

# James T. Teherani

Columbia University  
Assistant Professor, Department of Electrical Engineering  
500 West 120<sup>th</sup> Street, Room 1300  
New York, New York 10027



214.435.9761 (cell)  
j.teherani@columbia.edu  
<http://teherani.ee.columbia.edu>

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## Field of specialization

semiconductor device physics;  
modeling, simulation, and nanoscale fabrication of electronic devices built from 2D materials

## Education

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<b>Massachusetts Institute of Technology</b>	GPA 5.0/5.0	
PhD Electrical Engineering and Computer Science		2015
Thesis: <i>Fundamental Limits of the Switching Abruptness of Tunneling Transistors</i>		
Advisors: Prof. Judy Hoyt and Prof. Dimitri Antoniadis		
S.M. Electrical Engineering and Computer Science		2010
Thesis: <i>Band-to-band Tunneling in Silicon Diodes and Tunnel Transistors</i>		
Advisors: Prof. Judy Hoyt and Prof. Dimitri Antoniadis		
<b>The University of Texas at Austin</b>	GPA 4.0/4.0	
B.S. Electrical and Computer Engineering, Highest Honors		2008

## Professional Experience

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<b>Columbia University</b>		2015 – present
<i>Assistant Professor in the Department of Electrical Engineering</i>		
<b>MIT Department of Electrical Engineering and Computer Science</b>		2015
<i>Postdoctoral associate. Advisor: Prof. Antoniadis</i>		
<b>MIT Department of Electrical Engineering and Computer Science</b>		2008 – 2015
<i>Semiconductor device physics graduate researcher. Advisors: Prof. Hoyt and Prof. Antoniadis</i>		
<b>IBM Research, T. J. Watson Research Center, Yorktown Heights, New York</b>		2009
<i>Device physics intern. Advisor: Dr. Paul Solomon</i>		
<b>DRS Infrared Technologies, Dallas, Texas</b>		2005, 2007
<i>Engineering intern. Advisor: Jeffrey Beck</i>		

## Courses Taught

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<i>ELEN E6333: Semiconductor Device Physics</i>		Fall 2017
12 students; student evaluations: course 4.93/5, instructor 5.00/5		
<i>ELEN E9301: TPC: Theory and Practice of Device Scaling (co-taught with Prof. Theis)</i>		Spring 2017
25 students; student evaluations: course 4.94/5, instructor 4.92/5		

<i>ELEN E4301: Introduction to Semiconductor Devices</i>	<i>Fall 2016</i>
44 students; student evaluations: course 4.69/5, instructor 4.85/5	
<i>Electrical Engineering Lab for ENGI E1102: The Art of Engineering</i>	<i>Spring 2016</i>
~30 students; student evaluations: course 4.08/5, instructor 4.67/5	
<i>ELEN E4301: Introduction to Semiconductor Devices</i>	<i>Fall 2015</i>
16 students; student evaluations: course 4.94/5, instructor 4.75/5	
<i>ELEN E3106: Solid-state Devices and Materials (co-taught with Prof. Kymissis)</i>	<i>Fall 2015</i>
24 students; student evaluations: course 4.13/5, instructor 4.50/5	
<i>Electrical Engineering Lab for ENGI E1102: The Art of Engineering</i>	<i>Fall 2015</i>
~30 students; student evaluations unavailable	

## Supervised Research

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### MS/PhD

Abhinandan Borah, <i>Modeling Charge in Low DOS Systems</i>	<i>2016 – present</i>
Ankur Nipane, <i>Electrostatics of Low Dimensional Junctions</i>	<i>2016 – present</i>

### Postdoctoral Associates

Younghun Jung (co-advised with Prof. Hone)	<i>2016 – present</i>
Minsup Choi (co-advised with Prof. Hone)	<i>2017 – present</i>

### MS

Sirisha Jayanti, <i>Calculation of Potential Across Non-ideal PN Junctions</i>	<i>2017</i>
Punnu Jose Sebastian, <i>Fabrication of Encapsulated van der Waals Structures</i>	<i>2017 – 2018</i>
Tian Sun, <i>Large Field Electromagnet for Electronic Test Set</i>	<i>2017</i>

### Undergraduate

Rebecca Murray, <i>Numerical Modeling of Auger Generation</i>	<i>2016</i>
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### Visiting students

Marco Fratus, MS student from KTH Sweden/Politecnico di Milano	<i>2016 – present</i>
Yefei Zhang, MS/PhD student from Xi'an Jiaotong University	<i>2016 – 2018</i>
Jiayue Li, MS student from Nanjing University	<i>2016 – 2017</i>
Rui Ding, undergraduate from University of Science and Technology of China	<i>2016</i>

## Thesis Committees

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### Committee member

Hyungsik Kim, PhD in Electrical Engineering	<i>2017</i>
<i>Unconventional CVD Graphene and <math>\alpha</math>-MoO<sub>3</sub> Electronics for Very Large Scale Integration (VLSI)</i>	
Scott Trocchia, PhD in Electrical Engineering	<i>2017</i>
<i>Single-molecule Carbon Nanotube Field-effect Transistors for Genomic Applications</i>	

Amrita Masurkar, PhD in Electrical Engineering <i>Charge Injection and Transport in Pentacene Field-Effect Transistors</i>	2016
Tarun Chari, PhD in Electrical Engineering <i>Optimization Studies in Graphene Electronics</i>	2016
Daniel Chenet, PhD in Mechanical Engineering <i>2D Materials: Synthesis, Characterization, and Applications</i> , joined Intel	2016

## Publications

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(by convention, PI is typically listed last)

- J. Teherani**, Y. Zhang, and A. Nipane, "The Unique Electrostatics of Vertical Junctions to 2D Materials," *Int. J. High Speed Electronic Systems: 27th Connecticut Symposium on Microelectronics & Optoelectronics (CMOC)*, 2018.
- J. Teherani**, "The Auger FET: a Novel Device Concept for Subthermal Switching," *IEEE Electron Devices Technology and Manufacturing (EDTM) Conference*, 2018.
- M. Choi, Y. Jung, D. Rhodes, B. Kim, **J. Teherani**, J. Hone, and W. Yoo, "Study of Contact Properties for Semiconducting TMDCs Using Via Contacts Embedded in h-BN," *Bulletin of the American Physical Society*, 2018.
- A. Nipane, S. Jayanti, A. Borah, and **J. Teherani**, "Electrostatics of lateral p-n junctions in atomically thin materials," *Journal of Applied Physics*, vol. 122, no. 19, p. 194501, Nov. 2017.
- A. Kerelsky, A. Nipane, D. Edelberg, D. Wang, X. Zhou, A. Motmaendadgar, H. Gao, S. Xie, K. Kang, J. Park, **J. Teherani**, and A. Pasupathy, "Absence of a Band Gap at the Interface of a Metal and Highly Doped Monolayer MoS<sub>2</sub>," *Nano Lett.*, Sep. 2017.
- J. Teherani**, "A Comprehensive Theoretical Analysis of Hole Ballistic Velocity in Si, SiGe, and Ge: Effect of Uniaxial Strain, Crystallographic Orientation, Body Thickness, and Gate Architecture," *IEEE Transactions on Electron Devices*, vol. 64, no. 8, pp. 3316–3323, Aug. 2017.
- A. Kerelsky, A. Nipane, D. Edelberg, D. Wang, M. Cheng, A. Dadgar, H. Gao, K. Kang, J. Park, **J. Teherani**, and A. Pasupathy, "Band Structure Evolution in Vertically Contacted MoS<sub>2</sub> Probed Using Scanning Tunneling Spectroscopy," in *Bulletin of the American Physical Society*, vol. Volume 62, Number 4, March 2017.
- J. Teherani**, S. Agarwal, W. Chern, P. Solomon, E. Yablonovitch, and D. Antoniadis, "Auger generation as an intrinsic limit to tunneling field-effect transistor performance," *Journal of Applied Physics*, vol. 120, no. 8, p. 084507, Aug. 2016.
- J. Teherani**, W. Chern, S. Agarwal, J. Hoyt, and D. Antoniadis, "A framework for generation and recombination in tunneling field-effect transistors," in *2015 Fourth Berkeley Symposium on Energy Efficient Electronic Systems (E3S)*, 2015, pp. 1–3.
- J. Teherani**, "Fundamental limits of the switching abruptness of tunneling transistors," Thesis, Massachusetts Institute of Technology, 2015.
- J. Teherani**, W. Chern, D. Antoniadis, and J. Hoyt, "Ultra-Thin, High Quality HfO<sub>2</sub> on Strained-Ge MOS Capacitors with Low Leakage Current," *ECS Transactions (also presented at the ECS SiGe, Ge, and Related Compounds Symposium)*, vol. 64, no. 6, pp. 267–271, Oct. 2014.

- T. Yu, **J. Teherani**, D. Antoniadis, and J. Hoyt, "Effects of substrate leakage and drain-side thermal barriers in In<sub>0.53</sub>Ga<sub>0.47</sub>As/GaAs<sub>0.5</sub>Sb<sub>0.5</sub> quantum-well tunneling field-effect transistors," *Appl. Phys. Express*, vol. 7, no. 9, p. 094201, Sep. 2014.
- S. Agarwal, **J. Teherani**, J. Hoyt, D. Antoniadis, and E. Yablonovitch. "Engineering the Electron-Hole Bilayer Tunneling Field-Effect Transistor," *IEEE Transactions on Electron Devices*, vol. 61, no. 5, pp. 1599–1606, April 2014.
- W. Chern, P. Hashemi, **J. Teherani**, D. Antoniadis, and J. Hoyt, "Record Hole Mobility at High Vertical Fields in Planar Strained Germanium on Insulator with Asymmetric Strain," *IEEE Electron Device Letters*, vol. 35, no. 3, pp. 309–311, March 2014.
- J. Teherani**, "Uniaxial and Biaxial Stress/Strain Calculator for Semiconductors," on *nanoHUB.org*, 2014.
- T. Yu, **J. Teherani**, D. A. Antoniadis, and J. Hoyt, "InGaAs/GaAsSb Quantum-Well Tunnel-FETs With Tunable Backward Diode Characteristics," *IEEE Electron Device Letters*, vol. 34, no. 12, pp. 1503–1505, Dec. 2013.
- J. Teherani**, T. Yu, D. Antoniadis, and J. Hoyt, "Electrostatic design of vertical tunneling field-effect transistors," *Third Berkeley Symposium on Energy Efficient Electronic Systems*, Oct. 2013.
- J. Teherani**, W. Chern, D. Antoniadis, and J. Hoyt, "Simulation of Enhanced Hole Ballistic Velocity in Asymmetrically Strained Germanium Nanowire Trigate p-MOSFETs," *IEEE International Electron Devices Meeting (IEDM)*, 2013, pp. 32.4.1–32.4.4.
- J. Teherani** and J. Hoyt, "A Physically-Intuitive Method for Calculation of the Local Lattice Constant from a High-Resolution Transmission Electron Microscopy Image by Fourier Analysis," *arXiv e-print 1309.3155*, Sep. 2013.
- J. Teherani**, "TEM Lattice Calculator," on *nanoHUB.org*, 2013.
- S. Agarwal, **J. Teherani**, J. Hoyt, D. Antoniadis, and E. Yablonovitch, "Optimization of the electron hole bilayer tunneling field effect transistor," *Device Research Conference (DRC)*, 2013, pp. 109–110.
- J. Teherani**, S. Agarwal, E. Yablonovitch, J. Hoyt, and D. Antoniadis, "Impact of Quantization Energy and Gate Leakage in Bilayer Tunneling Transistors," *IEEE Electron Device Letters*, vol. 34, no. 2, pp. 298–300, Feb. 2013.
- W. Chern, P. Hashemi, **J. Teherani**, T. Yu, Y. Dong, G. Xia, D. Antoniadis, and J. Hoyt, "High mobility high-K-all-around asymmetrically-strained Germanium nanowire trigate p-MOSFETs," *IEEE International Electron Devices Meeting (IEDM)*, 2012, pp. 16.5.1–16.5.4.
- J. Teherani**, W. Chern, D. Antoniadis, J. Hoyt, L. Ruiz, C. Poweleit, and J. Menéndez, "Extraction of large valence-band energy offsets and comparison to theoretical values for strained-Si/strained-Ge type-II heterostructures on relaxed SiGe substrates," *Phys. Rev. B*, vol. 85, no. 20, p. 205308, May 2012.
- P. Hashemi, W. Chern, H. Lee, **J. Teherani**, Y. Zhu, J. Gonsalvez, G. Shahidi, and J. Hoyt, "Ultrathin Strained-Ge Channel P-MOSFETs With High-K/Metal Gate and Sub-1-nm Equivalent Oxide Thickness," *IEEE Electron Device Letters*, vol. 33, no. 7, pp. 943–945, July 2012.
- P. Solomon, I. Lauer, A. Majumdar, **J. Teherani**, M. Luisier, J. Cai, and S. Koester, "Effect of uniaxial strain on the drain current of a heterojunction tunneling field effect transistor," *IEEE Electron Device Letters*, vol. 32, no. 4, pp. 464–466, April 2011.
- J. Teherani**, "Band-to-band tunneling in silicon diodes and tunnel transistors," S.M. thesis, Massachusetts Institute of Technology, Cambridge, MA, 2010.

- P. Hashemi, **J. Teherani**, and J. Hoyt, "Investigation of hole mobility in gate-all-around Si nanowire p-MOSFETs with high-k/metal-gate: effects of hydrogen thermal annealing and nanowire shape," *IEEE International Electron Device Meeting (IEDM)*, 2010, pp. 34.5.1–34.5.4.
- J. Beck, R. Scritchfield, B. Sullivan, **J. Teherani**, C. Wan, M. Kinch, M. Ohlson, M. Skokan, L. Wood, P. Mitra, M. Goodwin, and J. Robinson, "Performance and modeling of the MWIR HgCdTe electron avalanche photodiode," *Journal of Elec. Materials (co-published in Proc. of SPIE)*, vol. 38, no. 8, pp. 1579–1592, 2009.
- H. Schaake, M. Kinch, D. Chandra, F. Aqariden, P. Liao, D. Weirauch, C.-F. Wan, R. Scritchfield, W. Sullivan, **J. Teherani**, and H. Shih, "High-Operating-Temperature MWIR Detector Diodes," *Journal of Electronic Materials*, vol. 37, no. 9, pp. 1401–1405, Sep. 2008.

## Grants

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### Current

*Sponsor:* National Science Foundation

*Title:* CAREER: Exploiting Many-Particle Physics for Low-Energy Nanoelectronics

*Lead PI:* J. Teherani

*Total Amount:* \$500,000

*Award Period:* 2/15/2018 – 1/31/2023

*Location:* Columbia University

*Sponsor:* National Science Foundation

*Title:* Collaborative Research: REU Site: Nano-NY

*Lead PI:* I. Kymissis (Columbia University)

*Total Amount:* \$372,997

*Award Period:* 4/1/2018 – 3/31/2020

*Location:* Columbia University

### Pending

*Sponsor:* National Science Foundation

*Title:* Probing the Physics of Metal Contacts to 2D Materials through Novel Techniques

*Lead PI:* J. Teherani

*Total Amount:* \$498,172

*Award Period:* 6/1/2018 – 5/31/2021

*Location:* Columbia University

*Sponsor:* National Science Foundation

*Title:* Howard-Columbia Partnership for Research and Education in Superatomic and 2D Materials (PRES2M)

*Lead PI:* S. Gatica (Howard University)

*Total Amount:* \$600,000

*Award Period:* 10/1/2018 – 9/30/2024

*Location:* Columbia University

## Awards and Honors

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Edward and Carole Kim Faculty Involvement Award — for excellent teaching and service to students	2018
National Science Foundation CAREER Award	2018
National Science Foundation Graduate Fellowship	2010 – 2015
George E. Smith Award (best paper in IEEE Electron Device Letters journal)	2014
NSF Center for Energy Efficient Electronics Science Leadership Award	2014
National Defense Science and Engineering Graduate Fellowship (NDSEG)	2010 – 2013
National Nanotechnology Infrastructure Network (NNIN) International Winter School Fellow	2011
Purdue University, Network for Computation Nanotechnology Summer School Scholarship	2011
University of Texas, Engineering Foundation Undergraduate Endowed Presidential Scholarship	2007
University of Texas, B. N. Gafford Scholarship in Electrical and Computer Engineering	2006
DRS Technologies Academic Scholarship	2006

## Invited Talks

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The 27 <sup>th</sup> Connecticut Symposium on Microelectronics & Optoelectronics (CMOC) <i>The Unique Electrostatics of Vertical Junctions to 2D Materials</i>	April 2018
2018 IEEE Electron Devices Technology and Manufacturing (EDTM) Conference <i>The Auger FET: a Novel Device Concept for Subthermal Switching</i>	March 2018
University of Texas at Austin <i>Auger generation as an intrinsic limit to tunneling field-effect transistor performance</i>	Feb. 2017
Massachusetts Institute of Technology, Microsystems Tech. Annual Research Conference <i>Opportunities after Graduate School</i>	Jan. 2017
Steep Slope Workshop at École Polytechnique Fédérale de Lausanne <i>Auger generation as an intrinsic limit to tunneling field-effect transistor performance</i>	Sept. 2016
IBM T. J. Watson Research Center <i>Auger generation as an intrinsic limit to tunneling field-effect transistor performance</i>	Aug. 2016
DRS Infrared Technologies <i>Auger generation as an intrinsic limit to tunneling field-effect transistor performance</i>	July 2016
Purdue University <i>Auger generation as an intrinsic limit to tunneling field-effect transistor performance</i>	June 2016
University of Notre Dame <i>Auger Generation as a Fundamental Limit to the Off-state of TFETs</i>	Feb. 2016

## Service

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### University Service

Faculty Advisor, Columbia University Amateur Radio Club	2018 – present
Faculty Advisor, Columbia University Society of Women Engineers	2016 – present
Member, Department of Electrical Engineering Undergraduate Committee	2015 – present

**Service to the Discipline**

Editor, IEEE Transactions on Electron Devices, Special Issue on 2D Materials for Electronic, Optoelectronic and Sensor Devices	2017 – present
Member, IEEE Electron Device Society, Nanotechnology Committee	2017 – present
Panelist, Department of Defense National Defense Science and Engineering Graduate (NDSEG) Fellowship	2017, 2018

**Public Outreach**

MakeCU Hardware Hackathon, Faculty Judge	2018
SAT Physics Workshop for Students from <i>Bronx Center for Science and Mathematics</i>	2018
Columbia Engineering Achievers in Graduate Education (EngAGE), diversity recruitment <i>Lecture on Graduate Education and Research</i>	2017, 2018
Society of Women Engineers, Faculty Panel on Research and Career Opportunities	2017
Educational Outreach Video, <a href="#">Is Moore's Law Ending?</a>	2017
Society of Women Engineers, Engineering Exploration Experience, <i>Electricity from our Bare Hands</i>	2017
Columbia Engineering Outreach Programs, Inside Engineering	
<i>John Ericsson Middle School, Brooklyn, New York</i>	2018
<i>Mott Hall II Middle School, Manhattan, New York</i>	2017
<i>Mott Hall II Middle School, Manhattan, New York (second visit)</i>	2017
<i>Scholars' Academy, Queens, New York</i>	2016
<i>Lower East Side Preparatory High School, Manhattan, New York</i>	2016
<i>Mott Hall II Middle School, Manhattan, New York</i>	2016
<i>Bayside High School, Bronx, New York</i>	2016
GOALS (Greater Opportunities Advancing Leadership and Science) for Girls	2016
Society of Women Engineers, Engineering Exploration Experience, <i>How Computer Chips Work</i>	2016
MakeCU Hardware Hackathon, <i>How to Hack Like An Engineer</i>	2016
Science & Engineering Expo at the School at Columbia, <i>How to Make Computer Chips</i>	2016
Society of Women Engineering, Panel on Undergraduate Research	2015
MIT+K12 Videos, <a href="#">What is a Semiconductor?</a>	2015
<i>Video creator and actor, engaging, entertaining, and educational STEM video with 190,000 views</i>	
MIT+K12 Videos, <a href="#">How Computers Compute</a>	2014
<i>Video creator and actor, engaging, entertaining, and educational STEM video with 30,000 views</i>	
MIT Online Science, Technology, and Engineering Community (MOSTEC)	2013, 2014
<i>Guest lecturer, STEM enrichment lecture to inspire underserved high school seniors</i>	
MIT Educational Studies Program, Spark	2013
<i>Teacher, taught Saturday classes to ~100 students middle school students on computer chip fabrication</i>	
MIT Minority Introduction to Engineering and Science (MITES)	2012
<i>Guest lecturer, STEM program serving under-represented high school juniors</i>	

- MIT+K12 and Khan Academy, [Series and Parallel Circuits: A Water Analogy](#) 2012  
*Video and experiment creator and actor*, demonstration of different types of circuits with **12,000 views**
- Cambridge Science Festival IDEAS Competition 2012  
*Mentor*, advised team in local green technologies competition
- MIT Society of Women Engineers, Women in Science & Engineering Program (WiSE) 2012  
*Guest lecturer*, STEM outreach to inspire young women
- MIT Society of Women Engineers, Keys to Empowering Youth 2010  
*Guest lecturer*, engineering outreach to middle school girls
- University of Texas, UTeach Outreach 2006 – 2007  
*Teacher*, taught a weekly hands-on science unit to four local elementary school classrooms
- University of Texas, Student Engineers Educating Kids (SEEK) 2006  
*Mentor*, academic weekly mentor to students from disadvantaged middle schools