academic year*". 2007-2008.
- HA10. Nominated by **Maryland Science Academy** for Outstanding Young Engineer award. 2007.
- HA11. Plenary talk for NanoDay at the University of Maryland. 2007.
- HA12. **Briefed JASONS summer study** on "Control in Micro-Fluidic Systems". The JASONS are a group of 40-50 tenured faculty with high credentials, including Nobel laureates, who advise government agencies on emerging technology research areas. 2007.
- HA13. Selected for membership in Council of Outstanding Young Engineering Alumni, Georgia Institute of Technology. Membership is reserved for alumni of the engineering

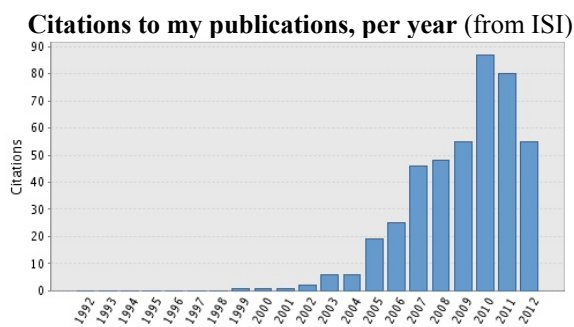
- college under forty years of age who have distinguished themselves through professional practice and or service to GT, the profession, or society-at-large. 2006.
- HA14. Outstanding Professor AIAA award. 2005-2006.
 - HA15. Invited by the National Science Foundation to be a part of the **US delegation for US-Japan Young Researcher in Nano Program**, in US March 2006, in Japan Oct 2006.
 - HA16. Won best paper in session award for conference paper (C33): Armani et al, ISIC-MED, 2005.
 - HA17. Patent awarded invention of the year in 2004 at the University of Maryland within the Physical Science category. One winner was chosen in each of the six categories by the Office of Technology Commercialization and by an external review process (P16).
 - HA18. Awarded ‘rainmaker’ status by the Vice President of Research at the University of Maryland for securing major contract and grant support. 2004.
 - HA19. Conference paper chosen as best presentation at conference: G.Barrett et al. ASME, 2004 (conference paper C44).
 - HA20. Patent invention of the year finalist, one of three in 2003 (for patent P17).
 - HA21. **NSF CAREER award**, for “Feedback Control of Micro-Fluidic Packets and the Bio-Particles Within Them”, 2003.

PUBLICATIONS

Publications include 1 edited book, 5 book chapters, 39 peer-reviewed journal articles, 63 peer-reviewed conference publications or presentations, and 18 filed patents. (Of these, 4 articles, 4 conference publications, and 1 patent are based on prior research before arriving at UMD.)

Below, **my students and post-docs are bolded**, jointly advised staff are underlined, and their status at the time of submission is marked by a superscript *u* for undergraduates, *m* for masters, *g* for graduate/PhD students, and *p* for post-docs. I have worked closely with experts in a variety of application domains. Such *collaborators are italicized* and include Depireux (speech/ hearing, UMD), Dormer (physician, Oklahoma Univ.), Emmert-Buck (clinician/ pathologist, NIH), Fourkas (nonlinear optics, UMD), Rutel (radiology, Oklahoma Univ.), Smela (soft-MEMS, UMD), and Waks (nano-photonics, UMD). Remaining authors whose role is not explicitly marked (e.g. F.Yesilkoy, M.Tangrea) are the students, post-docs, and research scientists of the italicized collaborators. Typically, first authors contributed the most effort. The author or authors who intellectually supervised the research are marked by an asterix * and usually appear last.

As of July 2012, my journal publications have been cited 432 times (according to ISI Web of Knowledge, not including self-citations) and all my publications, so including book chapters and conference articles, have been cited 886 times (according to Google Scholar which counts self-citations)¹. My *h-index*² is 12 according to ISI and 16 according to Google, and my *m*-



¹ ISI does not count books, book chapters, conferences, and patents. Google Scholar includes these publications but does not differentiate self versus non-self citations. Both indexes are available on my web-page at: <http://www.controlofmicrobio.umd.edu/publications/index.html>

² The largest number *h* such that *h* publications have at least *h* citations.

index (same as *h*-index but only for papers authored at the University of Maryland) is 11 (via ISI) or 14 (via Google Scholar).

Books

- B1. J. Gorman*, **B.Shapiro***, co-editors of “Control of MEMS to Atoms”, *Springer Verlag*, ISBN (1441958312), 2012 edition (16 Dec 2011).

Chapters in Books

All book chapters, except BC1 with Peckerar, were peer-reviewed.

- BC1. F.Yesilkoy, C.Ropp^g, Z.Cummins^g, R.Probst^p, *E.Waks*, **B.Shapiro**, *M.Peckerar**, “New Applications and Emerging Technologies”, editor M.Feldman, chapter in “Nanolithography: The Art of Fabricating Nanoelectronic, Nanophotonic, and Nanobiologic Devices and Systems”, *Woodhead Publishing LTD, Cambridge*. In-press.
- BC2. M.Armani^g, Z.Cummins^g, J.Gong, P.Mathai^p, R.Probst^p, C.Ropp^g, *E.Waks*, S.Walker^g, **B.Shapiro***, “Feedback Control of Micro-Flows”, chapter for “Control of MEMS to Atoms”, editors *J.Gorman* and **B.Shapiro**, *Springer Verlag*, ISBN (1441958312), 2012 edition (16 Dec 2011).
- BC3. A.Komace^p, R.Lee, A.Nacev^g, R.Probst^p, A.Sarwar^p, *I.Rutel*, *D.Depireux*, *K.Dormer*, **B.Shapiro***, “Putting Therapeutic Nanoparticles Where They Need To Go By Magnet Systems Design and Control”, editor TK Thanh, chapter in “Magnetic Nanoparticles: From Fabrication to Biomedical and Clinical Applications”, *CRC Press/ Taylor & Francis*, Jan 2012.
- BC4. M.Armani^g, R.Probst^p, **B.Shapiro***, “Fabricating Micro-Fluidic Channels Using a Vinyl Sign Plotter”, chapter for “Lab on a Chip Technology: Fabrication and Microfluidics”, editors K.E.Herold, A.Rasooly, *Caister Academic Press*, Aug 2009.
- BC5. **B.Shapiro***, “Control of Microfluidics” chapter entry for “Encyclopedia of Microfluidics and Nanofluidics”, editor D. Li. *Springer Verlag*, Sep 2008.

Journal Articles

Published and Accepted

- J1. *J.B.Freund**, **B.Shapiro**, “Transport of Particles by Magnetic Forces and Cellular Blood Flow in a Model Microvessel”, *Physics of Fluids*, vol 24, pg 051904-1 – 12, published online 29 May 2012.
- J2. A.Nacev^g, R.Probst^p, S.Kim^m, A.Komace^p, A.Sarwar^p, R.Lee^u, *D.Depireux*, *M.Emmert-Buck*, **B.Shapiro***, “Towards Control of Magnetic Fluids in Patients: Directing Therapeutic Nanoparticles to Disease Locations”, *IEEE Control System Magazine (CSM)*, vol 32, no 3, pg 32-74, June 2012. [Invited tutorial paper. Got journal cover.]
- J3. R.Probst^p, Z.Cummins^g, C.Ropp^g, *E.Waks*, **B.Shapiro***, “Flow Control of Small Objects On-Chip: Manipulating Live Cells, Quantum Dots, and Nano-Wires”, *IEEE Control System Magazine (CSM)*, vol 32, no 2, pg 26-53, April 2012. [Invited tutorial paper. Got journal cover.]

- J4. **A.Komae**^p, **B.Shapiro**^{*}, “Steering a Ferromagnetic Particle by Optimal Magnetic Feedback Control”, *IEEE Transactions on Control Systems Technology*, vol 20, issue 4, pg 1011-1024, July 2012.
- J5. **A.Sarwar**^p, *A.Nemirovski*, **B.Shapiro**^{*}, “Optimal Halbach Permanent Magnet Designs for Maximally Pulling and Pushing Nanoparticles”, *Journal of Magnetism and Magnetic Materials (JMMM)*, vol 324, issue 5, pg 742-754, March 2012.
- J6. **A.Nacev**^g, **S.Kim**^m, J.Rodriguez-Canales, M.Tangrea, **B.Shapiro**^{*}, *M.R.Emmert-Buck*^{*}, “A Dynamic Magnetic Shift Method to Increase Nanoparticle Concentration in Cancer Metastases: A Feasibility Study using Simulations on Autopsy Specimens”, *International Journal of Nanomedicine (IJN)*, vol 2011:6, pg 2907-2923, Nov 2011.
- J7. **M.Armani**^{g3}, M.Tangrea, **B.Shapiro**^{*}, *M.Emmert-Buck*^{*}, *E.Smela*^{*}, “Quantifying mRNA Levels Across Tissue Sections with 2D-RT-qPCR”, *Analytical and Bioanalytical Chemistry*, vol 400, pg 3383-93, July 2011.
- J8. **R.Probst**^p, **J.Lin**^u, **A.Komae**^p, **A.Nacev**^g, **Z.Cummins**^g, **B.Shapiro**^{*}, “Planar Steering of a Single Ferrofluid Drop by Optimal Minimum Power Dynamic Feedback Control of Four Electromagnets at a Distance”, *Journal of Magnetism and Magnetic Materials (JMMM)*, vol 323, pg 885-896, April 2011.
- J9. **A.Nacev**^g, C.Beni, *O.Bruno*, **B.Shapiro**^{*}, “The Behaviors of Ferromagnetic Nanoparticles In and Around Blood Vessels under Applied Magnetic Fields”, *Journal of Magnetism and Magnetic Materials (JMMM)*, vol 323, issue 6, pg 651-668, March 2011.
- J10. **R.Probst**^p, **B.Shapiro**^{*}, “Three-Dimensional Electrokinetic Tweezing: Device Design, Modeling, and Control Algorithms”, *Journal of Micromechanics and Micro-engineering*, vol 21, no 2, article-number 027004, Jan 2011.⁴
- J11. **P.Mathai**^p, *A.Berglund*, *A.Liddle*, **B.Shapiro**^{*}, “Simultaneous Positioning and Orientation of a Single Nano-Object by Flow Control”, *New Journal of Physics*, vol 13, pg 013027, Jan 2011.
- J12. **A.Nacev**^g, C.Beni, *O.Bruno*, **B.Shapiro**^{*}, “Magnetic Nanoparticle Transport within Flowing Blood and into Surrounding Tissue”, *Nanomedicine*, vol 5, no 9, pg 1459-1466, Nov 2010.
- J13. C.Ropp^g, **Z.Cummins**^g, **R.Probst**^p, S.Qin, *J.T.Fourkas*, **B.Shapiro**^{*}, *E.Waks*^{*}, “Positioning and Immobilization of Individual Quantum Dots with Nanoscale Precision”, *NanoLetters*, 10(11), pg 4673-4679, Oct 2010.
- J14. C.Ropp^g, **R.Probst**^g, **Z.Cummins**^g, R.Kumar, *A.Berglund*, *S.Srinivasan*, *E.Waks*^{*}, **B.Shapiro**^{*}, “Manipulating Quantum Dots to Nanometer Precision by Control of Flow”. *NanoLetters*, 10(7), pg 2525-2530, May 2010.
- J15. **M.Armani**^g, J.Rodriguez-Canales, J.Gillespie, M.Tangrea, H.Erickson, *M.R.Emmert-Buck*, **B.Shapiro**^{*}, *E.Smela*^{*}, “2D-PCR: A Method of Mapping DNA in Tissue Sections” *Lab on a Chip*, vol 9, pg 3526-3534, Dec 2009.
- J16. **S.Walker**^g, *R.H.Nochetto*, **B.Shapiro**^{*}, “Electrowetting with Contact Line Pinning: Computational Modeling and Comparisons with Experiments”, *Physics of Fluids*, vol 23, issue 10, article 102103, Oct 2009.
- J17. M.E.Piyasena, R.Newby, **B.Shapiro**^{*}, *E.Smela*^{*}, “Electroosmotically Driven Micro-Fluidic Actuators”. *Sensors and Actuators B: Chemical*, vol 141, issue 1, pg 263-269, Aug 2009.
- J18. **B.Shapiro**^{*}, “Towards Dynamic Control of Magnetic Fields to Focus Magnetic Carriers to Targets Deep Inside the Body”, *Journal of Magnetism and Magnetic Materials (JMMM)*, vol 321, no 10, pg 1594-1599, May 2009. [Invited submission.]

³ M.Armani was co-advised with E.Smela for 2D-PCR, but not for particle control or magnetic targeting.

⁴ Downloaded over 250 times in its first month on the JMM website.

- J19. **J.West**^m, *T.Otero*, **B.Shapiro**^{*}, *E.Smela*^{*}, “Chronoamperometric Study of Conformational Relaxation in PPy(DBS)”, *Journal of Physical Chemistry. B*, vol 113, no 5, pg 1277-1293, Jan 2009.
- J20. X.Wang^g, **B.Shapiro**^{*}, *E.Smela*^{*}, “Development of a Model for Charge Transport in Conjugated Polymers”, *Journal of Physical Chemistry. C*, vol 113, no 1, pg 382-401, Jan 2009.
- J21. M. Tomizuka^{*}, L.A. Bergman, **B.Shapiro**, R.Shoureshi, B.F. Spencer, Jr., “Bio-Inspired Autonomous Engineered Systems”, *Smart Structures and Systems*, vol 3, no 4, Oct 2007.
- J22. **P.Mathai**^g, **B.Shapiro**^{*}, “Interconnection of Subsystem Reduced-Order Models in the Electrothermal Analysis of Large Systems”, *IEEE Transactions on Components and Packaging Technologies*, vol 30, issue 2, pg 317 – 329, June 2007.
- J23. **B.Shapiro**^{*}, *E.Smela*, “Bending Actuators with Maximum Curvature and Force and Zero Interfacial Stress”, *Journal of Intelligent Material Systems and Structures (JIMSS)*, vol 18, pg 181-186, Feb 2007. [Invited for special issue.]
- J24. **S.Walker**^g, **B.Shapiro**^{*}, “Modeling the Fluid Dynamics of Electro-Wetting On Dielectric (EWOD)”, *Journal of Microelectromechanical Systems (JMEMS)*, vol 15, no 4, pg 986-1000, Aug 2006.
- J25. **M.Armani**^g, **S.Chaudhary**^g, **R.Probst**^g, **B.Shapiro**^{*}, “Using Feedback Control of Micro-Flows to Independently Steer Multiple Particles”, *Journal of Microelectromechanical Systems (JMEMS)*, vol 15, no 4, pg 945-956, Aug 2006.
- J26. **S.Chaudhary**^g, **B.Shapiro**^{*}, “Arbitrary Steering of Multiple Particles Independently in an Electroosmotically Driven Microfluidic System”, *IEEE Transactions on Control Systems Technology*, vol 14, issue 4, pg 669-680, July 2006.
- J27. M.Christophersen, **B.Shapiro**^{*}, *E.Smela*^{*}, “Characterization and Modeling of PPy Bilayer Microactuators. Part 1: Curvature”, *Sensors and Actuators B: Chemical*, vol 115, pg 596-609, June 2006.
- J28. **M.Armani**^u, **S.Chaudhary**^g, **R.Probst**^g, **S.Walker**^g, **B.Shapiro**^{*}, “Control of Micro-Fluidic Systems: Two Examples, Results, and Challenges”, *International Journal of Robust and Nonlinear Control*, vol 15, issue 16, pg 785-803, Nov 2005. [Invited paper]
- J29. **S.Walker**^g, **B.Shapiro**^{*}, “A Control Method for Steering Individual Particles Inside Liquid Droplets Actuated by Electrowetting”, *Lab on a Chip*, vol 12, no 1, pg 1404 – 1407, Oct 2005.
- J30. **B.Shapiro**^{*}, “Workshop on Control of Micro- and Nano-Scale Systems”, *IEEE Control Systems Magazine*, vol 25, pg 82-88, April 2005.
- J31. **I.Treise**^m, **N.Fortner**^u, **B.Shapiro**^{*}, *A.Hightower*, “Efficient Energy Based Modeling and Experimental Validation of Liquid Filling in Planar Micro-Fluidic Components and Networks”, *Lab on a Chip*, vol 5, no 3, pg 285-297, Jan 2005.
- J32. X. Wang^g, *E.Smela*^{*}, **B.Shapiro**^{*}, “Visualizing Ion Currents in Conjugated Polymers” *Advanced Materials*, vol 16, no 18, pg 1605–1609, Sept 2004.
- J33. **TW.Lin**^m, A.Modafe, **B.Shapiro**^{*}, *R.Ghodssi*^{*}, “Characterization of Dynamic Friction in MEMS-Based Microball Bearings”, *IEEE Transactions on Instrumentation and Measurement*, vol 53, no 3, pg 839-846, June 2004.
- J34. **B.Shapiro**^{*}, H.Moon, *R.Garrell*, *CJ.Kim*, “Equilibrium Behavior of Sessile Drops under Surface Tension, Applied External Fields, and Material Variations”, *Journal of Applied Physics*, vol 93, no 9, pg 5794-5811, May 2003.
- J35. **B.Shapiro**^{*}, “Creating Compact Models of Complex Electronic Systems: An Overview and Suggested Use of Existing Model Reduction and Experimental System Identification Tools”, *IEEE Transactions on Components and Packaging Technologies*, vol 26, no 1, pg 165-172, March 2003. [Invited paper]

- J36. **B.Shapiro**, *K.Willcox**, “Analyzing Mistuning of Bladed Disks by Symmetry and Reduced-Order Aerodynamic Modeling”, *Journal of Propulsion and Power*, vol 19, no 2, pg 307-311, March-April 2003.
- J37. **B.Shapiro*, “Solving for Mistuned Forced Response by Symmetry”, *Journal of Propulsion and Power*, vol 15, no 2, pg 310-325, March-April 1999.**
- J38. **B.Shapiro*, “Symmetry Approach to Extension of Flutter Boundaries via Mistuning”, *Journal of Propulsion and Power*, vol 14, no 3, pg 354-366, May-June 1998.**
- J39. **B.Shapiro*, B.T. Zinn, “High Frequency Nonlinear Vibrational Control”, *IEEE Transactions on Automatic Control*, vol 42, no 1, pg 83-90, Jan 1997.**

Name	Journal Summary	Impact Factor	Number Papers
Advanced Materials	Material science journal.	11.3	1
Analytical and Bioanalytical Chemistry	Chemistry journal.	3.7	1
IEEE Control System Magazine (CSM)	Broad-scope/survey journal for the control community.	2.5	3
IEEE Transactions on Automatic Control	Theory, design, and application of control systems.	3.1	1
IEEE Transactions on Components and Packaging Technologies	Packaging and integration of MEMS, electronic, photonic & other systems.	1.4	2
IEEE Transactions on Control Systems Technology	Design, realization, & operation of control systems.	2.0	2
IEEE Transactions on Instrumentation and Measurement	Development and use of novel measurement techniques.	1.2	1
International Journal of Nanomedicine (IJN)	Nanotechnology in diagnostics, therapeutics, and drug delivery.	4.5	1
International Journal of Robust and Nonlinear Control	A control journal – analysis and design for uncertain systems.	1.8	1
Journal of Applied Physics	Applied physics journal.	2.2	1
Journal of Intelligent Material Systems and Structures (JIMSS)	Materials journal, focused on smart structures.	1.8	1
Journal of Physical Chemistry, B.	Chemistry. B: Soft condensed matter & biophysical chemistry	4.4	1
Journal of Physical Chemistry, C.	C: Physical chemistry of nano-particles and nano-structures.	4.7	1
<i>Journal of Propulsion and Power</i>	<i>Aerospace journal: propulsion and power (e.g. jet engines).</i>	0.9	3
Journal of Magnetism and Magnetic Materials (JMMM)	Magnetism, magnetic materials. The magnetic drug targeting community publishes here.	1.4	4
Journal of Microelectro-mechanical Systems (JMEMS)	Advances in micro systems: fab, modeling, and experiments.	2.7	2
Journal of Micromechanics and Microengineering (JMM)	Also advances in micro systems (JMEMS and JMM overlap).	2.5	1

Lab on a Chip	“Laboratory on a chip”: micro/nano results on and off chips.	6.9	3
NanoLetters	Research in nano-science and nano-technology.	12.8	2
Nanomedicine	Nanotherapy journal, aimed at clinicians.	7.7	1
New Journal of Physics	Open-access physics journal.	3.6	1
Physics of Fluids	Fluid dynamics: covers theory, computation, and experiments.	2.0	2
Sensors and Actuators B: Chemical	Chemical sensors & actuators.	3.3	2
Smart Structures and Systems	Smart structures: e.g. sensors/actuators, health monitoring, etc	1.3	1
Five year impact factors taken from ISI Web of Knowledge and updated on Jan 2012. The JPP journal where my prior PhD work was published is marked in <i>gray italics</i> .			

Conference Presentations and Publications

Page and volume numbers in conference proceedings are provided when available. C59 to C63 are from my PhD studies. All presentations/publications were in peer-refereed conferences.

- C1. **B.Shapiro**^{*}, “Placing, and Immobilizing Nanoscopic Objects On-Chip with Nanoscale Precision by Flow Control”, *International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale (3M-NANO)*, Xi’an China, 29 Aug – 1 Sept 2012. [Invited plenary speaker.]
- C2. **Z.Shen**^p, **K.Chen**^u, **B.Shapiro**^{*}, “Measuring Low Concentrations of Fluorescent Magnetic Nanoparticles by Fluorescence Microscopy”, *International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale (3M-NANO)*, Xi’an China, 29 Aug – 1 Sept 2012.
- C3. **A.Nacev**^g, **S.H.Kim**^m, *J.Rodriguez-Canales*, *M.A.Tangrea*, **B.Shapiro**^{*}, *M.R.Emmert-Buck*, “Improving the Treatment of Hypoxic Breast Cancer Liver Metastases by using Dynamic Magnetic Shift”, *9th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, Minneapolis, MN, 22-26 May 2012. [Invited talk.]
- C4. **A.Sarwar**^p, *R.Lee*^u, *D.Depireux*, **B.Shapiro**^{*}, “Treating Tinnitus by Magnetic Pushing of Therapy: Rat Experiments”, *9th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, Minneapolis, MN, 22-26 May 2012. [Invited talk.]
- C5. **A.Sarwar**^p, *A.Nemirovski*, **B.Shapiro**^{*}, “Optimal Permanent Magnet Halbach Designs for Deeper Tissue Targeting”, *9th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, Minneapolis, MN, 22-26 May 2012. [poster]
- C6. **Z.Shen**^p, **A.Nacev**^g, **B.Shapiro**^{*}, “Fluorescence and Reflectance Co-Registered 3D Tissue Imaging System based on a Cryostat”, *9th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, Minneapolis, MN, 22-26 May 2012. [poster]
- C7. *D.Depireux*^{*}, *R.Lee*^u, **A.Sarwar**^p, **B.Shapiro**, “Drug Delivery to the Inner Ear of Rats using Magnetically Steered Nanoparticles”, *mid-winter meeting of the Associate for Research in Otolaryngology*, San Diego, CA, 25-29 Feb 2012.
- C8. **A.Komae**^p, **B.Shapiro**^{*}, “Magnetic Steering of a Distributed Ferrofluid Spot Towards a Deep Target with Minimal Spreading”, *50th IEEE Conference on Decision and Control and European Control Conference(CDC-ECC)*, pg 7950-5, Orlando FL, 12-15 Dec 2011.

- C9. C.Ropp^g, Z.Cummins^g, R.Probst^p, R.Kumar, S.Qin, J.Fourkas, S.R.Raghavan, **B.Shapiro**^{*}, E.Waks^{*}, “Selective Nano-Assembly of Single Quantum Dots on a Two Dimensional Surface”, *IEEE Nano 2011*, pg 1547-50, Portland Oregon, 15-18 Aug 2011.
- C10. **B.Shapiro**^{*}, “Deterministic Nanoscale Control: Flow Control of Cells and Quantum Dots to Nanometer Precision”, *2011 American Control Conference (ACC2011)*, part of “Control of Nanoscale Self-Assembly Tutorial Session” WeA18 (organized by M.Grover and **B.Shapiro**), San Francisco CA, June 29-July 1, 2011. [Presentation, no paper.]
- C11. R.Probst^p, Z.Cummins^g, **B.Shapiro**^{*}, “3-Dimensional Electrokinetic Tweezing for Micro and Nano Assembly”, *IEEE International Symposium on Assembly and Manufacturing (ISAM)*, pg 1-6, Tampere Finland, 25-27 May 2011.
- C12. M.Armani^p, Sam Sawhney, S.Kim^m, J.Rodriguez-Canales, J.Lin^u, R.Probst^p, A.Nacev^g, A.Komae^p, M.Tangrea, F.Cuttitta, **B.Shapiro**^{*}, M.Emmert-Buck^{*}, “Targeting Deep-Tissue Tumors Using Magnetic Nanoparticles”, *6th Annual Nano-Bio Think-Tank*, NCI, Bethesda MD, 17 May 2011.
- C13. A.Nacev^g, S.Kim^m, J.Rodriguez-Canales, M.A.Tangrea, **B.Shapiro**^{*}, M.Emmert-Buck^{*}, “Dynamic Magnetic Shifting: Simulating the Targeting of Insulated Breast Cancer Liver Metastases”, *Frontiers in BioMagnetic Particles II*, Charleston S.Carolina, 17 May 2011. [Published abstract, no paper.]
- C14. R.Probst^p, **B.Shapiro**^{*}, “3-Dimensional Electrokinetic Tweezing”, *6th IEEE International Conference on Nano/Micro Engineered and Molecular Systems (6th IEEE-NEMS 2011)*, pg 675-680, Kaohsiung, Taiwan, 20-23 Feb 2011.
- C15. C.Ropp^g, R.Probst^g, Z.Cummins^g, R.Kumar, L.Li, J.Fourkas, S.R.Raghavan, **B.Shapiro**^{*}, E.Waks^{*}, “Nano-Manipulation and Assembly of Preselected Single Quantum Dots Along a Two Dimensional Surface”, *2010 IEEE Nanotechnology Materials and Devices Conference (NMDC 2010)*, Monterey, California, 12-15 October 2010. [Page numbers not available.]
- C16. **B.Shapiro**^{*}, “Control of Small Things: From Steering Cells and Quantum Dots to Orienting Nanowires on Chip”, *IDETC/CIE ASME*, session MNS 6-1, Montreal Canada, 15-18 Aug 2010. [Oral presentation, no paper.]
- C17. A.Komae^p, **B.Shapiro**^{*}, “Steering a Ferromagnetic Particle by Magnetic Feedback Control: Algorithm Design and Validation”, *American Control Conference (ACC)*, pg 6543 – 6548, Baltimore, MD, June 30 - July 2, 2010.
- C18. **B.Shapiro**^{*}, K.Dormer, I.Rutel, “A Two-Magnet System to Push Therapeutic Nano-Particles”, *8th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, in *American Institute of Physics, Conference Proceeding Series 1311*, vol 1, pg 77-88, Rostock Germany, 25-29 May 2010. [Poster for same reason as C19 but was then invited to be published in the AIP conference proceedings.]
- C19. Z.Cummins^g, K.Dormer, A.Komae^p, J.Lin^u, A.Nacev^g, R.Probst^g, I.Rutel, **B.Shapiro**^{*}, “Manipulating Ferrofluid at a Distance: Magnets Pushing and Dynamic Control”, *8th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, Rostok Germany, 25-29 May 2010. [Since C20 was invited as an oral presentation, this one was presented as a poster.⁵]
- C20. A.Nacev^g, C.Beni, O.Bruno, **B.Shapiro**^{*}, “Predicting the Behavior of Magnetic Particles In-Vivo: Simulations versus Experiments”, *8th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, Rostok Germany, 25-29 May 2010. [Invited as oral presentation. Published abstract but no paper.]
- C21. A.M.Rosenberg, C.K.Zoon, E.S.Clark, M.Armani^g, **B.Shapiro**, E.Smela, J.C.Hanson, J.Rodriguez-Canales, M.R.Emmert-Buck, M.A.Tangrea^{*}, “Assessment of microRNA

⁵ Won 3rd place in poster competition, out of ~300 posters.

- Expression in Two-Dimensional Histopathological Fields of Breast Cancer”, *American Association for Cancer Research (AACR)*, Washington DC, April 17-21, 2010. [Poster.]
- C22. **K.Dormer***, S.Po, K.Chen, B.Scherlag, **I.Rutel**, K.Nguyen, S.Kyriyavar, B.Grady, **B.Shapiro**, X.Gao, X.Du, D.Bourne, KM.Fung, R.Kopke, “Magnetic Targeting of Therapeutics”, *First Global Congress on NanoEngineering for Medicine and Biology, Proceedings ASME (NEMB2010)*, paper NEMB2010-13022, pg 85 – 86, Houston TX, 7-10 Feb 2010.
- C23. **M.Armani^g**, J.Rodriguez-Canales, **M.Emmert-Buck**, **B.Shapiro***, **E.Smela***, “Mapping DNA in Tissues: A Spatially Resolved Array Technique with Integrated Tissue Transfer, DNA Extraction, Amplification and Detection”, *Lab-on-a-Chip World Congress*, San Francisco, 6-7 Aug 2009. [Page numbers not available.]
- C24. **B.Shapiro***, **I.Rutel**, **K.Dormer**, “Therapeutic Nano-Particles Magnetic Injector System (MIS)”, *Frontiers in the Characterization and Control of Magnetic Carriers*, Clemson University, 26-28 April 2009. [Invited talk⁶, published abstract but no paper.]
- C25. M.E.Piyasena, **B.Shapiro***, **E.Smela***, “A New EAP Based on Electroosmotic Flow: Nastic Actuators”, *SPIE EAPAD 2009*, vol 7287, pg 7259 – 7287, San Diego CA, 8-12 March 2009.
- C26. **M.Santos^{g*}**, **B.Shapiro**, “Relating Satellite Coverage to Orbital Geometry”, *AIAA/ AAS conference, in Orbital Dynamics, Perturbations, and Stability session*, paper AIAA-2008-6609, Honolulu Hawaii, 18-21 Aug 2008.
- C27. **B.Shapiro***, **R.Probst^g**, **H.E.Potts**, **D.A.Diver**, **A.S.Lubbe**, “Dynamic Control of Magnetic Fields to Focus Drug-Coated Nano-Particles to Deep Tissue Tumors”, *7th International Conference on the Scientific and Clinical Applications of Magnetic Carriers*, Vancouver BC, 21-24 May 2008. [Invited talk & published abstract, no paper.]
- C28. **B.Shapiro***, **R.Probst^g**, **H.E.Potts**, **D.A.Diver**, **A.S.Lubbe**, “Control to Concentrate Drug-Coated Magnetic Particles to Deep-Tissue Tumors for Targeted Cancer Chemotherapy”, *46th IEEE Conference on Decision and Control*, pg 3901-3906, New Orleans LA, 12-14 Dec 2007.
- C29. **P.Mathai^g**, **N.Martins***, **B.Shapiro***, “On the Detection of Gene Network Interconnections using Directed Mutual Information”, *Information Theory and Applications Workshop*, pg 274 – 283, La Jolla, CA, 29 Jan – 2 Feb 2007.
- C30. **M.Armani^g**, **S.Chaudhary^g**, **R.Probst^g**, **B.Shapiro***, “Steering and Trapping Multiple Particles by Feedback Flow Control: Theory and Experiments”, *Applied Physics Society (APS) March meeting*, paper BAPS.2006.K26.013, Baltimore MD, March 2006.
- C31. X.Wang^g, **B.Shapiro***, **E.Smela***, “Modeling Charge Transport in Conjugated Polymers”, *SPIE’s Annual International Symposium on Smart Structures and Materials (EAPAD)*, vol 6168, San Diego, CA, Feb 27 – 2 March 2006.
- C32. **P.Mathai^g**, **B.Shapiro***, **D.DeVoe**, S.Sivanesan, “Modeling and Simulation of Ampholyte Behavior in 2-Dimensional Isoelectric Focusing”, *2005 ASME International Mechanical Engineering Congress on Exposition*, paper IMECE2005-81854, Orlando FL, 5-11 Nov 2005.
- C33. **M.Armani^u**, **S.Walker^g**, **B.Shapiro***, “Modeling and Control of Electrically Actuated Surface Tension Driven Micro-Fluidic Systems”, *Joint 2005 International Symposium on Intelligent Control & 13th Mediterranean Conference on Control and Automation (2005 ISIC-MED)*, pg 131-138, Cyprus, Greece, 27-29 June 2005.⁷
- C34. **S.Fanning^m**, Y.Liu, M.Christophersen, M.Duerkop, **E.Smela***, **B.Shapiro***, “Polypyrrole/Gold Bilayer Characterization”, *EAPAD 2005*, vol 5759, pg 292-301, San Diego, CA, March 2005.

⁶ None of the 3 authors (Shapiro, Rutel, Dormer) could attend, so **R.Probst^g** presented the results.

⁷ Won best paper in session award.

- C35. **M.Armani**^u, **S.Chaudhary**^g, **R.Probst**^g, **B.Shapiro**^{*}, "Using Feedback Control and Micro-Fluidics to Steer Individual Particles", *MEMS 2005*, pg 855-858, Miami FL, 30 Jan - 3 Feb, 2005.⁸
- C36. X. Wang, *E.Smela*^{*}, **B.Shapiro**^{*}, "Modeling Ion Transport in Conjugated Polymers", *Second World Congress on Biomimetics, Artificial Muscles, and Nano-Bio*, Albuquerque NM, 6-8 Dec 2004. [Page numbers not available.]
- C37. **B.Shapiro**^{*}, *E.Smela*^{*}, "Ion and Electron Transport in PPy Conjugated Polymers (Conducting Plastic) Microactuators", *ASME International Mechanical Engineering Congress*, Anaheim, CA, 13 - 19 Nov 2004. [Shapiro invited speaker. Page numbers not available.]
- C38. X.Wang^g, **B.Shapiro**^{*}, *E.Smela*^{*}, "Modeling Conjugated Polymer Actuators: Understanding Ion Transport", *ASME International Mechanical Engineering Congress*, Anaheim, CA, 13 - 19 Nov 2004. [Shapiro invited speaker. Page numbers not available.]
- C39. X.Tan, A.Modafe, R.Hergert, N.Ghalichechian, **B.Shapiro**, *J.S.Baras*, and *R.Ghodssi*^{*}, "Vision-Based Microtribological Characterization of Linear Microball Bearings", *ASME/STLE International Joint Tribology Conference: Special Symposia on Contact Mechanics*, paper TRIB2004-64334, Long Beach, CA, 24-27 Oct 2004.
- C40. **M.Armani**^u, **S.Chaudhary**^g, **R.Probst**^g, **B.Shapiro**^{*}, "Micro Flow Control Particle Tweezers", *μTAS 2004*, Malmo Sweden, 26-30 Sept 2004. [Page numbers not available.]
- C41. **B.Shapiro**^{*}, "Summary of the NSF Workshop on Control and System Integration of Micro- and Nano-Scale Systems", *American Control Conference (ACC)*, Boston, MA, June 30 – July 2, 2004. [Invited presentation.]
- C42. X.Wang^g, **B.Shapiro**^{*}, *E.Smela*^{*}, "Understanding Ion Transport in Conjugated Polymers", *International Conference on Synthetic Metals (ICSM) 2004*, Wollongong, New South Wales, Australia 28 June - 2 July 2004. [Invited paper.]
- C43. *G.Barrett*^{*}, *E.Smela*, **B.Shapiro**, *S.Fanning*^m, L.H.Oh, M.S.Furst, J.Wallace, P.Sheth, N.Thakor, A.Natarajan, "The Development of a MEMS Based System for the Treatment of Urinary Incontinence", *19th ASME Nanomechanics Conference*, Reno, Nevada, 18 May 2004. [Page numbers not available.]⁹
- C44. *G.Barrett*^{*}, *E.Smela*, **B.Shapiro**, L.H.Oh, J.Wallace, N.Thakor, and A.Natarajan, "Nanotechnology: From Nanobots to Reality and Back Again", *G.Barrett invited speaker at Nanotechnology In Biomedical Innovation, Feynman Beltway Series*, Tysons Corner, VA, 6 May 2004.
- C45. **M.Manion**^u, N.Sergeev, **I.Treise**^m, **B.Shapiro**^{*}, *A.Rasooly*^{*}, "Hand-held Microfluidics Multi-channel Immunosensor for Detection of Multiple Microbial Toxins Simultaneously", *2004 Food and Drug Administration (FDA) Science Forum*, Washington DC, 18-19 May 2004.¹⁰
- C46. **S.Walker**^g, **B.Shapiro**^{*}, "Modeling the Fluid Dynamics of Electro-Wetting on Dielectric (EWOD)", *2004 Nanotech*, Boston, MA, 7-11 March 2004. [Page numbers not available.]
- C47. X.Wang^g, *E.Smela*^{*}, **B.Shapiro**^{*}, "Understanding Ion Transport in Conjugated Polymers", *SPIE's 11th Annual International Symposium on Smart Structures and Materials (EAPAD)*, vol 5385, pg 146-154, San Diego, CA, 15-18 March 2004. [Smela was an invited speaker.]

⁸ Chosen for oral presentation. Only 5% of the 750 submitted abstracts were accepted as oral presentations.

⁹ Chosen as best presentation at the conference.

¹⁰ Won the "Clear Science Communication Award" out of 412 competing posters. It is now displayed in the FDA commissioners office.

- C48. **B.Shapiro***, “Flow Control on the Micro-Scale for Bio-Chemical Sensing and Actuation”, *42nd AIAA Aerospace Sciences Meeting and Exhibit*, Reno, Nevada, 5-8 Jan 2004. [Page numbers not available.]
- C49. **B.Shapiro***, “Control Challenges in Micro Fluidic Systems and Nanoscale Transport Phenomena”, *42nd IEEE Conference on Decision & Control (CDC 2003)*, vol 3, pg 2126 – 2131, Maui, Hawaii, 9-12 Dec 2003.
- C50. **S.Chaudhary^g**, **B.Shapiro***, “Arbitrary Control of Multiple Particles in a Microfluidic Device”, *International Mechanical Engineering Congress and Exposition*, Washington DC, 16-21 Nov 2003. [Page numbers not available.]
- C51. **B.Shapiro***, **S.Walker^g**, **N.Fortner^u**, “Modeling Surface Tension under Applied Fields: Energy Methods, Stokes Flow, and Level Sets”, *7th US National Congress on Computational Mechanics (USNCCM)*, Albuquerque, New Mexico, July 2003. [Invited talk, with paper (but no page numbers available).]
- C52. **N.Fortner^u**, **B.Shapiro***, “Equilibrium and Dynamic Behavior of Micro Flows Under Electrically Induced Surface Tension Actuation Forces”, *2003 International Conference on MEMS, NANO, and Smart Systems (ICMEMS)*, pg 197-202, Banff, Alberta, Canada, July 2003. [Invited talk.]
- C53. **N.Fortner^u**, **B.Shapiro***, *A.Hightower*, “Modeling and Passive Control of Channel Filling for Micro Fluidic Networks with Thousands of Channels”, *American Institute of Aeronautics and Astronautics (AIAA) 33rd AIAA Fluid Dynamics Conference and Exhibit*, paper AIAA-2003-4015, Orlando, FL, June 2003.
- C54. Y.Liu, L.Oh, **S.Fanning^m**, **B.Shapiro**, *E.Smela**, “Fabrication of Folding Micro-Structures Actuated by Polypyrrole/Gold Bilayer”, *Transducers 2003*, vol 1, pg 786-789, Boston, MA, June 2003.
- C55. **B.Shapiro***, H.Moon, *R.Garrell*, *CJ.Kim*, “Modeling of Electrowetted Surface Tension for Addressable Microfluidic Systems: Dominant Physical Effects, Material Dependences, and Limiting Phenomena”, *Micro-Electro-Mechanical Systems (MEMS2003)*, pg 201-205, Kyoto, Japan, Jan 2003.
- C56. **B.Shapiro***, “Creating Reduced-Order Models for Electronic Systems: An Overview and Suggested Use of Existing Model Reduction and Experimental System Identification Tools”, *THERMES 2002, Thermal Challenges in Next Generation Electronic Systems*, vol 26, no 1, pg 165-172, Santa Fe, Jan 2002.
- C57. **D.Lin^m**, D.Wendland, **B.Shapiro***, *R.Ghodssi**, “Measurement of Rolling Friction for MEMS Applications”, *IUVSTA 15th International Vacuum Congress (IVC-15), AVS 48th International Symposium (AVS-48), 11th International Conference on Solid Surfaces (ICSS-11)*, San Francisco, CA, Oct 28-Nov 2, 2001.
- C58. **B.Shapiro***, “Model Reduction of Models for MEMS Friction Dynamics”, *Dynamics of Micro and Nanoscale Devices and Materials, mini-symposium held at the SIAM Pacific Rim Dynamics meeting*, Maui, Hawaii, Aug 2000 [Invited talk, no proceedings.]
- C59. **B.Shapiro***, **N.Fortner^u**, *A.Hightower*, “Surface Tension Flows in Bent Micro-Channels: An Energy Minimization Theory versus Experiment”, *Applied Physics Society, Nano-Scale Physics Applications session*, Seattle, March 2000. [Presentation, no published proceedings.]
- C60. **B.Shapiro***, “Characterizing Mode Localization by Symmetry”, *Joint Propulsion Conference 34th AIAA/ASME/SAE/ASEE*, Cleveland, OH, July 1998. [With paper in published proceedings.]
- C61. **B.Shapiro***, B.D.Coller, “Characterizing Optimal Mistuning by Symmetry Arguments”, *IEEE Conference on Control Applications*, pg 901-906, Hartford, CT, Oct 1997. [With paper in published proceedings.]

- C62. **B.Shapiro***, “Optimal Mistuning: An Analysis of Flutter Boundaries in Turbomachines”, *Joint Propulsion Conference 33rd AIAA/ASME/SAE/ASEE*, Seattle, WA, July 1997. [With paper in published proceedings.]
- C63. J. Doyle*, J.A. Primbs*, **B.Shapiro***, V. Nevistic*, “Nonlinear Games: Examples and Counter-examples”, *IEEE Conference on Decision and Control*, vol 4, pg 3915-3920, Kobe, Japan, Dec 1996. [With paper in published proceedings.]

Software

- S1. **B.Shapiro***, “Mistuning Analysis by Symmetry Techniques (MAST)”, 1999. Available at: <http://www.controlofmems.umd.edu/tools/tools.html>

Patents

Of the 18 submitted patent applications, only those that are publicly available on the USPTO site are shown below. Patents that have been allowed have **bolded** titles¹¹.

- P5. *I.Weinberg**, **B.Shapiro***, “Magnetic-Assisted Tumor Confinement Methodology and Equipment”. Patent filed 7 Nov 2012.
- P7. **B.Shapiro***, *I.Rutel*, “**Devices, Systems, and Methods for Magnetic-Assisted Therapeutic Agent Delivery**”. Patent filed 24 Feb 2010
- P8. *M.Emmert-Buck**, *M.Armani^g*, *E.Smela**, **B.Shapiro***, *M.Tangrea*, *J.Rodriguez-Canales*, *R.Chauqui*, *J.Gillespie*, “Methods and Systems for Purifying, Transferring, and/or Manipulating Nucleic Acids”. Patent filed 29 Jan 2010
- P9. **B.Shapiro***, *M.Emmert-Buck**, “Methods And Systems For Using Therapeutic, Diagnostic or Prophylactic Magnetic Agents”. Patent filed 19 May 2009.
- P12. **B.Shapiro***, **R.Probst^g**, *A.Lubbe*, *H.Potts*, *D.Diver*, “Methods and Systems for Magnetic Focusing of Therapeutic, Diagnostic or Prophylactic Agents to Deep Targets”. Patent filed 11 Dec 2008
- P15. **B.Shapiro***, *E.Smela*, “**Electrically driven microfluidic pumping for actuation**”. *Patent issued 28 April 2009*.
- P16. **B.Shapiro***, *P.Abshire*, *E.Smela**, *D.Wirtz*, “Cell Canaries for Biochemical Pathogen Detection”. Patent filed 30 Aug 2005.¹²
- P17. **B.Shapiro***, **S.Chaudhary^g**, **M.Armani^u**, **R.Probst^m**, “**Arbitrary and Simultaneous Control of Multiple Objects in Microfluidic Systems**”. *Patent issued 26 Jan 2010*.¹³
- P18. **B.Shapiro***, “**Rotors with Mistuned Blades**”. *Patent issued 30 Nov 1999*. [Patent is licensed by Pratt & Whitney, a subsidiary of United Technologies Corporation.]

Licensing of Patents

Two of my patents are already licensed. Six more are currently being negotiated for licensing.

¹¹ It can take up to 5-6 years for the US patent and trademark office (USPTO) to process a filed application.

¹² Won invention of the year within Physical Sciences at Univ. of MD in 2004. (One winner was chosen in each of six categories by the UMD Office of Technology Commercialization and an external review panel.)

¹³ 3rd place for invention of the year at the University of Maryland, in 2003.

CONSULTING

Company	Role / Subject
<i>Pulse Therapeutics</i>	On their Scientific Advisory Board / Magnetic drug targeting
<i>Ototronix</i>	Modeling of magnetic forces for a hearing aid.
Roche	Modeling and optimization of magnetic drug delivery.
NIST	Methods for control and sensing on the micro and nano scale.
Phillips	Modeling and optimization of active electrowetting color pixels for 'smart paper' flexible computer screens.
<i>Protiveris</i>	Modeling and design of micro-flows for improved label-free micro-cantilever antibody sensing.
<i>Infinite Biomedical Technologies</i>	Fluid/structure modeling and optimization of conjugated polymer actuated valves for implantable urinary incontinence devices.
<i>Cyto Pulses</i>	Characterization of electric fields produced in skin by array of micro needles; these used to deliver DNA therapy into skin cells.
PARC at Xerox	Modeling & control for directed assembly of multi-chip systems.
<i>Plowshare Technologies</i>	Characterization of fluid flow through hand held devices used to monitor inhaled volume of air by cigarette smokers.
<i>Nanostream</i>	Micro fluidics modeling and channel network design, to best use surface tension effects to direct fluid in functional chips.
Start-up companies are <i>italicized</i> .	

INVITED TALKS

Key invited talks are listed below. They include talks at both major US and foreign universities, seminars at research centers at home and abroad, a plenary seminar in China, and a presentation to the JASONs summer study program (the JASONs are a group of 40-50 tenured faculty with high credentials, including Nobel laureates, who advise government agencies on emerging research technology areas).

Type	Institution/Meeting	Date
Plenary Talk	3M-Nano Conference , Xi'an China	Aug 2012
Invited Talk	City of Hope Hospital (Pasadena, California)	May 2012
Invited Talk	University of California at Santa Barbara	May 2012
Invited Talk	Caltech (California Institute of Technology)	Feb 2012
Invited Talk	PARC (the research arm of Xerox)	Feb 2012
Invited Talk	UCSD (University of California at San Diego)	Feb 2012
Invited Talk	Harvard	Sept 2011
Invited Talk	MIT (Massachusetts Institute of Technology)	Apr 2011
Invited Talk	Royal Institute of Great Britain	Jun 2010
Invited Talk	University of Glasgow , Scotland	Jun 2010
Invited Talk	Roche Pharmaceuticals , Basel, Switzerland	Jun 2010
Invited Talk	University of Oldenburg , Germany	May 2010
Invited Talk ¹⁴	Frontiers of Engineering, hosted by the NAE (National Academy of Engineering) in Japan	Nov 2008
Invited Talk	Courant Institute of Mathematical Sciences	Mar 2008

¹⁴ Awarded 2nd place by audience vote for the seminar at this NAE meeting.

Invited Talk	Caltech (California Institute of Technology)	Oct 2007
Invited Talk	NIST (National Institute of Standards and Technology)	Jul 2007
Invited Talk	At JASONS summer study	Jun 2007
Invited Talk	University of Seattle	Dec 2006
Invited Talk	Berkeley	Aug 2005
Invited Talk	Stanford	Aug 2005
Invited Talk	Harvard	Apr 2005
Invited Talk	Johns Hopkins	Mar 2005
Invited Talk	Purdue	Sep 2002
Invited Talk	UCLA (University of California at Los Angeles)	Aug 2002
Invited Talk	Caltech (California Institute of Technology)	Aug 2002

TEACHING

From 2000 to 2009 I taught in the Aerospace Engineering department. In 2009 I took a sabbatical (no teaching) and then returned to teach one more class in Aerospace before starting to teach in the Bioengineering department from Fall 2010 onwards. I have twice won the Aerospace AIAA Outstanding Professor award (nominated and chosen by Aerospace students) and have been nominated for a Bioengineering teaching award.

Bioengineering Courses

The Feynman Lectures (BIOE689F/489F, Spring 2012): The Feynman Lectures on Physics (Addison-Wesley Publishing, 1963) are based on his 1961-62 lectures at Caltech and cover topics ranging from fluid flow and thermodynamics to electronics, magnetics, and optics with a precision, clarity, and insight that is uniquely Feynman. In 2012, I initiated a course in bio-engineering for under-graduates and graduate students where we go through one Feynman lecture a week. Lectures are chosen based on student interest and the students are tested on each lecture. In 2012 we covered 14 lectures from the principle of least action and time to thermodynamics, optics, and electromagnetics, as well as lectures on the physics of seeing and hearing.

Introduction to Feedback Control (BIOE471, Fall 2010/11): This course introduces bio-engineering junior undergraduates to the concepts and mathematics of feedback control. Teaching this course is a challenge – the subject is mathematically advanced but the students do not have the necessary background for it. To ameliorate the difficulty, the course is taught from Karl Astrom’s and Richard Murray’s book “Feedback Systems: An Introduction for Scientist and Engineers” (Princeton University Press, 2008) which is ‘intended to serve a diverse audience of scientists and engineers’ and ‘keep(s) the mathematical prerequisites to a minimum while being careful not to sacrifice rigor’. Students rate the course as extremely challenging but are able to absorb the material.

Aerospace Courses (from 2000 to 2008)

Rigid Body Dynamics (ENAE301, Fall 2001-9): This was a course on rigid body dynamics, from Newton’s laws to 3-dimensional gyroscopic effects, that I reworked in Fall 2002 and then taught for 7 years. Each assignment in the course went from the initial physics to the equations of motion, their solution, and computer animations of those solutions – thus the students could *see* if

their solutions were correct and could visualize how things move, from tennis balls to gyroscopes, bicycles, and Boeing aircraft.

Optimal and/or Robust Multivariate Control (ENAE644 or 742, Spring 2000-8): Advanced graduate control theory course. These courses covered linear robust and optimal control, with a few final weeks spent on nonlinear control aspects. In some cases it was taught as only an optimal control class, only a robust control class, or both subjects were combined into one faster class.

RESEARCH FUNDING

As of July 2012, have raised a total of \$6,171,000 as lead investigator (defined as ‘total amount’ in the 1st table + ‘total amount’ divided by number of lead investigators per grant in the 2nd table); my total share of funding has been \$5,433,000 (defined as ‘share for duration’ over all 3 tables); and I have been involved in \$30,980,000 of net raised funding (sum ‘total amounts’ over all 3 tables).

FUNDING RAISED AS LEAD INVESTIGATOR (Shapiro principle investigator and led the effort)						
Period	Title	Agency	Award Type	Shapiro share/yr	Share for duration	Total amount
<i>month/yr</i>				<i>listed in thousands of dollars</i>		
08/12 - 08/13	Magnetic Therapy Injection to Treat Hearing Loss <i>(in partnership with Otomagnetics LLC)</i>	Maryland Industrial Partnerships (MIPS)	regular	70	70	70
04/12 - 4/13	FDA Safety and Performance Assessment of Emerging Autonomous Neonatal Ventilators by State-of-the-Art Robust Analysis Methods	FDA	CERSI innovation award	25	25	25
03/09 – 3/12	Electroosmotically-Actuated Shape-Changing Materials with Large Stress and High Strain	AFOSR	unsolicited	73	220	660
08/08 - 08/12	Simulating the Dynamics of Electrowetting: Physics, Numerics, and Validation	NSF	unsolicited	60	178	310
09/10 - 12/11	Medical Application of a Magnetic Guidance System	Weinberg Medical Physics LLC	contract	20	20	20
03/09 – 3/11	Focusing of Drug-Coated Nano-Particles to Deep Tissue Tumors by Feedback Control	NCI / NIH	R21 ¹⁵	150	300	372
05/08 - 05/10	Steering Objects by Flow Control to Nanometer Precision	NIST	IPA	125	125	250
08/06 - 08/07	Electroosmotic Micro-Flow Pumping for High Stress/	Minta Martin ¹⁶	seed	52	52	170

¹⁵ Received a priority score of 116 on the 100-500 point NIH scale (scored in top 2.1% percentile).

¹⁶ An internal but competitive award mechanism within the Univ. of Maryland. Led to 3/09 AFOSR award.

	Strain Smart Actuator Materials					
05/04 - 05/05	Cheap, Handheld, Flow Control, Micro Tweezer System	Institute for Systems Research ¹⁷	seed	20	20	50
02/04 - 12/04	Funding for NSF workshop: "Control and System Integration of Micro- and Nano-Scale Systems"	NSF	panel & workshop funding	0	0	79
10/03 - 10/04	Micro Fluidic Devices for Geographical Mapping of 2-Dimensional Cancer Tissue Samples	ATC / NIH	seed	20	20	20
03/04 - 03/06	Compact Modeling of and State Estimation in Next Generation Data Centers	NYSERDA ¹⁸	regular	15	30	30
01/04 - 12/04	Steering Many Objects at Once in Micro Fluidic Systems by Feedback Control	TEDCO Technology Development Corporation	patent development	50	50	50
10/03 - 09/08	CAREER: Feedback Control of Micro-Fluidic Packets and the Bio-Particles Within Them	NSF	career award	80	400	400
01/04 - 01/07	Optimal Formations and Formation Deployment with Applications to TechSat 21	AFOSR	unsolicited	65	195	195
02/04 - 02/05	Model Based Optimization of Micro Fluidic Wells for Proteomic Sensing	MIPS	regular	70	70	70
03/01 - 09/02	SAMPEX Automation	NASA	seed	50	50	50
07/01 - 06/04	Investigation of Libration Orbits in the Earth/Moon System	NASA	seed	30	30	90
01/02 - 12/03	Modeling Surface Tension for Device Design	DARPA	seed	100	100	187
01/01 - 01/02	Control of Satellite Formations	Minta Martin	seed	50	50	50
NET (in thousands of \$)				1,125	2,005	3,148

¹⁷ Also an internal but competitive seed award. Helped lead to NIST and DARPA awards.

¹⁸ New York State Energy Research & Development Authority.

FUNDING JOINTLY LED WITH OTHERS (Shapiro PI or co-PI, co-led the effort)						
Period	Title	Agency	Award Type	Shapiro share/yr	Share for duration	Total amount
	title bolded if Shapiro PI					
<i>month/yr</i>	<i>list of other lead PIs</i>	<i>listed in thousands of dollars</i>				
10/11 - 10/14	Collaborative Research: First-Principles Based Control of Multi-Scale Meta-Material Assembly Processes <i>Bevan, Ford, Grover</i>	NSF	CDI- Type II	133	400	1,600
08/10 - 07/13	Spatial, High-Accuracy, Multiplexed Mapping of Genes in Human Tissue Sections <i>E.Smela</i>	NCI / NIH	IMAT	150	375	750
06/11 - 01/13	Zeno Based Opto- Electronics Using Semi- Conductor Quantum Dots Coupled to Nanocavities <i>E.Waks</i>	DARPA	Phase II	200	306	1,600
02/10 - 02/12	Magnetic Injector for Targeted Delivery of Therapeutics <i>I.Rutel</i>	NIH	R21	80	160	320
07/10 - 07/11	Metatronics for Ultra-Fast Low-Power Nanocircuits <i>E.Waks</i>	DARPA	seed	82	82	340
10/09 - 06/11	Zeno Based Opto- Electronics Using Semi- conductor Quantum Dots Coupled to Nanocavities <i>E.Waks</i>	DARPA	Phase I	200	306	1,600
02/10 - 01/11	Microfluidic Positioning of Nitrogen-Vacancy Centers for Coherent Detection of Magnetic Fields <i>E.Waks</i>	PFC	regular	25	25	75
10/08 - 10/10	Mapping Genes and Gene Expression in Human Tissue <i>M.Emmert-Buck</i>	Advanced Technology Center, NCI ¹⁹	joint staff support	70	140	140
05/08 - 11/08	Nano-Positioning Quantum Dots On-Chip for Long- Distance Quantum Communication and Many- Bit Computing <i>E.Waks</i>	DARPA	seed	113	113	225
11/07 - 11/08	Inferring the Gene/Protein Networks of Living Cells using Directed Information <i>N.Martins</i>	Institute for Systems Research	seed	25	25	50
06/04 - 12/04	On-Chip Hardware for	AFOSR	seed	30	30	70

¹⁹ Competitive funds at the Advanced Technology Center (ATC) at NCI to jointly support Mike Armani.

	Cell Monitoring: Contact Imaging and Notch Filtering <i>P.Abshire, E.Smela</i>					
01/02 - 01/03	Muscle-Like Conjugated Polymer Actuators for Flapping-Insect Micro-Air Vehicles <i>E.Smela</i>	Minta Martin	seed	50	50	100
NET (in thousands of \$)				1,158	2,012	6,870

FUNDING AS CO-INVESTIGATOR (co-PI, but did not help lead the effort)						
Period	Title	Agency	Award Type	Shapiro share/yr	Share for duration	Total amount
<i>Lead PI</i>	<i>listed in thousands of dollars</i>					
11/10 - 11/12 <i>J.Fourkas</i>	Assembly and Immobilization of Functional Nanomaterials for Device Applications	NSF (portion of MRSEC center)	MRSEC sub-award	23	47	140
05/09 - 05/10 <i>P.Abshire</i>	Complex Sample Preparation for Cell-Based Detection	MIPS	regular	60	60	155
05/09 - 05/11 <i>P.Abshire</i>	Wireless Sensor for Standoff Detection of Improvised Explosive Devices (IEDs)	NSF	SBIR	15	30	300
01/09 - 01/14 <i>Granatstein</i>	Center for Applied Electromagnetics	ONR	center	30	150	2,137
06/08 - 06/10 <i>P.Abshire</i>	Handheld Cell-Based Bio-Sensor for Complex Samples	Defense Intelligence Agency	contract	120	360	900
04/08 - 04/18 <i>S.Humbert</i>	Center on Micro-System Mechanics	Army	center	40	40	10,000
08/05 - 08/06 <i>C.Cadou</i>	Integrated Fuel Cell Micro Power System	Minta Martin	seed	50	50	150
03/05 - 03/06 <i>P.Abshire</i>	Integrated Transduction, Actuation, and Control for Cell-Based Sensing	NSF	unsolicited	80	80	240
12/04 - 12/06 <i>G.Bajpai</i>	Computational Tools for Feedback Controllers	NASA	SBIR Phase II	67	134	600
05/04 - 05/09 <i>I.Chopra</i>	Micro Hovering Air Vehicles: Revolutionary Concepts and Navigation Advancements	Army	MURI	50	250	5,250
07/03 - 07/04 <i>G.Bajpai</i>	High Performance Flow Analysis and Control Tools for Aerial Vehicles	NASA	SBIR Phase I	15	15	70
08/02 - 01/03 <i>E.Smela</i>	Modeling Charge Transport in Conjugated Polymers	Army	seed	5	5	30
01/03 - 01/06 <i>D.DeVoe</i>	Nanofluidic Networks for Single-Molecule Protein Analysis	NSF	NIRT	50	150	750
01/02 - 01/05	Integrated Array Detection	USDA	unsolici	15	45	240

<i>A.Rasooly</i>	System for Food Microbial Pathogens		ted			
NET (in thousands of \$)			620	1,416	20,962	

RESEARCH GROUP

My research group currently consists of 7 post-docs, 3 PhD students, 6 undergraduates, and 2 very talented high school students. Of these, 2 post-docs and 1 undergrad are jointly co-advised (marked by shading with the co-advisor noted).

CURRENT GROUP				
Name	Period	Level	Jointly advised with	Explanatory Comments
<u>M.Armani</u>	11/10 - ...	post-doc	<i>Emmert-Buck</i>	Former PhD. Now joint with <i>Buck</i> at NIH
M.Black	12/11 - ...	undergrad		Bioengineering undergraduate student
K.Chen	01/12 - ...	undergrad		Bioengineering undergraduate student
C.Cherry	02/12 - ...	undergrad		Bioengineering undergraduate student
Z.Cummins	01/08 - ...	PhD		Transferred from AE to BioE with me
R.Hilaman	09/11 - ...	undergrad		Bioengineering undergraduate student
A.Isser	summers 2011 & 12	high-school		Very talented high-school student, did one summer, returned for second summer
A.Komae	3/09–9/12	post-doc		Control theory post-doc
<u>P.Mathai</u>	01/11 - ...	post-doc	<i>A.Liddle</i>	Former PhD. Now joint w/ <i>Liddle</i> at NIST
P.Malik	summer 12	high-school		Another very talented high-school student
G.Massaccesi	02/12 - ...	undergrad		Bioengineering undergraduate student
A.Nacev	01/08 - ...	PhD		Was former AE undergrad with me
<u>D.Pant</u>	05/10 - ...	post-doc	<i>E.Smela</i>	Research with <i>Smela</i> on 2D-PCR
<u>N.Podesta</u>	12/11 - ...	undergrad	<i>D.Depireux</i>	Ear targeting experiments with <i>Depireux</i>
R.Probst	05/10 - ...	post-doc		A former PhD, stayed on as a post-doc
B.Rhamaswamy	08/11 - ...	PhD		BioE graduate student
A.Sarwar	01/10 - ...	post-doc		Control theory + experiments post-doc
Z.Shen	05/11 - ...	post-doc		Control theory + imaging/experiments

List current as of June 2012

To date, my lab has graduated 7 PhD students and 14 masters students. The table below lists student names and graduation dates (co-advised students are shaded). Subsequent placement of these students has varied from Aerospace, startup, and consulting companies to government labs and a mathematics faculty position. Some group members, e.g. A.Nacev and R.Probst, chose to stay in the group (Nacev from undergrad to PhD and Probst from a PhD to a post-doc) while some others have gone on to new institutions (M.Armani to NIH, P.Mathai to NIST) but have elected to continue collaborating with my group.

GRADUATED MEMBERS							
PhDs		Masters				Undergrads*	
M.Armani	2010	F.Anzinger	2002	J.Schumacher	2007	A.Daiub	M.Manion
<u>J.Rambo</u>	2006	M.Becker	2003	P.Schwind	2005	C.Bacon	R.Metzger
S.Chaudhary	2011	E.Chen	2005	I.Treise	2004	M.Chinn	R.Miller
M.Santos	2007	<u>S.Fanning</u>	2005	J.West	2009	N.Fortner	P.Nitsch
S.Walker	2007	R.Jarabek	2004	K.White	2006	I.Fushman	D.Proffen
<u>P.Mathai</u>	2009	T.Karacay	2004			J.Lin	J.Robinson

R.Probst	2010	S.Kim	2010			V.Mehta	D.Tseng
		S.Pfisterer	2005			J.King	E.Ulrich
		TW.Lin	2002			P.Kutty	J.Wesley
<i>*Who stayed for at least 3 months List current as of June 2012</i>							

SERVICE

Service for Departments

Fischell Department of Bioengineering (2010 – present)

- SB1. **Biomedical Devices Institute Steering Committee**, Feb 2012 – present.
- SB2. **Review of mathematics curriculum for bioengineering undergraduate program** (together with Dr. Ian White), Nov – Dec 2011.
- SB3. **Chaired faculty search committee for the bioengineering department**, Sept 2010 – June 2011.
- SB4. **Undergraduate Capstone advising** – advise teams of 3-6 students on a research project for their capstone class, about 2-4 teams per year, from 2010 – present.
- SB5. **Undergraduate curriculum advising**. Each semester advise about 20 students. From 2010 – present.
- SB6. **Graduate student advising (outside my own group)**. Provided career advice to graduate students in Bioengineering, as well as in other departments (Mechanical, Math, Electrical, ...) on: recommendations for post-doctoral positions, information on type of research carried out at various research laboratories and companies, plus suggestions for students who are interested in starting, or being involved in, start-up companies.

Aerospace Engineering (2000 – 2009)

- SA1. **Graduate student admissions committee**, multiple years from 2000 to 2009.
- SA2. **Faculty search committee**, 2005.
- SA3. **Integrated the Aerospace and Mechanical control theory curricula**. Enabled AE and ME to not double-offer essentially the same courses, this allowed both departments to use their faculty resources more efficiently, 2001 – 2002.
- SA4. **Committee to evaluate computing toolbox course** for the Aerospace department, 2001.
- SA5. **Undergraduate curriculum advising**. Each year advised about 30 students. From 2000 – 2009.

The Institute for Systems Research (2000 – present)

- SI2. **Facilities and services committee**, 2008 – 2009.
- SI3. **Educational program committee**, 2006 – 2008.
- SI4. **ISR research directions committee**: to determine research thrusts in control of micro and nano-scale systems, 2007.

Service for the Engineering College and the University

- SC1. **Appointment, Promotion, and Tenure (APT) committee**, college level, served as a representative for the Bioengineering department, Sept 2011 – Sept 2014.
- SC2. **Committee to better integrate undergraduate mathematics & engineering curricula**, March 2008.
- SC3. **Member on panel ‘How to win an NSF Career Grant?’**, aimed at helping new faculty win the CAREER award, served twice: May 2004 and May 2005.

External Service

In addition to routine service such as reviewing journal and conference papers, and NSF, AFOSR, and NIH grant proposals, the list below shows other external service items:

- SE1. **Organizing committee** for International Conference on Manipulation, Manufacturing, and Measurement on the Nanoscale – **3M-Nano conference**, Xi’an, China, Sept 2012.
- SE2. **Co-organizer “Control of Nanoscale Self Assembly” tutorial session** at American Control Conference (ACC2011), San Francisco CA, June 29-July 1, 2011.
- SE3. Board member of **The Open Nanomedicine Journal**, 2006-2010.
- SE4. **Chair “Control of Biological Systems” session** at Conference on Decision and Control (CDC), New Orleans, LA, Dec 2007.
- SE5. On **panel to review NIH P41 center grants**, March 2007.
- SE6. NSF panel to **review CAREER proposals** for Civil and Mechanical Systems (CMS) NSF division, 2005.
- SE7. **Program Committee and Associate Editor for 2005 American Control Conference**.
- SE8. Served on **panel at American Control Conference** for **“Writing a winning NSF CAREER proposal”** session, Boston MA, June 2004.
- SE9. **Organized session at American Control Conference** to report results of the March 2004 NSF workshop and to overview the state-of-the-art in micro/nano controls research, Boston MA, June 2004.
- SE10. **Organized “Control and System Integration of Micro and Nano-Scale Systems” NSF panel/workshop²⁰**, March 2004.
- SE11. **Organized “Modeling versus Design for Micro Fluidics in I: Aerospace Systems and II: Bio-Chem Applications” workshop** at 42nd AIAA conference, Jan 2004.
- SE12. **Co-chaired “Micro and Nanofluidics (Invited)” session** at 42nd AIAA conference, Jan 2004.
- SE13. **Co-chaired “Microfluidics” session** at 42nd AIAA conference, Jan 2004.

²⁰ Over 400 people applied to attend this NSF workshop. Led choosing of 90 experts in modeling, control, biochemistry, micro and nano fabrication from across the US, these experts then made recommendations to NSF for future funding directions. The workshop final report is available online and also through NSF.