

Alan C. Seabaugh, Professor of Electrical Engineering

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Education:

B.S.E.E. (1977), M.S.E.E. (1979), Ph.D.E.E. (1985)

Electrical Engineering, University of Virginia, Charlottesville, Virginia

M.S. thesis: GaAs liquid phase epitaxy for millimeter wave Schottky diodes

Advisor: Robert J. Mattauch

Ph.D. thesis: Transient photoresistance spectroscopy of deep levels in high resistivity semiconductors

Advisor: James D. Oliver

Professional Experience:

University of Notre Dame, Department of Electrical Engineering

Director, Notre Dame Center for Nano Science and Technology (ND*nano*) (2018 – present)

<https://nano.nd.edu/>

Frank M. Freimann Professor of Electrical Engineering (2015 – present)

Frank M. Freimann Director, STARnet Center for Low Energy Systems Technology (LEAST)

least.nd.edu/ (2013 – 2017)

Frank M. Freimann Director of the Midwest Institute for Nanoelectronics Discovery (MIND)

mind.nd.edu (2010 – 2013)

ND*nano* Associate Director (2000 –2013)

Professor of Electrical Engineering, University of Notre Dame (1999 – 2015)

Raytheon, Dallas (1997 –1999)

Senior Fellow (1999)

Texas Instruments (1986 –1997)

Distinguished Member Technical Staff (1997)

Senior Member Technical Staff (1991 – 1997)

Member Technical Staff (1986 – 1991)

University of Texas at Dallas

Visiting Lecturer: EE3301 Electrical Network Analysis (1987)

EE6320 Semiconductor Device Theory (1988, 1996)

EE3310 Electronic Devices (1989)

EE6321 Advanced Semiconductor Device Theory (1997)

National Bureau of Standards Electronics Engineer (1979-1986)

NBS graduate research fellowship (1981-84)

Research Interests:

Electron devices and circuits, nanoelectronics, nanofabrication, nanotechnology

Energy harvesting and storage, microwave and mm-wave technology

Tunneling-based devices and circuits: transistors, memory, rectifiers

Contents:

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2. Teaching – University of Notre Dame
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1. Awards:

- Notre Dame Research REF-ie Award (2019) for impact on university research community, 18 July 2019.
- Notre Dame Faculty Recognition Award (2015), Notre Dame Stadium, 14 November 2015.
- ISCS Quantum Devices Award (2011) for “seminal contributions and leadership in semiconductor devices and circuits based on quantum mechanical tunneling such as tunnel field-effect transistors and resonant tunneling transistors.”
- IEEE Fellow (2003) “for contributions to high speed and nanoelectronic device and circuit technology.”
- Outstanding Teacher Award 2001.
- DARPA Sustained Superior Performance award (1997)
- DARPA Outstanding Performance by a Project Manager award (1998)
- *IEEE Computer Society Outstanding Paper Award* (coauthored, 1994)
- *TI Achievement Award* for “Demonstration of the world’s first room temperature resonant tunneling integrated circuit” (1992)
- Teacher of the Year Award University of Texas at Dallas, IEEE student chapter (1989-1990)
- *TI Achievement Award* for “Demonstration of the world’s first pseudomorphic bipolar quantum resonant tunneling transistor” (1988).

2. Teaching - University of Notre Dame:

- EE40446 IC Fabrication (2020) – EE41446 Lab
- EE60546 IC Fabrication (2020) – EE61546 Lab
- EE67052 Tunnel Field-Effect Transistors (2013, 2015)
- EE30347 Fundamentals of Semiconductors (2012, 2014, 2016)
- EE40448 Electrical Energy Extraction (2008, 2011)
- EE60542 Analog Integrated Circuit Design (2008, 2010-2019)
- EE20242 Electronics I (2006-7),
- EE67026 Energy-Constrained Devices and Circuits (2006),
- EE67024 Communications Circuit Design (2005)
- EE486 Digital and Analog Integrated Circuits (2005),
- EE30348 Electromagnetic Fields and Waves (2000, 2002, 2009, 2010, 2017)
- EE598F Analog CMOS Design (2001, 2003, 2004)
- EE598 RF Integrated Circuit Design (2002)
- EE556 Fundamentals of Semiconductor Physics (2001, 2003, 2004)
- EE30342 Electronics II (2000-2, 2009)
- EE598F Advanced IC Laboratory Techniques (2000)
- EE598F Advanced Studies in Semiconductor Devices (1999)

3. Professional Memberships and Committees:

- IEEE SOI-3D-Subthreshold Microelec. Technol. Unified Conf. (S3S) Program Committee (2018-2019)
- U.S. - European Union Workshop on 2D (Two Dimensional) Layered Materials and Devices, Technical Program Chair, 2017, General Chair 2018.
- Berkeley Energy Efficient Electronics Symposium (E3S) Program Committee (2016-2017)
- Editorial Advisory Board (EAB) Applied Physics Letters (2016-2022)
- Steep Transistors Workshop (2015, 2016, 2017)
- IEEE Int. Electron Dev. Meeting Technical Program Com., Nano Device Subcommittee (2013, 2014)
- Editorial Advisory Board, Solid State Electronics (2012 - present)
- Editor, Special issue of IEEE J. Electron Devices devoted to Tunnel Transistors (2015)
- Editor, IEEE Trans. Electron Dev. (2010-2013)
- Member APS
- VLSI Symp. Technical Program Committee (2009-2012)
- IEEE NANO 2010 Technical Program Committee
- IEEE Electron Device Society Nanotechnology Committee Chair (2001-2004)
- Device Res. Conf. (DRC) Technical Program Committee (1993-1995, 2001-2003), Local Arrangements Chair (2001), Technical Program Chair (2004), General Chair (2005), Executive Board (2005 -2015)
- Silicon Nanoelectronics Workshop Technical Program Chair (1996), General Chair (1998), Program committee (1999-2001, 2010)
- Int. Electron Dev. Mtg. technical program committee (1999, 2000, 2013-2014)
- Reviewer for Electronics Lett., IEEE Electron Dev. Lett., IEEE Trans. Electron Dev., Appl. Phys. Lett., J. Appl. Phys., Electronics Letters, Nano Letters, J. Vacuum Society B, Science, ...
- IEEE Proceedings guest editor - Quantum Devices and Their Applications (1999).
- Patent Committee: Texas Instruments (1991-1997)
- Patent Committee Raytheon Systems Company (1997-1999)
- SRC Si Tunnel Diode and CMOS/HBT Integration Workshop organizer (1999)

Publications Summary (1/2018)

Journal Publications	129
Book Chapters	6
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Ph.D. Dissertations Advised	16
M.S. Theses Advised	5
U.S. Patents	25
Pending and Provisional Patents	0
Foreign Patents	10

4. Journal Publications

- J132. P. Pandey, W.-S. Hwang, K. R. Udayakumar, T. S. Moise, and A. C. Seabaugh, "Programming-pulse dependence of ferroelectric partial polarization: insights from a comparative study of PZT and HZO capacitors," May 2020.
- J131. S. Fathipour, P. Paletti, S. Fullerton-Shirey, and Alan Seabaugh, "Electric-double-layer *p-i-n* junctions in WSe₂," submitted *Nat. Sci. Rep.*, April 2020.
- J130. P. Paletti, R. Yue, C. Hinkle, and A. Seabaugh, "High mobility WSe₂ thin film transistors grown at low temperature by molecular beam epitaxy on atomic-layer-deposited oxides," submitted *npj2D* 4 March 2020.
- J129. A. Chaney, H. Turski, K. Nomoto, Z. Hu, J. Encomendero, S. Rouvimov, T. Orlova, P. Fay, A.

- Seabaugh, H.G. Xing, and D. Jena, "Gallium nitride tunneling field-effect transistors exploiting polarization fields," *Appl. Phys. Lett.* **116**, 073502 (2020). DOI: <https://doi.org/10.1063/1.5132329>
- J128. Y. Zhang, S. Rouvimov, X. Yuan, K. Gonzalez Serrano, A. Seabaugh, and S. Howard, "Resolution enhancement of transmission electron microscopy by super-resolution radial fluctuations," *Appl. Phys. Lett.* vol. 116, no. 4, 044105, 16 Jan 2020. DOI: <https://doi.org/10.1063/1.5128353>
- J127. M. Asghari Heidarlou, P. Paletti, B. Jariwala, J. A. Robinson, S. K. Fullerton-Shirey, and A. C. Seabaugh, "Batch-fabricated WSe₂-on-sapphire field-effect transistors grown by chemical vapor deposition," *IEEE T Electron Dev*, vol. 67, no. 4, pp. 1839–1844, Apr. 2020. DOI: <https://doi.org/10.1109/TED.2020.2974450>
- J126. P. Paletti, S. Fathipour, M. Remškar, and A. Seabaugh, "Quantitative, experimentally-validated, model of MoS₂ nanoribbon Schottky FETs from subthreshold to saturation," vol. 125, no. 6, *J. Appl. Phys.*, Feb 2020. DOI: <https://doi.org/10.1063/1.5127769>
- J125. P. Paletti, K. Gonzalez-Serrano, and A. Seabaugh, "Time-dependent subthreshold swing arising from the dynamic response of complex oxide gates," submitted to *Trans. Electron Dev.*, 30 Jul 2019.
- J124. W. S. Hwang, P. Zhao, S. G. Kim, R. Yan, G. Klimeck, A. Seabaugh, S. K. Fullerton-Shirey, H. G. Xing, and D. Jena, "Room-temperature graphene-nanoribbon tunneling field-effect transistors," *npj 2D Materials and Applications*, vol. 3, no. 1, p. 666, Nov. 2019. DOI: <https://doi.org/10.1038/s41699-019-0127-1>
- J123. P. Paletti, R. Yue, C. Hinkle, S. K. Fullerton-Shirey, and A. Seabaugh, "Two-dimensional electric-double-layer Esaki diode," *npj 2D Materials and Applications*, vol. 3, no. 1, 1-6, Apr. 2019. DOI: <https://doi.org/10.1038/s41699-019-0101-y>
- J122. C. Alessandri, P. Pandey, A. Abusleme, and A. Seabaugh, "Monte Carlo simulation of switching dynamics in polycrystalline ferroelectric capacitors," *IEEE Trans. Electron Dev.*, vol. 66, no. 8, pp. 3527–3534, Jul. 2019. DOI: <https://doi.org/10.1109/TED.2019.2922268>
- J121. C. Alessandri, P. Pandey, A. Abusleme, and A. Seabaugh, "Switching dynamics of ferroelectric Zr-doped HfO₂," *IEEE Elec. Dev. Lett.*, vol. 39, no. 11, pp. 1780-1783, Nov. 2018. DOI: <https://doi.org/10.1109/LED.2018.2872124>
- J120. D. R. Kazanov, A. V. Poshakinskiy, V. Y. Davydov, A. N. Smirnov, I. A. Eliseyev, D. A. Kirilenko, M. Remškar, S. Fathipour, A. Mintairov, A. Seabaugh, B. Gil, and T. V. Shubina, "Multiwall MoS₂ tubes as optical resonators," *Appl. Phys. Lett.*, vol. 113, no. 10, pp. 101106–6, Sep. 2018. DOI: <https://doi.org/10.1063/1.5047792>
- J119. K. Xu, M. M. Islam, D. Guzman, A. C. Seabaugh, A. Strachan, and S. K. Fullerton-Shirey, "Pulse dynamics of electric double layer formation on all-solid-state graphene field-effect transistors," *ACS Appl. Mat. & Interfaces*, vol. 10, no. 49, pp. 43166–43176, Nov. 2018. DOI: <https://pubs.acs.org/doi/10.1021/acsami.8b13649>
- J118. T. A. Ameen, H. Ilatikhameneh, P. Fay, A. Seabaugh, R. Rahman, and G. Klimeck, "Alloy engineered nitride tunneling field-effect transistor: a solution for the challenge of heterojunction TFETs," *IEEE Trans. Electron Dev.*, vol. 66, no. 1, pp. 736–742, Dec. 2018. DOI: <https://doi.org/10.1109/TED.2018.2877753>
- J117. H. Lu, P. Paletti, W. Li, P. Fay, T. Ytterdal, and A. Seabaugh, "Tunnel FET analog benchmarking and circuit design," *IEEE J. Explor. Solid-State Comput. Devices Circuits*, vol. 4, pp. 19–25 (2018). DOI: <https://doi.org/10.1109/JXCDC.2018.2817541>
- J116. C. Alessandri, S. Fathipour, H. Li, I. Kwak, A. Kummel, M. Remškar, and A. C. Seabaugh, "Reconfigurable electric double layer doping in an MoS₂ nanoribbon transistor," *IEEE Trans. Electron Dev.*, vol. 64, no. 12, pp. 5217–5222, Dec. 2017. DOI: <https://doi.org/10.1109/TED.2017.2767501>
- J115. W.-H. Wang, C. Gong, W. Wang, F. Kong, H. Kim, S. K. Fullerton-Shirey, A. Seabaugh, and K. Cho, "Energetics of metal ion adsorption on and diffusion through crown ethers: first principles study on two-dimensional electrolyte," *Solid State Ionics*, vol. 301, no. C, pp. 176–181, Mar. 2017. DOI: <https://doi.org/10.1016/j.ssi.2017.01.029>
- J114. S. Fullerton, K. Xu, H. Lu, W. Wang, H. Kim, I. Kwak, K. Cho, A. Kummel and A. Seabaugh, "Electrostatic double layer flash memory based on two-dimensional crystals," *Amer. Inst. Chem. Engr. (AIChE)* November 13-18, 2016, San Francisco. DOI: <https://doi.org/10.1149/MA2017-01/12/825>
- J113. H.-M. Li, K. Xu, B. Bourdon, H. Lu, Y.-C. Lin, J. A. Robinson, A. C. Seabaugh, and S. K. Fullerton-

- Shirey, “Electric double layer dynamics in polyethylene oxide LiClO₄ on graphene transistors,” *J. Phys. Chem. C.*, 121, 16996–17004 (2017). DOI: <https://doi.org/10.1021/acs.jpcc.7b04788>
- J112. K. Xu, H. Lu, E. W. Kinder, A. Seabaugh, and S. K. Fullerton-Shirey, “Monolayer solid-state electrolyte for electric double layer gating of graphene field-effect transistors,” *ACS Nano*, vol. 11, no. 6, pp. 5453–5464, Jun. 2017. DOI: <https://doi.org/10.1021/acsnano.6b08505>
- J111. S. Fathipour, P. Pandey, S. Fullerton-Shirey, and A. Seabaugh, “Electric-double-layer doping of WSe₂ field-effect transistors using polyethylene-oxide cesium perchlorate,” *J Appl Phys*, vol. 120, no. 23, p. 234902, Dec. 2016. DOI: <https://doi.org/10.1063/1.4971958>
- J110. J. H. Park, S. Fathipour, I. Kwak, K. Sardashti, C. Ahles, S. Vishwanath, H. G. Xing, S. Fullerton-Shirey, A. Seabaugh, A. Kummel, “Atomic layer deposition of Al₂O₃ on WSe₂ functionalized by titanyl phthalocyanine,” *ACS Nano*, vol. 10, no. 7, pp. 6888–6896, Jul. 2016. DOI: <https://doi.org/10.1021/acsnano.6b02648>
- J109. H. Lu, W. Li, Y. Lu, P. Fay, T. Ytterdal, and A. Seabaugh, “Universal charge-conserving TFET SPICE model incorporating gate current and noise,” *IEEE J. Explor. Solid-State Comput. Devices Circuits*, vol. 2, pp. 20–27, 2016. DOI: <https://doi.org/10.1109/JXCDC.2016.2582204>
- J108. M. R. Müller, R. Salazar, S. Fathipour, H. Xu, K. Kallis, U. Künzelmann, A. Seabaugh, J. Appenzeller, and J. Knoch, “Gate-controlled WSe₂ transistors using a buried triple-gate structure,” *Nanoscale Res. Lett.*, pp. 1–6, Nov. 2016. DOI: <https://doi.org/10.1186/s11671-016-1728-7>
- J107. W.-H. Wang, C. Gong, W. Wang, S. K. Fullerton-Shirey, A. Seabaugh, and K. Cho, “First-principles study of crown ether and crown ether-Li complex interactions with graphene,” *J. Phys. Chem. C*, vol. 119, no. 34, pp. 20016–20022, Aug. 2015. DOI: <https://doi.org/10.1021/acs.jpcc.5b07049>
- J106. H. Lu, I. Kwak, J. H. Park, K. O’Neill, T. Furuyama, N. Kobayashi, A. Seabaugh, A. Kummel, and S. K. Fullerton-Shirey, “Solution-cast monolayers of cobalt crown ether phthalocyanine on highly ordered pyrolytic graphite,” *J. Phys. Chem. C*, vol. 119, no. 38, pp. 21992–22000, Sep. 2015. DOI: <https://doi.org/10.1021/acs.jpcc.5b05233>
- J105. S. Fathipour, M. Remškar, A. Varlec, A. Ajoy, R. Yan, S. Vishwanath, S. Rouvimov, W. S. Hwang, H. G. Xing, D. Jena, and A. Seabaugh, “Synthesized multiwall MoS₂ nanotube and nanoribbon field-effect transistors,” *Appl. Phys. Lett.* 106, 022114 (2015). DOI: <https://doi.org/10.1063/1.4906066>
- J104. H.-M. Li, D. Lee, D. Qu, X. Liu, J. Ryu, A. Seabaugh, and W. J. Yoo, “Ultimate thin vertical p-n junction composed of 2D layered molybdenum disulphide,” *Nat. Comm.* 6, pp. 1-9, Mar. 2015. DOI: <https://doi.org/10.1038/ncomms7564>
- J103. W. Li, S. Sharmin, H. Ilatikhameneh, R. Rahman, Y. Lu, J. Wang, X. Yan, A. Seabaugh, G. Klimeck, D. Jena, and P. Fay, “Polarization-engineered III-nitride heterojunction tunnel field-effect transistors,” *IEEE J. Explor. Solid-State Comput. Devices Circuits*, vol. 1, pp. 28–34, Jul. 2015. DOI: <https://doi.org/10.1109/JXCDC.2015.2426433>
- J102. H. Xu, S. Fathipour, E. Kinder, A. Seabaugh and S. Fullerton-Shirey, “Reconfigurable ion gating in 2H-MoTe₂ field-effect transistors using PEO:CsClO₄ solid polymer electrolyte,” *ACS Nano*, vol. 9, 4900-4910 May 2015. DOI: <https://doi.org/10.1021/nn506521p>
- J101. Z. Jiang, Y. Lu, Y. Tan, Y. He, M. Povolotskyi, T. Kubis, A. Seabaugh, P. Fay, and G. Klimeck, “Quantum transport in AlGaSb/InAs TFETs with gate field in-line with tunneling direction,” *IEEE Trans. Electron Dev.*, vol. 62, 2445-2449 (2015). DOI: <https://doi.org/10.1109/TED.2015.2443564>
- J100. H. Lu, D. Esseni, and A. Seabaugh, “Universal analytic model for tunnel FET circuit simulation,” *Solid State Electronics* 108, pp. 110-117 (2015). DOI: <https://doi.org/10.1016/j.sse.2014.12.002>
- J99. W. S. Hwang, P. Zhao, K. Tahy, L. Nyakiti, V. Wheeler, R. Myers-Ward, C. Eddy, K. Gaskill, J. Robinson, W. Haensch, H. Xing, A. Seabaugh, and D. Jena, “Graphene nanoribbon field-effect transistors on wafer-scale epitaxial graphene on SiC substrates,” *APL Materials*, 3, 011101-9 (2015). DOI: <https://doi.org/10.1063/1.4905155>
- J98. S. Fathipour, N. Ma, W. S. Hwang, V. Protasenko, S. Vishwanath, H. G. Xing, H. Xu, D. Jena, J. Appenzeller, and A. Seabaugh, “Exfoliated multilayer MoTe₂ field-effect transistors,” *Appl. Phys. Lett.* 105, 19210 (2014). DOI: <https://doi.org/10.1063/1.4901527>
- J97. G. Fiori, F. Bonaccorso, G. Iannaccone, T. Palacios, D. Neumaier, A. Seabaugh, S. K. Banerjee, and L. Colombo, “Electronics based on two-dimensional materials,” *Nature Nanotech.* 9, 768-799 (2014).

- DOI: <https://doi.org/10.1038/nano.2014.207>
- J96. H. Lu and A. Seabaugh, "Tunnel field-effect transistors: state-of-the-art," *IEEE J. Electron Devices Soc.*, vol. 2, no. 4, pp. 44–49 (2014). DOI: <https://doi.org/10.1109/JEDS.2014.2326622>
- J95. W. S. Hwang, K. Tahy, P. Zhao, L. O. Nyakiti, V. D. Wheeler, R. L. Myers-Ward, C. R. Eddy Jr., D. K. Gaskill, H. Xing, A. Seabaugh, and D. Jena, "Electronic transport properties of top-gated epitaxial-graphene nanoribbon field-effect transistors on SiC wafers," *J. Vac. Sci. Technol. B*, 32, pp. 012202 (2014). DOI: <https://doi.org/10.1116/1.4861379>
- J94. W. S. Hwang, A. Verma, H. Peelaers, V. Protasenko, S. Rouvimov, H. Grace Xing, A. Seabaugh, W. Haensch, C. Van de Walle, Z. Galazka, M. Albrecht, R. Fornari, and D. Jena, "High-voltage field effect transistors with wide-bandgap β -Ga₂O₃ nanomembranes," *Appl. Phys. Lett.*, vol. 104, no. 20, 203111, May (2014). DOI: <https://doi.org/10.1063/1.4879800>
- J93. Q. Zhang, Y. Lu, C. A. Richter, D. Jena, and A. Seabaugh, "Optimum band gap and supply voltage in tunnel FETs," *IEEE Trans. Electron Dev.*, 61, 2719-2724 (2014). DOI: <https://doi.org/10.1109/TED.2014.2330805>
- J92. A. Seabaugh, "The tunneling transistor," *IEEE Spectrum*, vol. 50, pp. 35–62 (2013). <https://spectrum.ieee.org/semiconductors/devices/the-tunneling-transistor>
- J91. W. S. Hwang, M. Remškar, R. Yan, T. Kosel, J. K. Park, B. J. Cho, W. Haensch, H. G. Xing, A. Seabaugh, and D. Jena, "Comparative study of chemically synthesized and exfoliated multilayer MoS₂ field effect transistors," *Appl. Phys. Lett.*, 102, 043116 (2013). DOI: <https://doi.org/10.1063/1.4789975>
- J90. Q. Zhang, R. Li, R. Yan, T. Kosel, H. G. Xing, A. Seabaugh, K. Xu, O. A. Kirillov, D. J. Gundlach, C. A. Richter, and N. V. Nguyen, "A unique photoemission method to measure semiconductor heterojunction band offsets," *Appl. Phys. Lett.*, 102, 012101, (2013). DOI: <https://doi.org/10.1063/1.4772979>
- J89. K. Xu, C. Zeng, Q. Zhang, R. Yan, P. Ye, K. Wang, A. Seabaugh, H. Xing, J. Suehle, C. Richter, D. Gundlach, and N. Nguyen, "Direct measurement of Dirac point energy at the graphene/oxide interface," *Nano Lett.* 13, 131-136 (2013). DOI: <https://doi.org/10.1021/nl303669w>
- J88. R. Yan, Q. Zhang, O. Kirillov, W. Li, J. Basham, A. Boosalis, X. Liang, D. Jena, C. Richter, A. Seabaugh, D. Gundlach, H. Xing, and N. Nguyen, "Graphene as transparent electrode for direct observation of hole photoemission from silicon to oxide," *Appl. Phys. Lett.* 102, 123106 (2013). DOI: <https://doi.org/10.1063/1.4796169>
- J87. K. Karda, S. Sutar, J. Nahas, J. Brockman, and A. Seabaugh, "Bistable-body tunnel SRAM," *IEEE Trans. Nanotechnology* 11, 1067-1071 (2012). DOI: <https://doi.org/10.1109/TNANO.2010.2053555>
- J86. N. S. Do, D. Schaeztl, B. Dey, A. Seabaugh, and S. Fullerton-Shirey, "Influence of Fe₂O₃ nanofiller shape on the conductivity and thermal properties of solid polymer electrolytes: Nanorods versus nanospheres," *J. Phys. Chem. C*, 116, 21216 (2012). DOI: <https://doi.org/10.1021/jp3059454>
- J85. Q. Liu, L. Dong, Y. Liu, R. Gordon, P. Ye, P. Fay, and A. Seabaugh, "Frequency response of LaAlO₃/SrTiO₃ all-oxide field-effect transistors," *Solid-State Electronics*, 76, 1-4 (2012). DOI: <https://doi.org/10.1016/j.sse.2012.05.044>
- J84. R. Yan, Q. Zhang, W. Li, I. Calizo, T. Shen, C. Richter, A. Hight-Walker, X. Liang, A. Seabaugh, D. Jena, H. Xing, D. Gundlach, and N. V. Nguyen, "Determination of graphene work function and graphene-insulator-semiconductor band alignment by internal photoemission spectroscopy," *Appl. Phys. Lett.*, 101, 022105, 2012. DOI: <https://doi.org/10.1063/1.4734955>
- J83. W. S. Hwang, M. Remškar, R. Yan, V. Protasenko, K. Tahy, S. D. Chae, P. Zhao, A. Konar, H. Xing, A. Seabaugh, and D. Jena, "Transistors with chemically synthesized layered semiconductor WS₂ exhibiting 10⁵ room temperature modulation and ambipolar behavior," *Appl. Phys. Lett.*, 101, 013107 (2012). DOI: <https://doi.org/10.1063/1.4732522>
- J82. W. S. Hwang, K. Tahy, X. Li, H. Xing, A. Seabaugh, C. Y. Sung, and D. Jena, "Transport properties of graphene nanoribbon transistors on chemical-vapor-deposition grown wafer-scale graphene," *Appl. Phys. Lett.*, 100, 203107 (2012). DOI: <https://doi.org/10.1063/1.4716983>
- J81. G. Zhou, Y. Lu, R. Li, Q. Zhang, Q. Liu, T. Vasen, H. Zhu, J.-M. Kuo, T. Kosel, M. Wistey, P. Fay, A. Seabaugh, and H. Xing, "InGaAs/InP tunnel FETs with a subthreshold swing of 93 mV/dec and I_{ON}/I_{OFF} ratio near 10⁶," *IEEE Electron Dev. Lett.*, 33, 6, pp. 782-84 (2012).

- DOI: <https://doi.org/10.1109/LED.2012.2189546>
- J80. W. S. Hwang, K. Tahy, R. L. Myers-Ward, P. M. Campbell, C. R. Eddy Jr., D. K. Gaskill, H. Xing, A. C. Seabaugh, and D. Jena, "Fabrication of top-gated epitaxial graphene nanoribbon FETs using hydrogen-silsesquioxane," *J. Vac. Sci. Technol. B*, 30, 03D104, (2012).
DOI: <https://doi.org/10.1116/1.3693593>
- J79. Y. Lu, G. Zhou, R. Li, Q. Liu, Q. Zhang, T. Vasen, S. D. Chae, T. Kosel, M. Wistey, H. Xing, A. Seabaugh, and P. Fay, "Performance of AlGaSb/InAs TFETs with gate electric field and tunneling direction aligned," *IEEE Electron Device Lett.*, 33, pp. 655-657 (2012).
DOI: <https://doi.org/10.1109/LED.2012.2186554>
- J78. R. Li, Y. Lu, G. Zhou, Q. Liu, S. D. Chae, T. Vasen, W. S. Hwang, Q. Zhang, P. Fay, T. Kosel, M. Wistey, H. Xing, and A. Seabaugh, "AlGaSb/InAs tunnel field-effect transistor with on-current of 78 $\mu\text{A}/\mu\text{m}$ at 0.5 V," *IEEE Electron Device Lett.*, 33, pp. 363-365 (2012).
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- B1. M. A. Reed and A. C. Seabaugh, “Prospects for semiconductor quantum devices,” *Molecular and Biomolecular Electronics*, ed. R. Birge, Adv. Chem. Ser. 240, pp. 15-42 (Amer. Chem. Soc. NY 1994).

6. Short Courses

5. A. C. Seabaugh, “Steep subthreshold swing transistors,” *2017 VLSI-TSA*, Hsinchu, Taiwan.
4. A. Seabaugh, “Tunnel transistors based on two-dimensional crystals – the quest for low voltage technology.” *2015 Muju Int. Winter School*, Muju, Korea.

3. A. C. Seabaugh and B. Dunn, "Nanotechnology: Its future and its implications," *Notre Dame Mendoza School of Business, Army Senior Executive Education Program*, July (2012).
2. A. Seabaugh, "Tunnel field-effect transistor - Engineering a better switch," short course, *Int. Electron Dev. Meeting*, December 4, 2011, Washington, DC.
1. A. C. Seabaugh and P. Mazumder, "Nanoelectronic devices, circuits, and systems," *Gov. Microcircuits Appl. Conf. Short Course*, Arlington, VA (1998).

7. Invited Papers and Presentations

- I133. A. Seabaugh, P. Paletti, M. Asghari Heidarlou, K. Gonzalez Serrano, and P. Pandey, "2D Esaki junctions, Schottky-barrier and tunnel field-effect transistors, and the path to applications," *Graphene & 2D Materials International Conference and Exhibition*, New York, 20-21 February 2020.
- I132. A. Seabaugh, P. Paletti, A. Palit, K. González-Serrano, and P. Pandey, "Dynamics of ferroelectric and ionic memories: physics and applications," *2019 Int. Conf. on ASIC (ASICON)*, Chongqing, China, Oct. 29 - Nov. 1, 2019. DOI: <https://doi.org/10.1109/ASICON47005.2019.8983607>
- I131. A. Seabaugh, C. Alessandri, P. Paletti, P. Pandey, K. Gonzalez, and M. Asghari Heidarlou, "Low-voltage steep-subthreshold-swing transistors," *Norwegian University of Science and Technology (NTNU)*, Trondheim, Norway, 17-19 June 2019.
- I130. A. Seabaugh, C. Alessandri, P. Paletti, P. Pandey, K. Gonzalez, and M. Asghari Heidarlou, "Ferroelectric and ionic gates: action and function," *Norwegian PhD Network on Nanotechnology for Microsystems*, Tromsø, Norway, 17-19 June 2019.
- I129. A. Seabaugh, C. Alessandri, P. Paletti, P. Pandey, K. Gonzalez, and M. Asghari Heidarlou, "Ferroelectric and ionic analog memory," *2019 Int. Nanodevices and Computing Conf. (INC)*, Grenoble, France, 3-5 April 2019.
- I128. A. Seabaugh, C. Alessandri, M. Asghari Heidarlou, K. Gonzalez-Serrano, P. Paletti, P. Pandey, S. Fullerton-Shirey, A. Strachan, and A. Abusleme, "Switching dynamics of ferroelectrics and ionic gates for steep transistors and analog weight storage," *Microelectronics Institute, Peking University*, Beijing, 22 October 2018.
- I127. A. Seabaugh, C. Alessandri, M. Asghari Heidarlou, K. Gonzalez-Serrano, P. Paletti, and P. Pandey, S. Fullerton, C. Hinkle, A. Kummel, J. Robinson, and A. Strachan, "Emerging phenomena at metal-X-semiconductor interfaces for electronics," *2018 Structures and Materials Intelligence Seminar (SMIS), MITRE*, Building 3, McLean, VA, 13-14 June 2018.
- I126. A. Seabaugh, "Electronic applications of 2D materials," *2017 NSF Nanoscale Science and Engineering Grantees Conf.*, Arlington, Va., Dec. 12-13, 2017.
- I125. A. Seabaugh, "Why ferroelectrics and 2D semiconductors are on the electron device horizon," *Boise State University*, 5 April 2017.
- I124. A. Seabaugh and S. Fullerton-Shirey, "Polymer/semiconductor electric double layers for memory and selectors," *Micron Technology*, Boise, Idaho, 30 September 2016.
- I123. A. Seabaugh, C. Alessandri, M. A. Heidarlou, H.-M. Li, L. Liu, H. Lu, S. Fathipour, P. Paletti, P. Pandey, and T. Ytterdal, "Steep slope transistors: tunnel FETs and beyond," *2016 46th European Solid-State Device Research Conference (ESSDERC)* pp. 349–351. DOI: <https://doi.org/10.1109/ESSDERC.2016.7599658>
- I122. A. Seabaugh, "Low voltage steep subthreshold swing transistors for beyond-CMOS analog and digital applications," *École Polytechnique Fédérale de Lausanne (EPFL)*, 20 July 2016.
- I121. A. Seabaugh, S. Fathipour, H.-M. Li, P. Paletti, E. Kinder, L. Liu, H. Lu, M. Asghari, K. González, P. Pandey, C. Alessandri, M. Remškar, and S. Fullerton-Shirey, "2D Tunnel FETs," 19 July 2016, IBM Zurich, Switzerland.
- I120. A. Seabaugh, H. Lu, and S. Fathipour, "Tunnel transistors on transition metal dichalcogenide channels," *IMEC*, Leuven, Belgium, May 13, 2016.
- I119. A. Seabaugh, H. Lu, and S. Fathipour, "Low-voltage steep subthreshold swing transistors," *Int. Nanotech. Conf. Comm. and Coop. (INC12)* Leuven, Belgium, May 12, 2016.

- I118. A. Seabaugh, S. Fathipour, W. Li, H. Lu, J. H. Park, A. Kummel, D. Jena, S. Fullerton-Shirey, and P. Fay, "Steep subthreshold swing tunnel FETs: GaN/InN/GaN and transition metal dichalcogenide channels," *2015 Int. Electron Dev. Meeting*, Washington DC, 12 December.
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- I118. A. Seabaugh, "Ion-doped transition metal dichalcogenide transistors," Jožef Stefan Institute, 13 May 2015, Ljubljana, Slovenia
- I117. A. Seabaugh, H. Lu, J. Appenzeller, S. Datta, D. Jena, V. Narayanan, and B. Wallace, "Center for low energy systems technology (LEAST)," *Government Microcircuit Applications & Critical Technology Conf. (GOMAC)*, March 23-26, 2015, St. Louis, MO.
- I116. A. Seabaugh, "Tunnel field-effect transistors for low voltage electronics," *Altera Corporation*, 18 Dec. 2014, San Jose, CA.
- I115. A. Seabaugh and H. Lu, "Tunnel field-effect transistors – update," *Int. Conf. Solid-State and Integrated Circuit Technology (ICSICT)*, 29 October 2014, Guilin, China.
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- I114. A. Seabaugh, "Tunnel field-effect transistors – the promise and the reality," *Workshop In the Quest of Zero Power: Energy Efficient Computing Devices and Circuits, E2 Switch European Project*, 26 Sept. 2014 Venice, Italy.
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- I113. A. Seabaugh, "Tunnel field-effect transistors: status and challenges," *TSMC*, Taipei, Taiwan, 5 May 2014.
- I112. A. Seabaugh, H. Lu, N. Ma, S. Fathipour, E. Kinder, S. Sabnis, H. Xu, M. Asghari Heidarlou, W. S. Hwang, S. Fullerton-Shirey, and D. Jena, "Materials challenges for steep transistors," *Collaborative Conf. on Materials Res. (CCMR)*, June 23-27, 2014, Incheon/Seoul, South Korea.
- I111. A. Seabaugh and Hao Lu, "Is there life beyond CMOS?" *Int. Electron Dev. Meeting Rump Session*, Washington, DC, 10 December 2013.
- I110. A. Seabaugh, S. Fathipour, H. Xu, N. Ma, E. Kinder, S. Sabnis, S. Fullerton, H. Xing, and D. Jena, "Tunnel FETs based on 2D crystals," *SEMATECH Beyond CMOS Workshop*, Washington, DC, 8 December 2013.
- I109. A. Seabaugh, "The tunneling transistor," *IEEE SPECTRUM*, vol. 50, no. 10, pp. 35–62, September 2013. DOI: <https://spectrum.ieee.org/semiconductors/devices/the-tunneling-transistor>
- I108. A. Seabaugh, "Benchmarking low-voltage steep devices, circuits, and systems," *SRC Nanoelectronics Res. Initiative Benchmarking Workshop*, Rockville, MD, 23 October 2013.
- I107. A. Seabaugh, "The best tunnel diode and tunnel transistor circuits," *TxACE Analog Symp.*, University of Texas at Dallas, Richardson, TX, 21 October 2013.
- I106. A. Seabaugh, "Low-voltage, steep-subthreshold, beyond-CMOS technology," *IEEE SOI-3D-Subthreshold Microelectronics Technology Unified Conf.*, Monterey, CA, 8 October 2013.
- I105. A. Seabaugh, "Steep Subthreshold Swing Transistors," Yonsei University, 6 September 2013.
- I104. A. Seabaugh, "Steep Subthreshold Swing Transistors," SKKU Graphene Center, 6 September 2013.
- I103. A. Seabaugh, "III-V tunnel field-effect transistors and beyond," *Samsung Electronics*, Seoul, Korea, 5 September 2013
- I102. A. Seabaugh, "Recent progress in III-V tunnel FETs," *Topical Workshop on Heterostructure Microelectronics (TWHM)*, Hakodate, Japan, 2 September 2013.
- I101. A. Seabaugh, "DARPA/SRC Center for Low Energy Systems Technology," *University of California, Berkeley NSF Center for Energy Efficient Electronics Science Seminar*, 11 July 2013.
- I100. A. Seabaugh, "The transistor has changed the world. What next?" *Dev. Res. Conf. rump session*, Notre Dame, 25 June 2013.
199. A. Seabaugh, "Steep subthreshold swing transistors," *Int. Symp. on Extremely Low Voltage VLSI Devices and Circuits*, Kyoto, Japan, 15 June 2013
198. A. Seabaugh, "Beyond CMOS transistors," *TechConnect World*, National Harbour, MD, 14 May 2013.
197. A. Seabaugh, "Steep subthreshold swing transistors for low voltage computing," *2013 SEMINATEC*, May 3, University of Campinas, Campinas, Brazil.

196. A. Seabaugh, "Steep subthreshold swing transistors," *University of California, Los Angeles*, 2 April 2013, UCLA, CA.
195. A. Seabaugh, "Nanoelectronics Devices and Circuits," *Pontificia Universidad Católica de Chile (PUC)*, 11 October 2012, Santiago, Chile
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193. A. Seabaugh, "Low-voltage tunnel transistors: Benchmarking and circuits," *Int. Conf. on IC Design and Technology (ICICDT)*, 30 May 2012, Austin, TX.
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167. A. Seabaugh, "Tunneling-based nanoelectronics for power reduction," *7th Topical Workshop on Heterostructure Microelectronics (TWHM)*, (Kazusa Akademia Center), Kisarazu, Chiba, Japan, August 21–24, 2007.
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