

## Ian Appelbaum

[appelbaum@ee.udel.edu](mailto:appelbaum@ee.udel.edu)

217C Evans Hall, University of Delaware

Newark, DE, 19716

(302) 831-3295

### Education

1. Ph.D. in Physics, Massachusetts Institute of Technology, Cambridge, MA, 2003.
2. B.S. Summa Cum Laude in Physics and Mathematics, Rensselaer Polytechnic Institute, Troy, NY, 1997.

### Appointments

1. Assistant Professor, Department of Electrical & Computer Engineering, University of Delaware, 9/04-Present.
2. Postdoctoral Fellow, Division of Engineering and Applied Sciences, Harvard University, 6/03-9/04

### Media

Appelbaum's research in spintronics has attracted much attention from the science and technology media, including Scientific American, New Scientist, MIT Technology Review, La Recherche (France), Computer Power User, Materials Today, c't (Germany), Electronic Design, Nature Nanotechnology, ACS Chemical & Engineering News, and dozens of science news websites in the US and abroad. A full list is available at:

<http://www.ee.udel.edu/~appelbau/research.html>

As quoted by:

Scientific American: "It's a beautiful piece of work."

New Scientist: "This is a very important demonstration... It's an important step for the community."

MIT Technology Review: "It's a very ingenious scheme to electrically generate and transport spins in silicon, [to] electrically detect the spins, and doing all of this on a chip."

### External Funding

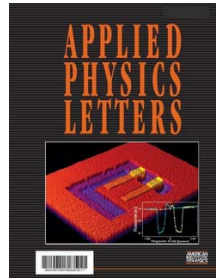
1. ONR/DEPSCoR, "Future Spintronics for Today's Electronics", \$484,370 (PI, 6/1/08-5/31/11)
2. NSF, "CAREER: Silicon Spintronics", \$400,000 (PI, 6/1/08-5/31/13)
3. Office of Naval Research, "Elements of Silicon-based Spintronic Circuits", \$248,652 + \$30K UD equipment match (PI, 10/1/07-9/31/10)
4. DARPA, "Silicon Spintronics for Quantum Computation", \$230,000 (PI, 7/1/07-1/31/09)
5. Department of Energy, "Imaging of Buried Nanoscale Luminescent Layers", \$478,433 (PI, 8/1/07-7/31/10)
6. Office of Naval Research, "All-Electrical Spin Detection in III-V Semiconductors", \$149,557 + \$50K UD equipment match (PI, 1/1/06-12/31/06)
7. DARPA, "Electron Spin Detection for Silicon Spintronics", \$100,000 (PI, 5/1/06-4/31/07)
8. NSF, "Tunneling Spectroscopy for Nanofabricated Biochemical Sensors", \$240,001 (co-PI, 6/1/06-5/31/09).

## Publications

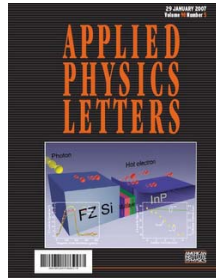
1. B.Q. Huang and Ian Appelbaum, "Spin Dephasing in Drift-Dominated Semiconductor Spintronics Devices", Phys. Rev. B **77**, 165331 (2008)
2. J. Li, B.Q. Huang, and Ian Appelbaum, "Oblique Hanle Effect in Semiconductor Spintronic Devices", Appl. Phys. Lett. **92**, 142507 (2008).
3. B.Q. Huang, D.J. Monsma, and Ian Appelbaum, "Coherent spin transport through a 350-micron-thick Silicon wafer", Phys. Rev. Lett. **99**, 177209 (2007).
4. Ian Appelbaum, B.Q. Huang, and D.J. Monsma, "Electronic measurement and control of spin transport in silicon", Nature **447**, 295 (2007).
5. B.Q. Huang, D.J. Monsma, and Ian Appelbaum, "Experimental realization of a silicon spin field-effect transistor", Appl. Phys. Lett. **91**, 072501, (2007).
6. B.Q. Huang, L. Zhao, D.J. Monsma, and Ian Appelbaum, "35% magnetocurrent with spin transport through Si", Appl. Phys. Lett. **91** 052501 (2007).
7. B.Q. Huang, D.J. Monsma, and Ian Appelbaum, "Spin lifetime in silicon in the presence of parasitic electronic effects", J. Appl. Phys. **102**, 013901 (2007).
8. Ian Appelbaum and D.J. Monsma, "Transit-Time Spin Field-Effect-Transistor", Appl. Phys. Lett. **90**, 262501 (2007) and on Jun. 25, 2007 cover.
9. L. Zhao, P. Thompson, N.N. Faleev, D.W. Prather, and Ian Appelbaum, "Two-Photon Passive Electro-Optic Up-Conversion in a GaAs/AlGaAs Heterostructure Device", Appl. Phys. Lett. **90**, 121132 (2007).
10. B.Q. Huang, I. Altfeder, and Ian Appelbaum, "Spin-Valve Photo-Transistor", Appl. Phys. Lett. **90**, 052503 (2007) and on Jan. 29, 2007 cover.
11. I. Altfeder, B.Q. Huang, Ian Appelbaum, and B.C. Walker "Self-assembly of Epitaxial Monolayers for Vacuum Wafer Bonding", Appl. Phys. Lett. **89**, 223127 (2006).
12. K.J. Russell, V. Narayanamurti, Ian Appelbaum, M.P. Hanson, and A.C. Gossard, "Hot-electron mean free path of ErAs thin films grown on GaAs determined by metal-base transistor ballistic electron emission spectroscopy", Phys. Rev. B **74**, 205330 (2006).
13. M.R. Olson, K.J. Russell, V. Narayanamurti, J.M. Olson, and Ian Appelbaum, "Linear photon upconversion of 400 meV in an AlGaInP/GaInP quantum well heterostructure to visible light at room temperature", Appl. Phys. Lett. **88**, 161108 (2006).
14. B.Q. Huang and Ian Appelbaum, "Perpendicular Hot-Electron Transport in the Spin-Valve Photodiode", J. Appl. Phys. **100**, 034501 (2006).
15. W. Yi, I. Appelbaum, K.J. Russell, V. Narayanamurti, R. Schalek, M.P. Hanson, and A.C. Gossard, "Vertically integrated optics for ballistic electron emission luminescence: Device and microscopy characterizations" J. Appl. Phys. **100**, 013105 (2006).
16. I. Appelbaum, P. Thompson, and P.J.A. van Schendel, "A modified Nanosurf scanning tunnelling microscope for ballistic electron emission microscopy and spectroscopy", Meas. Sci. Technol. **17**, N13-N16 (2006).
17. W. Yi, I. I. Kaya, I. B. Altfeder, I. Appelbaum, D. M. Chen, and V. Narayanamurti, "Dual-probe scanning tunneling microscope for study of nanoscale metal-semiconductor interfaces", Rev. Sci. Instrum. **76**, 063711 (2005).
18. K.J. Russell, I. Appelbaum, V. Narayanamurti, M.P. Hanson, and A.C. Gossard, "Transverse momentum Non-Conservation at the ErAs/GaAs interface", Phys. Rev. B Rapid **71**, 121311(R) (2005).

19. Ian Appelbaum and V. Narayanamurti, "Monte Carlo calculations for metal-semiconductor hot-electron injection via tunnel-junction emission", Phys. Rev. B **71**, 045320 (2005).
20. Ian Appelbaum, W. Yi, K.J. Russell, V. Narayanamurti, M.P. Hanson, and A.C. Gossard, "Vertically Integrated Optics for Ballistic Electron Emission Luminescence Microscopy", Appl. Phys. Lett. **86** 063110 (2005).
21. K.J. Russell, I. Appelbaum, W. Yi, F.C. Capasso, D.J. Monsma, C.M. Marcus, V. Narayanamurti, M.P. Hanson, and A.C. Gossard, "Avalanche Spin-Valve Transistor", Appl. Phys. Lett. **85**, 4502 (2004).
22. Ian Appelbaum, K.J. Russell, I. Shalish, V. Narayanamurti, M.P. Hanson, and A.C. Gossard, "Ballistic Hole Emission Luminescence", Appl. Phys. Lett. **85**, 2265 (2004).
23. Wei Yi, Ian Appelbaum, K.J. Russell, V. Narayanamurti, M.P. Hanson, and A.C. Gossard, "Ballistic Electron Emission Luminescence of an InAs Quantum Dot Heterostructure", Appl. Phys. Lett. **85**, 1990 (2004).
24. Ian Appelbaum, T. Wang, J.D. Joannopoulos, and V. Narayanamurti, "Ballistic Hot Electron Transport in Nanoscale Semiconductor Heterostructures: Exact Self-Energy of a Three-Dimensional Periodic Tight Binding Hamiltonian", Phys. Rev. B **69**, 165301 (2004).
25. Ian Appelbaum, K.J. Russell, M. Kozhevnikov, V. Narayanamurti, M.P. Hanson, and A.C. Gossard, "Room-Temp. Ballistic Electron Emission Luminescence Spectroscopy with a Scanning Tunneling Microscope", Appl. Phys. Lett. **84**, 547 (2004).
26. Ian Appelbaum, K.J. Russell, D.J. Monsma, V. Narayanamurti, C.M. Marcus, M.P. Hanson, and A.C. Gossard, "Luminescent Spin-Valve Transistor", Appl. Phys. Lett. **83**, 4571 (2003).
27. Ian Appelbaum, D.J. Monsma, K.J. Russell, V. Narayanamurti, and C.M. Marcus, "Spin-Valve Photo-Diode", Appl. Phys. Lett. **83**, 3737 (2003) and Nov. 3 2003 cover
28. Ian Appelbaum, K.J. Russell, V. Narayanamurti, D.J. Monsma, C.M. Marcus, M.P. Hanson, A.C. Gossard, H. Temkin, and C.H. Perry, "Ballistic Electron Emission Luminescence", Appl. Phys. Lett. **82**, 4498 (2003).
29. K.J. Russell, Ian Appelbaum, H. Temkin, C.H. Perry, V. Narayanamurti, M.P. Hanson, and A.C. Gossard, "Room-Temperature Electro-Optic Up-Conversion via Internal Photo-Emission", Appl. Phys. Lett. **82**, 2960 (2003).
30. Ian Appelbaum, R. Sheth, I. Shalish, K.J. Russell, and V. Narayanamurti, "Experimental test of the planar tunneling model for Ballistic Electron Emission Spectroscopy", Phys. Rev. B **67**, 155307 (2003).
31. Ian Appelbaum, J.D. Joannopoulos, V. Narayanamurti, "Alternative paradigm for physical computing", Phys. Rev. E **66**, 66612 (2002).
32. R.E. Martinez II, I. Appelbaum, C. V. Reddy, R. Sheth, K. J. Russell, V. Narayanamurti, J.-H. Ryou, U. Chowdhury, and R. D. Dupuis, "Electron transport through strongly coupled AlInP/GaN superlattices", Appl. Phys. Lett. **81**, 3576 (2002).
33. Ian Appelbaum, T. Wang, S. Fan, J.D. Joannopoulos, and V. Narayanamurti, "Can silicon dimers form logic gates?", Nanotechnology **12**, 391 (2001).
34. S. Fan, Ian Appelbaum, and J.D. Joannopoulos, "Near-Field Scanning Optical Microscopy as a simultaneous probe of photonic crystals: a computational study", Appl. Phys. Lett. **75**, 3461 (1999).
35. P.G. Kwiat, E. Waks, A.G. White, Ian Appelbaum, and P.H. Eberhard, "Ultrabright source of polarization-entangled photons", Phys Rev. A **60**, R773 (1999).

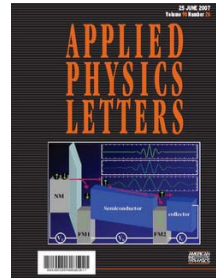
## Journal Covers



11/3/03



1/29/07



6/25/07

## Presentations

1. New Frontiers in Spintronics, Institute for Advanced Studies, Jerusalem, Israel, Spring 2009 (scheduled) – invited
2. Materials Research Society Spring Meeting, San Francisco, 4/13/09 (scheduled) – invited
3. 3<sup>rd</sup> International SiGe, Ge, & Related Compounds Symposium/ 214th Electrochemical Society Meeting, Honolulu 10/12/08 (scheduled) – invited
4. 4<sup>th</sup> International Workshop on "Spin Phenomena in Reduced Dimensions" Regensburg, Germany, 9/24-9/27/08 (scheduled) – invited
5. Gordon Research Conference on Magnetic Nanostructures, Grenoble, 8/31/08 (scheduled) – invited
6. 29<sup>th</sup> International Conference on the Physics of Semiconductors, Rio de Janeiro, Brazil, July 2008 (scheduled) – invited
7. NanoElectronics 2008, RWTH Aachen, Germany, 5/15/08 (scheduled) – invited
8. UCLA, Electrical Engineering, seminar 4/14/08
9. Purdue University, Electrical Engineering, seminar, 4/11/08
10. University of Pennsylvania, Electrical Engineering, seminar, 4/2/08
11. Northeastern University, Physics & ECE joint seminar, 3/20/08
12. American Physical Society, New Orleans, 3/12/08 – invited
13. NIST, Gaithersburg, MD, seminar 3/4/08
14. 2<sup>nd</sup> ATI/IFCAM International Workshop on Spin Currents, Tohoku University, Sendai, Japan, 2/19/08 – invited
15. Brown University, Engineering, seminar 2/14/08
16. University of Maryland, Physics, seminar 2/7/08
17. IBM T.J. Watson Research Center, Physical Sciences Seminar, 2/1/08
18. Purdue University, Electrical Engineering, seminar 1/24/08
19. University of Pittsburgh, Physics, colloquium 1/7/08
20. Adv. Workshop on 'Frontiers in Electronics', Cozumel, 12/16/07 – invited paper
21. Materials Research Society Fall Meeting, Boston, 11/26/07 – invited
22. Magnetism and Magnetic Materials Conference, Tampa, 11/8/07 – invited
23. 115<sup>th</sup> Lectureship of the Zhong-Guan-Cun Forum on Condensed Matter Physics, Chinese Academy of Sciences, Institute of Physics, Beijing, China, 11/2/07
24. Nanjing University, Physics, Nanjing, China, colloquium 11/1/07
25. Fudan University, Physics, Shanghai, China, colloquium 10/31/07
26. Kavli Frontiers in Science Symposium (U.S. National Academy of Sciences and Chinese Institute of Physics), Beijing, China, 10/29/07 – invited
27. SUNY Albany, Nanoscale Science and Engineering, colloquium 10/19/07

28. SUNY Buffalo, Department of Physics, colloquium 10/4/07
29. Spintech IV, Maui, 06/21/07
30. American Physical Society, Denver, 3/5/07
31. ONR Program Review, Denver, 3/10/07
32. University of Delaware, Physics and Astronomy, seminar 2/27/07
33. American Physical Society, Baltimore, 3/06 – poster
34. Materials Research Society, Boston, 11/05 – poster
35. University of Delaware, Electrical and Computer Engineering, seminar 9/27/04
36. University of Delaware, Physics and Astronomy, seminar 9/21/04
37. Virginia Tech, Physics, seminar 2/28/04
38. Lehigh University, Physics, colloquium 2/23/04
39. Drexel University, Physics, colloquium 2/9/04
40. University of Delaware, Electrical and Computer Engineering, colloquium 1/20/04
41. Rensselaer Polytechnic Institute, Physics, colloquium 9/24/03

### **Research Group**

#### Graduate Students

1. Biqin Huang – graduated with PhD 1/08
2. Zhao Lai (2<sup>nd</sup> year) – passed qual 6/07
3. Xu Jing (1<sup>st</sup> year)
4. Li Jing (1<sup>st</sup> year)

#### Postdoctoral Fellows

1. Hyuk-Jae Jang – joined 7/1/07 from U. Minnesota Physics
2. Igor Alfeder (2/1/06-4/31/07) – now at Wright Patterson AFB

#### Undergraduate students

1. Peter Thompson – Summer '05 and '06
2. Jason Hamant – Summer '07

### **Synergistic Activities**

1. Proposal reviewer: NSF, Research Corporation, and DOE
2. Referee: Physical Review Letters, Physical Review B, Applied Physics Letters, etc.
3. Consultant, Phiar Corp.
4. Organizing Committee, 2008 Chinese-American Kavli Frontiers in Science Symposium, US National Academy of Sciences
5. Member, Materials Research Society and Life Member, American Physical Society
6. U.S. Patent 7244997, “Magneto-Optical Transducer”
7. 2 provisional patent applications

### **Awards**

1. 2008 Outstanding Junior Faculty Member for the College of Engineering (UD)
2. 2008 NSF CAREER award
3. 2007 Best paper, Advanced Workshop on 'Frontiers in Electronics'
4. 2007 Cambridge NanoTech Research Award
5. 2001 MIT Graduate Poster Session award
6. 1998 G. Howard Carragan Award (RPI) “For outstanding scholarship”
7. 1998 Hertz Foundation - Grant recipient
8. 1997 Summer Institutes in Applied Science – Lawrence Livermore National Lab
9. 1996 Los Alamos National Laboratory summer intern

10. 1996 Rensselaer Founder's Award
11. 1996 MIT CMP-CMSE summer scholar

### **Service**

1. Chair, ECE recruitment film committee (11/06- )
2. Chair, COE elections committee (12/07- )
3. ECE Graduate committee (8/07- )
4. ECE Health & Safety committee (4/07- )
5. Graduate Oral Qualifier Exams (6/05, 6/06, 6/07)
6. Coordinator search committee (hired V. Grypa)
7. PhD thesis defense committee (5/31/07, Liviu Zarbo, Prof. Nikolic, DPA)
8. Recruitment: B&G Saturdays (10/04 and 10/06), Delaware Decision Days (7/05)
9. Undergraduate curriculum committee
10. Daicar-Bata prize selection committee (10/06, DPA)
11. BioNano Search Committee (hired S. Cloutier) and faculty candidate events
12. Conceived and executed weekly Materials & Devices seminar (Spring '05)
13. Cleanroom coordinator search committee (hired K. Krag-Jensen)

### **Teaching**

#### Fall 07: ELEG340 SOLID-STATE ELECTRONICS

"Highly knowledgeable... he was a great teacher and really knew what he was talking about... More than willing to provide help or extra material to students who seek it... genuinely cares about how his students perform in his class... very helpful and open to any questions at any time... Professor did a tremendous job teaching the subject. Lectures were very effective and clear. This class made me realize how much i love engineering..."

#### Spring 07: ELEG240 PHYSICAL ELECTRONICS

"Great teacher... effective, and helpful... available for help almost any time... the course has better prepared me for my future engineering courses... the topics we covered were very interesting..."

#### Fall 06: ELEG340 SOLID-STATE ELECTRONICS

"Professor provides slides with the material and explains the slides well... Professor Appelbaum exhibits great knowledge of the subject material. Lectures are straightforward... Dr. Appelbaum was able to instill a passion for the subject matter... The level of caring presented was appropriate and genuine... overall this was one of my favorite courses this semester... Tablet PC worked well. Being able to see equations derived by hand allowed for better understanding of method. Published notes online both before and after class was also good.... All of the tools used in the course made it much easier for us to take notes and follow the instruction, without having to be pages behind on a blackboard about to get erased, as has been the situation with other instructors. This use of technology should be continued and suggested to other faculty because it works, is appreciated, and definitely aids the learning process..."

#### Spring 06: ELEG/PHYS667 MAGNETISM AND SPINTRONICS

"The professor is nice and well prepared. Thank you....He is a good researcher with huge knowledge in this field. Young, energetic and ambitious researcher, I learned a lot in depth from him....The course should be made compulsory for students specializing in Magnetism and Spintronics related fields..."

Fall 05: ELEG340 SOLID-STATE ELECTRONICS

“The instructor is one of, if not the best that I have had... He is very knowledgeable of the subject matter and communicates it well... He was also very helpful in office hours.... Professor’s knowledge of the material was thorough. Lectures were well presented... Professor Appelbaum is a very good professor. He is extremely smart and knowledgeable of the material in this class... Very extensive knowledge of the material... I liked Appelbaum's visual teaching method...”

Fall 04: ELEG667-018/PHYS667-018 SPINTRONICS

“Dr Appelbaum is a good instructor, helps students a lot, he supplies them with extra information, he is interested in the subject and is well-prepared... it was very beneficial for my research. Now I feel more comfortable in the literature. I got a better understanding of what is going on in spintronics... the class was very well structured and included all the basics. In the presentations more advanced topics were included and the instructor made sure the explanations were clear the most important points were made.... I enjoyed the course very much and it was very useful.... One really good thing was that the instructor was asking for feedback and taking that into consideration. Thank you, Prof. Appelbaum for the interesting course... I think Dr. Ian is a very good teacher. I learn a lot in this class.... Its helped me to clarify a lot of confusion in my mind and also taught me quite a lot new knowledge.... Thank you very much professor A!! We learned a lot and we really appreciate your effort in teaching this course!!... Was a great class, nice exposure to pertinent literature and basic physics. I learned a lot and am in a position to learn even more about spintronics...”