Jeehwan Kim

Associate Professor of Mechanical Engineering
Associate Professor of Materials Science and Engineering

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Research Projects

Neuromorphic computing	- 1R-based ANN arrays for online training/inference (NSF) - Artificial synapses based on single-crystalline ReRAM (SRC)
Remote epitaxy, **Graphene-based layer transfer**	- III-V/III-N MicroLEDs - Freestanding InGaAs-based IR Photodectors (LG) - Freestanding Multifunctional complex oxides for magnetoelectric coupling (DARPA) - SiC/III-N power electronics (ROHM, Analog Device)
Renewable energy, **Energy storage**	- Wafer recycling technique for GaAs solar cells based on remote epitaxy (DOE) - High efficiency III-V multi-junction solar cells based on remote epitaxy (AFRL) - Single-crystalline all solid-state battery (Hyundai Motors)
Heterointegration, **Flexible electronics**	- Skin strain sensor arrays (Amore Pacific) - Flexible/transparent microLEDs - Self-powered IoT system
Two-dimensional materials	- Monolayer-by-monolayer splitting of wafer-scale 2D materials - Wafer-scale single-crystalline 2D materials - Wafer-scale 2D heterostructures

Education

Ph.D.	Materials Science and Engineering	University of California at Los Angeles, CA, USA	2008
M.S.	Materials Science and Engineering	Seoul National University, Seoul, Korea	1999
B.S.	Materials Science and Engineering	Hongik University, Seoul, Korea	1997

Work Experience

Massachusetts Institute of Technology, *Cambridge, MA* Mechanical Engineering, Materials Science and Engineering	Associate Professor	2018 – date
Massachusetts Institute of Technology, *Cambridge, MA* Research Laboratory of Electronics	Principal Investigator	2016 – date
Massachusetts Institute of Technology, *Cambridge, MA* Department of Materials Science and Engineering	Assistant Professor	2016 – 2018
Massachusetts Institute of Technology, *Cambridge, MA* Department of Mechanical Engineering	Assistant Professor	2015 – 2018
IBM T.J. Watson Research Center, *Yorktown Heights, NY* Department of Silicon Technology	Research Staff Member	2008 – 2015
IBM T.J. Watson Research Center, *Yorktown Heights, NY* Department of Silicon Technology	Research Intern	2007

Teaching Experience

2.671 Instrument and Measurement 2017
Massachusetts Institute of Technology, MA
2.674 Micro-Nano Engineering Laboratory 2016
Massachusetts Institute of Technology, MA
2.001 Mechanics & Materials 2015
Massachusetts Institute of Technology, MA
MSE 104, Introduction to Materials Science 2005 – 2006
University of California at Los Angeles, CA

Awards

IBM Faculty Award 2016
IBM Corporation
Lam Research Foundation Grant 2016
LAM Research
Master Inventor of IBM Corporation 2012
IBM
High Value Patent Application Awards (10 times) 2011 – 2015
IBM
Invention Achievement Awards (23 times) 2009 – 2015
IBM

Professional Activities

Technical Committee/Chair
Organizer of Compound Semiconductor Week 2018, IEEE Electron Device Society, The International Conference on Silicon Epitaxy and Hetero-structures, The International Society for Optics and Photonics
Journal referee
Nature Communications, Science Advances, Advanced Materials, ACS Nano, Scientific Reports, Small, Nanoscale, Applied Physics Letters, Journal of Materials Chemistry A, IEEE Electron Device Letters, IEEE transactions on Nanotechnologies, Journal of Electrochemical Society, Organic Electronics

Articles Featuring Prof. Kim's Research Achievement

Nature News & Views: Tightening grip
https://www.nature.com/articles/s41563-018-0020-x
MIT News: Engineers design artificial synapse for "brain-on-a-chip" hardware
http://news.mit.edu/2018/engineers-design-artificial-synapse-brain-on-a-chip-hardware-0122
The Verge: MIT researchers say new chip design takes us closer to computers that work like our brains
https://www.theverge.com/2018/1/24/16927040/ai-neuromorphic-engineering-computing-mit-brain-chip
eeNews: Low power artificial synapse chip points was to artificial brain
http://www.eenewseurope.com/news/low-power-artificial-synapse-chip-points-way-artificial-brain-0
Nature News & Views: Materials Science: Crystals align through graphene
http://www.nature.com/nature/journal/v544/n7650/full/544301a.html
MIT News: Not stuck on silicon
http://news.mit.edu/2017/graphene-copy-machine-cheaper-semiconductor-wafers-0419
EETimes: New Method Cuts Cost of GaAs Circuits
http://www.eetimes.com/document.asp?doc_id=1331617
IEEE Spectrum: Graphene Makes Infinite Copies of Compound Semiconductor Wafers
http://spectrum.ieee.org/nanoclast/semiconductors/materials/graphene-makes-infinite-copies-of-exotic-semiconductor-wafers
MIT News: Researchers "iron out" graphene
http://news.mit.edu/2017/iron-out-graphene-wrinkles-conductive-wafers-0403

EETimes: IBM Conquers Wafer-Scale Graphene
http://www.eetimes.com/document.asp?doc_id=1324128
IBM Research News: First wafer-scale single-crystalline monolayer graphene
http://ibmresearchnews.blogspot.com/2013/11/exfoliating-wafer-scale-graphene-down.html#fbid=Ramw25RHxOc
IBM Research News: Growing single-crystalline materials on reusable graphene
http://ibmresearchnews.blogspot.com/2014/09/growing-single-crystalline-materials-on.html
EETimes Europe: GaN for analog boosted by IBM tape lift-off
http://www.electronics-eetimes.com/en/gan-for-analog-boosted-by-ibm-tape-lift-off.html?cmp_id=7&news_id=222922628&page=2
Electronics Weekly: Will 2015 be the key year for graphene?
http://www.electronicsweekly.com/news/research/materials-rd/will-2015-key-year-graphene-2015-01/
Electronics Weekly: Graphene gets another real use – blue LED fabrication
http://www.electronicsweekly.com/news/research/graphene-gets-another-real-use-blue-led-production-2014-10/
Semiconductor Today: Van der Waals epitaxy of GaN and blue LEDs http://www.semiconductor-today.com/news_items/2014/OCT/IBM_021014.shtml
Compound Semiconductor: Big Blue ambition
http://www.compoundsemiconductor.net/article/95377-big-blue-ambition.html
Compound Semiconductor: US researchers use graphene to make flexible blue LEDs on plastic
http://www.compoundsemiconductor.net/article/95059-us-researchers-use-graphene-to-make-flexible-blue-leds-on-plastic.html

List of Publications

Journal Papers (Corresponding authors)

1. Sanghoon Bae, Wei Kong, Hyun Kum, and **Jeehwan Kim***
   "Growths and applications of three-dimensional materials on two-dimensional materials"
   Nature Materials (2018) *In preparation*, *Invited review*

2. Jaewoo Shim, Sang-Hoon Bae, Wei Kong, Kuan Qiao, Daniel Nezich, Ruike Zhao, Suresh Sundaram, Xin Li, Yunjo Kim, Chanyeol Choi, Doyoon Lee, Ruoyu Yue, Kyusang Lee, Jagadeesh Moodera, Xuanhe Zhao, Christopher Hinkle, Abdallah Ougazzaden, and **Jeehwan Kim***
   "Atomic precision control of wafer-scale two-dimensional materials: From multilayers precisely into monolayers"
   Science (2018) *Under Revision*

3. Wei Kong, Huashan Li, Kuan Qiao, Yunjo Kim, Kyusang Lee, Tom Osadchy, Richard J Molnar, D. Kurt Gaskill, Rachael L. Myers-Ward, Kevin M. Daniels, Yuewei Zhang, Suresh Sundram, Yang Yu, Sang-hoon Bae, Siddharth Rajan, Yang Shao-Horn, Abdallah Ougazzaden, Jeffrey C. Grossman*, and **Jeehwan Kim***
   "Polarity governs atomic interaction through two-dimensional materials"
   Nature Materials (2018) *Under Revision*

4. Shinhyun Choi, Scott Tan, Yunjo Kim, Chanyeol Choi, Pai-Yu Chen, and Shimeng Yu, and **Jeehwan Kim***,
   "SiGe Epitaxial Memory for Neuromorphic Computing with reproducible high performance based on engineered dislocations",
   Nature Materials, Vol. 17, 335–340 (2018) *Featured as a table of content cover*

5. Yunjo Kim, Samuel S. Cruz, Kyusang Lee, Babatunde O. Alawode, Chanyeol Choi, Yi Song, Jared M. Johnson, Chris Heidelberger, Wei Kong, Shinhyun Choi, Kuan Qiao, Eugene A. Fitzgerald, Jing Kong, Alexie M. Kolpak, Jinwoo Hwang, and **Jeehwan Kim***,
   "Remote epitaxy through graphene enables two-dimensional material-based layer transfer"
   Nature, Vol. 544, 340–343 (2017) *Featured as a front cover*

6. Sang-Hoon Bae, Xiaodong Zhou, Seyoung Kim, Yun Seog Lee, Samuel Cruz, Yunjo Kim, James B. Hannon, Yang Yang, Devendra K. Sadana, Frances M. Ross, Hongsik Park, and **Jeehwan Kim***
   "Unveiling the carrier transport mechanism in epitaxial graphene for forming wafer-scale, single-domain graphene",
   Proceedings of the National Academy of Science, Vol. 114, 4082-4086 (2017)

7. Talia Gershon, Yun Seog Lee, Teodor K. Todorov, Wei Wang, Mark T. Winkler, Marinus Hopstaken,Oki Gunawan, **Jeehwan Kim***
   "Atomic layer deposited aluminum oxide for interface passivation of $Cu_2ZnSn(S,Se)_4$ thin-film solar cells
   Advanced Energy Materials, 1600198 (2016)

8. **Jeehwan Kim*,** Ziruo Hong*, Gang Li, Tze-bin Song, Jay Chey, Devendra Sadana, and Yang Yang*, "10.5% amorphous silicon/polymer tandem photovoltaic cell", ***Nature Communications***, Vol. 6, 6391 (2015)

9. **Jeehwan Kim***, Can Bayram*, Hongsik Park*, Cheng-Wei Cheng, Christos Dimitrakopoulos, John A. Ott, Kathleen B. Reuter, Stephen W. Bedell, and Devendra K. Sadana, "Principle of direct van der Waals epitaxy of single-crystalline films on epitaxial graphene", ***Nature Communications,*** Vol. 5, 4836 (2014)

10. **Jeehwan Kim***, Corsin Battaglia*, Mathieu Charrière, Augustin Hong, Wooshik Jung, Hongsik Park, Christophe Ballif, and Devendra Sadana, "9.4% efficient three-dimensional amorphous silicon solar cells on high aspect-ratio glass microcones", ***Advanced Materials***, Vol. 26, 4082 (2014)

11. **Jeehwan Kim*,** Homare Hiroi*, Teodor K. Todorov*, Oki Gunanwan, Masaru Kuwahara, Tayfun Gokmen, Dhruv Nair,

Marinus Hopstaken, Byungha Shin, Hiroki Sugimoto, and David Mitzi, "High-efficiency $Cu_2ZnSn(S,Se)_4$ solar cells by applying a double In_2S_3/CdS emitter" ***Advanced Materials,*** Vol. 26, 7427 (2014) *Frontispiece*

12. **Jeehwan Kim***, Hongsik Park*, James B. Hannon, Stephen W. Bedell, Keith Fogel, Devendra K. Sadana, Christos Dimitrakopoulos*, "Layer-resolved graphene transfer via engineered strain layers", ***Science,*** Vol. 342, 833 (2013)

13. **Jeehwan Kim***, Augustin Hong, Bhupesh Chandra, George Tulevski, and Devendra K. Sadana, "Engineering of contact resistance between transparent single-walled carbon nanotube films and a-Si:H single junction solar cells by gold nanodots", ***Advanced Materials,*** Vol. 24, 1899 (2012)

14. **Jeehwan Kim***, Augustin J. Hong, Jae-Woong Nah, Byungha Shin, Frances M. Ross, and Devendra K. Sadana, "Three-Dimensional a-Si:H Solar Cells on Glass Nanocone Arrays Patterned by Self-Assembled Sn Nanospheres", ***ACS Nano,*** Vol. 6, 265 (2012)

15. **Jeehwan Kim***, Stephen W Bedell, and Devendra Sadana, "Multiple implantation and multiple annealing of phosphorus doped germanium to achieve n-type activation near theoretical limit" ***Applied Physics Letters,*** Vol. 101, 112107 (2012)

16. **Jeehwan Kim***, Ahmed Abou-Kandil, Augustin J. Hong, Mohamed Saad, Devendra K. Sadana, and Tze-Chiang Chen, "Efficiency Enhancement of a-Si:H single junction solar cells by a-Ge:H incorporation at the p-type a-SiC:H/transparent conducting oxide interface", ***Applied Physics Letters,*** Vol. 99, 062102 (2011)

17. **Jeehwan Kim***, Stephen W. Bedell, and Devendra K. Sadana , "Improved germanium n+/p diodes formed by coimplantation of antimony and phosphorus", ***Applied Physics Letters,*** Vol. 98, 082112 (2011)

18. **Jeehwan Kim***, Ahmed Abou-Kandil, Keith Fogel, Harold Hovel, and Devendra K Sadana "The role of high work-function metallic nanodots on the performance of a-Si:H solar cells : Offering ohmic contacts to light trapping", ***ACS Nano,*** Vol. 4, 7331 (2010)

19. **Jeehwan Kim***, Daniel Inns, Keith Fogel, and Devendra K. Sadana, "Surface texturing of single-crystalline silicon solar cells using low density SiO_2 films as an anisotropic etch mask", ***Solar Energy Materials and Solar Cells,*** Vol. 94, 2091 (2010)

20. **Jeehwan Kim***, Daniel Inns, and Devendra K. Sadana, "Investigation on critical failure thickness of hydrogenated/non-hydrogenated amorphous silicon films", ***Journal of Applied Physics,*** Vol. 107, 073507 (2010)

21. **Jeehwan Kim***, Stephen W. Bedell, Siegfried Maurer, Rainer Loesing, and Devendra K. Sadana, "Activation of implanted n-type dopants in Ge over the active concentration of 1×10^{20} cm^{-3} using co-implantation of Sb and P", ***Electrochemical and Solid-state Letters***, Vol 13, H12 (2010)

22. **Jeehwan Kim***, Daniel Inns, and Devendra K. Sadana, "Cracking behavior of evaporated amorphous silicon films", ***Thin Solid Films***, Vol. 518, 4908 (2010)

23. **Jeehwan Kim***, Stephen Bedell, Devendra Sadana, "> 10^{20} cm^{-3} n-doping in Ge by Sb/P Co-implants: n+/p Diodes with Improved Rectification", ***ECS Transactions,*** Vol 33, 201 (2010)

24. **Jeehwan Kim***, Jae Young Lee, and Ya-Hong Xie, "Fabrication of dislocation-free Si films under uniaxial tension via oxidation of porous Si substrates", ***Thin Solid Films***, Vol 516, 7599 (2008)

25. **Jeehwan Kim***, Biyun Li, and Ya-Hong Xie, "A method for fabricating dislocation-free tensile-strained SiGe films via the oxidation of porous Si substrates", ***Applied Physics Letters***, Vol 91, 252108 (2007)

26. **Jeehwan Kim*** and Ya-Hong Xie, "The fabrication of dislocation-free tensile strained Si thin films using controllably oxidized porous Si substrates", ***Applied Physics Letters***, Vol 89, 152117 (2006)

Journal Papers (Contributing-authored)

1. Piran R. Kidambi, Michael S. Boutilier, Luda Wang, Doojon Jang, **Jeehwan Kim**, and Rohit Karnik, "Selective Nanoscale Mass Transport across Atomically Thin Single Crystalline Graphene Membranes", ***Advanced Materials***, (2017)

2. Jaewoo Shim, Seo-Hyeon Jo, Minwoo Kim, Young Jae Song, **Jeehwan Kim**, and Jin-Hong Park, "Light-Triggered Ternary Device and Inverter Based on Heterojunction of van der Waals Materials", ***ACS Nano***, Vol. 11, 6319 (2017)

3. Jaewoo Shim, Hyo Seok Kim, Yoon Su Shim, Dong-Ho Kang, Hyung-Youl Park, Jaehyeong Lee, Jaeho Jeon, Seong Jun Jung, Young Jae Song, Woo-Shik Jung, Jaeho Lee, Seongjun Park, **Jeehwan Kim**, Sungjoo Lee, Yong-Hoon Kim, and Jin-Hong Park, "Extremely Large Gate Modulation in Vertical Graphene/WSe2 Heterojunction Barristor Based on a Novel Transport Mechanism", ***Advanced Materials***, Vol. 28, 5293 (2016)

4. Can Bayram, John Ott, Kuen-Ting Shiu, Cheng-Wei Cheng, Yu Zhu, **Jeehwan Kim**, Manijeh Razeghi, and Devendra Sadana, "Cubic Phase GaN on Nano-grooved Si (100) via Maskless Selective Area Epitaxy", ***Advanced Functional Materials***, Vol. 24, 4492 (2014), *Frontispiece*

5. In-yeal Lee, Hyung-Youl Park, Jin-hyung Park, Gwangwe Yoo, Myung-Hoon Lim, Junsung Park, Rathi Servin, Woo-Shik Jung, **Jeehwan Kim**, Sang-Woo Kim, Yonghan Roh, Gil-Ho Kim and Jin-Hong Park, "Poly-4-vinylphenol and Poly(melamine-co-formaldehyde)-based Graphene Passivation Method for Flexible, Wearable and Transparent Electronics", ***Nanoscale,*** Vol. 6, 3830 (2014)

6. Young T Chae, **Jeehwan Kim**, Hongsik Park, and Byungha Shin, "Building Energy Performance Evaluation of Building Integrated Photovoltaic (BIPV) Window with Semi-transparent Solar Cells", ***Applied Energy,*** Vol. 129, 217 (2014)

7. Seong-Uk Yang, Seung-Ha Choi, Jongtaek Lee, **Jeehwan Kim**, Woo-Shik Jung, Hyun-Yong Yu, Yonghan Roh, Jin-Hong Park, "Depth-Controllable Ultra Shallow Indium Gallium Zinc Oxide/Gallium Arsenide Hetero Junction Diode", ***Journal of Alloys and Compounds***, Vol. 561, 228 (2013)

8. Osama Tobail, **Jeehwan Kim**, and Devendra Sadana, "Method to Determine the Collection Length in Field-Driven a-$Si_{1-x}Ge_x$:H Solar Cells", ***Energy Procedia***, Vol. 10, 213 (2011)

9. J. Liu, T. M. Lu, **J. Kim**, K. Lai, D. C. Tsui, and Y. H. Xie, "The proximity effect of the regrowth interface on two-dimensional electron density in strained Si", ***Applied Physics Letters***, Vol 92, 112113 (2008)

10. J. Liu, **J.H. Kim**, Y.H. Xie, T.M. Lu, and K. Lai, "Epitaxial growth of two-dimensional electron gas (2DEG) in strained silicon for research on ultra-low energy electronic processes", ***Thin Solid Films***, Vol 517, 45 (2008)

11. T. M. Lu, J. Liu, **J. Kim**, K. Lai, D. C. Tsui, and Y. H. Xie, "Capacitively induced high mobility two-dimensional electron gas in undoped $Si/Si_{1-x}Ge_x$ heterostructures with atomic-layer-deposited dielectric", ***Applied Physics Letters***, Vol 90, 182114 (2007)

12. Z. M. Zhao, T. S. Yoon, W. Feng, B.Y. Li, **J. H. Kim**, J. Liu, O. Hulko, Y. H. Xie, H. M. Kim, K. B. Kim, H. J. Kim, K. L. Wang, C. Ratsch, R. Caflisch, D. Y. Ryu, and T. P. Russell, "The challenges in guided self-assembly of Ge and InAs quantum dots on Si", ***Thin Solid Films***, Vol 508, No.1, 195 (2006)

144 US Patents (70 Issued, 74 pending)

1	Grant #	9,459,797	Uniformly distributed self-assembled cone-shaped pillars for high efficiency solar cells
2	Grant #	9,443,997	Hybrid CZTSSe photovoltaic device
3	Grant #	9,443,957	Self-aligned source and drain regions for semiconductor devices
4	Grant #	9,418,870	Silicon germanium-on-insulator formation by thermal mixing
5	Grant #	9,401,397	Reduction of defect induced leakage in III-V semiconductor devices
6	Grant #	9,394,178	Wafer scale epitaxial graphene transfer
7	Grant #	9,379,259	Double layered transparent conductive oxide for reduced schottky barrier in photovoltaic devices
8	Grant #	9,337,436	Transferable transparent conductive oxide
9	Grant #	9,337,274	Formation of large scale single crystalline graphene
10	Grant #	9,331,220	Three-dimensional conductive electrode for solar cell
11	Grant #	9,324,813	Doped zinc oxide as N.sup.+ layer for semiconductor devices
12	Grant #	9,324,794	Self-formation of high-density arrays of nanostructures
13	Grant #	9,324,566	Controlled spalling using a reactive material stack
14	Grant #	9,318,641	Nanowires formed by employing solder nanodots
15	Grant #	9,312,132	Method of forming high-density arrays of nanostructures
16	Grant #	9,306,107	Buffer layer for high performing and low light degraded solar cells
17	Grant #	9,231,133	Nanowires formed by employing solder nanodots
18	Grant #	9,214,577	Reduced light degradation due to low power deposition of buffer layer
19	Grant #	9,203,022	Resistive random access memory devices with extremely reactive contacts
20	Grant #	9,190,549	Solar cell made using a barrier layer between p-type and intrinsic layers
21	Grant #	9,153,729	Atomic layer deposition for photovoltaic devices
22	Grant #	9,123,842	Photoreceptor with improved blocking layer
23	Grant #	9,123,838	Transparent conductive electrode for three dimensional photovoltaic device
24	Grant #	9,105,854	Transferable transparent conductive oxide
25	Grant #	9,105,805	Enhancing efficiency in solar cells by adjusting deposition power
26	Grant #	9,099,664	Transferable transparent conductive oxide
27	Grant #	9,096,050	Wafer scale epitaxial graphene transfer
28	Grant #	9,093,290	Self-formation of high-density arrays of nanostructures
29	Grant #	9,070,617	Reduced S/D contact resistance of III-V mosfet using low temperature metal-induced crystallization of n+ Ge
30	Grant #	9,059,272	Self-aligned III-V MOSFET fabrication with in-situ III-V epitaxy and in-situ metal epitaxy and contact formation
31	Grant #	9,059,271	Self-aligned III-V MOSFET fabrication with in-situ III-V epitaxy and in-situ metal epitaxy and contact formation
32	Grant #	9,059,013	Self-formation of high-density arrays of nanostructures
33	Grant #	9,040,428	Formation of metal nanospheres and microspheres
34	Grant #	9,040,340	Temperature grading for band gap engineering of photovoltaic devices
35	Grant #	9,035,282	Formation of large scale single crystalline graphene
36	Grant #	8,933,456	Germanium-containing release layer for transfer of a silicon layer to a substrate
37	Grant #	8,927,857	Silicon: hydrogen photovoltaic devices, such as solar cells, having reduced light induced degradation and method of making such devices
38	Grant #	8,916,451	Thin film wafer transfer and structure for electronic devices
39	Grant #	8,916,409	Photovoltaic device using nano-spheres for textured electrodes
40	Grant #	8,901,695	High efficiency solar cells fabricated by inexpensive PECVD

41	Grant #	8,889,466	Protective insulating layer and chemical mechanical polishing for polycrystalline thin film solar cells
42	Grant #	8,889,456	Method of fabricating uniformly distributed self-assembled solder dot formation for high efficiency solar cells
43	Grant #	8,878,055	Efficient nanoscale solar cell and fabrication method
44	Grant #	8,866,003	Solar cell employing an enhanced free hole density p-doped material and methods for forming the same
45	Grant #	8,859,321	Mixed temperature deposition of thin film silicon tandem cells
46	Grant #	8,846,440	Germanium photodetector
47	Grant #	8,841,544	Uniformly distributed self-assembled solder dot formation for high efficiency solar cells
48	Grant #	8,841,162	Germanium photodetector
49	Grant #	8,828,504	Deposition of hydrogenated thin film
50	Grant #	8,822,317	Self-aligned III-V MOSFET diffusion regions and silicide-like alloy contact
51	Grant #	8,735,210	High efficiency solar cells fabricated by inexpensive PECVD
52	Grant #	8,685,858	Formation of metal nanospheres and microspheres
53	Grant #	8,679,947	Self-formation of high-density defect-free and aligned nanostructures
54	Grant #	8,653,360	Compositionally-graded band gap heterojunction solar cell
55	Grant #	8,642,431	N-type carrier enhancement in semiconductors
56	Grant #	8,628,999	Solar cell made in a single processing chamber
57	Grant #	8,628,996	Uniformly distributed self-assembled cone-shaped pillars for high efficiency solar cells
58	Grant #	8,624,361	Self-formation of high-density defect-free and aligned nanostructures
59	Grant #	8,617,938	Device and method for boron diffusion in semiconductors
60	Grant #	8,614,116	Germanium photodetector
61	Grant #	8,536,043	Reduced S/D contact resistance of III-V MOSFET using low temperature metal-induced crystallization of n+ Ge
62	Grant #	8,476,152	N-type carrier enhancement in semiconductors
63	Grant #	8,354,694	CMOS transistors with stressed high mobility channels
64	Grant #	8,343,863	N-type carrier enhancement in semiconductors
65	Grant #	8,304,272	Germanium photodetector
66	Grant #	8,298,923	Germanium-containing release layer for transfer of a silicon layer to a substrate
67	Grant #	8,178,430	N-type carrier enhancement in semiconductors
68	Grant #	8,039,371	Reduced defect semiconductor-on-insulator hetero-structures
69	Grant #	7,935,612	Layer transfer using boron-doped SiGe layer
70	Grant #	7,754,008	Method of forming dislocation-free strained thin films
71	Publication #	20140147958	atomic layer deposition for photovoltaic devices
72	Publication #	20150340536	atomic layer deposition for photovoltaic devices
73	Publication #	20140217408	buffer layer for high performing and low light degraded solar cells
74	Publication #	20160204290	buffer layer for high performing and low light degraded solar cells
75	Publication #	20130298980	cone-shaped holes for high efficiency thin film solar cells
76	Publication #	20150263191	cone-shaped holes for high efficiency thin film solar cells
77	Publication #	20130298971	cost-efficent high power pecvd deposition for solar cells
78	Publication #	20150255650	cost-efficient high power pecvd deposition for solar cells
79	Publication #	20160111576	cost-efficient high power pecvd deposition for solar cells
80	Publication #	20160240620	doped zinc oxide and n- doping to reduce junction leakage
81	Publication #	20160190260	doped zinc oxide as n+ layer for semiconductor devices
82	Publication #	20140127853	double layered transparent conductive oxide for reduced schottky barrier in photovoltaic devices
83	Publication #	20160300965	double layered transparent conductive oxide for reduced schottky barrier in photovoltaic devices

84	Publication #	20130092213	efficiency restoration in a photovoltaic cell
85	Publication #	20130092214	efficiency restoration in a photovoltaic cell
86	Publication #	20140014162	efficiency restoration in a photovoltaic cell
87	Publication #	20140120655	enhancing efficiency in solar cells by adjusting deposition power
88	Publication #	20150228728	formation of large scale single crystalline graphene
89	Publication #	20150228824	formation of metal nanospheres and microspheres
90	Publication #	20150083036	gallium nitride material and device deposition on graphene terminated wafer and method of forming the same
91	Publication #	20150084074	gallium nitride material and device deposition on graphene terminated wafer and method of forming the same
92	Publication #	20160020283	hetero-integration of iii-n material on silicon
93	Publication #	20110272010	high work function metal interfacial films for improving fill factor in solar cells
94	Publication #	20150188682	hybrid zero-forcing beamforming method and apparatus
95	Publication #	20160240610	junction interlayer dielectric for reducing leakage current in semiconductor devices
96	Publication #	20160276524	led light extraction enhancement enabled using self-assembled particles patterned surface
97	Publication #	20160276628	led light extraction enhancement enabled using self-assembled particles patterned surface
98	Publication #	20100221867	low cost soi substrates for monolithic solar cells
99	Publication #	20150027521	low reflection electrode for photovoltaic devices
100	Publication #	20160268377	low resistance contact for semiconductor devices
101	Publication #	20160300925	low resistance contact for semiconductor devices
102	Publication #	20140124019	low vacuum fabrication of microcrystalline solar cells
103	Publication #	20140127852	low vacuum fabrication of microcrystalline solar cells
104	Publication #	20070111468	method for fabricating dislocation-free stressed thin films
105	Publication #	20130048061	monolithic multi-junction photovoltaic cell and method
106	Publication #	20160072002	nanowires formed by employing solder nanodots
107	Publication #	20160233361	nanowires formed by employing solder nanodots
108	Publication #	20120325305	ohmic contact between thin film solar cell and carbon-based transparent electrode
109	Publication #	20150249212	optoelectronics integration by transfer process
110	Publication #	20130344644	photoreceptor with improved blocking layer
111	Publication #	20150075608	photovoltaic device using nano-spheres for textured electrodes
112	Publication #	20130312828	photovoltaic device with band-stop filter
113	Publication #	20140196780	photovoltaic devices with an interfacial band-gap modifying structure and methods for forming the same
114	Publication #	20160260859	photovoltaic devices with an interfacial band-gap modifying structure and methods for forming the same
115	Publication #	20140306306	protective insulating layer and chemical mechanical polishing for polycrystalline thin film solar cells
116	Publication #	20160079456	reduced light degradation due to low power deposition of buffer layer
117	Publication #	20150270428	reduction of light induced degradation in thin film silicon solar cells
118	Publication #	20150243888	resistive random access memory devices with extremely reactive contacts
119	Publication #	20120285517	schottky barrier solar cells with high and low work function metal contacts
120	Publication #	20160268128	selective epitaxy using epitaxy-prevention layers
121	Publication #	20130001659	self-aligned iii-v mosfet diffusion regions and silicide-like alloy contact

122	Publication #	20130309830	self-aligned iii-v mosfet fabrication with in-situ iii-v epitaxy and in-situ metal epitaxy and contact formation
123	Publication #	20150235903	self-aligned iii-v mosfet fabrication with in-situ iii-v epitaxy and in-situ metal epitaxy and contact formation
124	Publication #	20150228501	silicon germanium-on-insulator formation by thermal mixing
125	Publication #	20160268460	single crystalline cztsse photovoltaic device
126	Publication #	20160268468	single crystalline cztsse photovoltaic device
127	Publication #	20160071995	solar cell made using a barrier layer between p-type and intrinsic layers
128	Publication #	20120285518	solar cell with interdigitated back contacts formed from high and low work-function-tuned silicides of the same metal
129	Publication #	20160204304	substrate-free thin-film flexible photovoltaic device and fabrication method
130	Publication #	20110212622	surface texturing using a low quality dielectric layer
131	Publication #	20120222730	tandem solar cell with improved absorption material
132	Publication #	20150263199	tandem solar cell with improved absorption material
133	Publication #	20120318335	tandem solar cell with improved tunnel junction
134	Publication #	20130000706	tandem solar cell with improved tunnel junction
135	Publication #	20150228833	temperature grading for band gap engineering of photovoltaic devices
136	Publication #	20140220764	thin film wafer transfer and structure for electronic devices
137	Publication #	20150255641	three-dimensional conductive electrode for solar cell
138	Publication #	20160204286	three-dimensional conductive electrode for solar cell
139	Publication #	20140004648	transparent conductive electrode for three dimensional photovoltaic device
140	Publication #	20150325713	transparent conductive electrode for three dimensional photovoltaic device
141	Publication #	20150280023	uniformly distributed self-assembled cone-shaped pillars for high efficiency solar cells
142	Publication #	20140065752	uniformly distributed self-assembled solder dot formation for high efficiency solar cells
143	Publication #	20120285520	wafer bonded solar cells and fabrication methods
144	Publication #	20150336800	wafer scale epitaxial graphene transfer

Invited Talks

1. **Harvard University** "Material challenges and opportunities in next generation electronics: From non-silicon electronics to artificial neural network", 2018
2. **Hong Kong Polytechnic University** "Material challenges and opportunities in next generation electronics: From non-silicon electronics to artificial neural network", 2018
3. **Huawei** "New paradigm of resistive memory that can enable large-scale neuromorphic computing", Shenzhen, China, 2018
4. **Boston University** "Material challenges and opportunities in next generation electronics: From non-silicon electronics to artificial neural network", 2018
5. **Naval Research Laboratory** "Material challenges and opportunities in next generation electronics: From non-silicon electronics to artificial neural network", 2018
6. **MRS Fall** "Uniform epitaxial SiGe memory by one dimensional filament confinement for large-scale synaptic arrays", Boston, 2017
7. **MIT Mechanical Engineering Colloquium**, "Material challenges and opportunities in next generation electronics: From non-silicon electronics to artificial neural network", 2017
8. **Hynix** "New paradigm of resistive memory that can enable large-scale neuromorphic computing", Ichon, Korea, 2018
9. **Tsinghua University** "2D material-based layer transfer based on remote epitaxy & uniform epitaxial RAM towards large-scale neuromorphic arrays", 2017

10. **University of California, Berkeley** "2D material-based layer transfer based on remote epitaxy & uniform epitaxial RAM towards large-scale neuromorphic arrays", 2017
11. **Stanford University** "2D material-based layer transfer based on remote epitaxy & uniform epitaxial RAM towards large-scale neuromorphic arrays", 2017
12. **University of California, Santa Barbara** "2D material-based layer transfer based on remote epitaxy & uniform epitaxial RAM towards large-scale neuromorphic arrays", 2017
13. **University of Illinois, Urbana-Champaign** "2D material-based layer transfer based on remote epitaxy & uniform epitaxial RAM towards large-scale neuromorphic arrays", 2017
14. **University of Massachusetts, Amherst** "Innovation in epitaxy still required for next generation computing", 2017
15. **2D Electronic Materials Symposium** "Remote epitaxy through graphene" Santa Fe, NM, 2017
16. "Recent Advance in graphene-based layer transfer", **ECS**, New Orleans, LA, 2017
17. "Recent Advance in graphene-based layer transfer", **TMS**, San Diego, CA, 2017
18. "Graphene-based layer transfer", **Semicon Korea**, Seoul, 2017
19. "Extremely cost-effective semiconductor layer transfer & Advanced epitaxial RAM", **MIT-Japan conference**, Tokyo, 2017
20. "Recent Advance in graphene-based layer transfer", **MRS** Fall, Boston, 2016
21. "Advanced ReRAM for neuromorphic computing", **Samsung**, Seoul, Korea, 2016
22. "Nanoelectronics Group at MIT", **Seoul National University**, Seoul, Korea, 2016
23. "Nanoelectronics Group at MIT", **KAIST**, Daejon, Korea, 2016
24. "Nanoelectronics Group at MIT", **Hynix**, Ichon, Korea, 2016
25. "Graphene-based layer transfer for low-cost, high-throughput, high-efficiency solar cells", **LG Electronics**, Seoul, Korea, 2015
26. "Single-crystalline graphene and its application for semiconductor layer transfers", **Lincoln Laboratory**, 2015
27. "Single-crystalline graphene and its application for semiconductor layer transfers", **NASA Jet Propulsion Laboratory**, Los Angeles, 2015
28. "Single-crystalline graphene and its application for semiconductor layer transfers, **SKKU**, Seoul, Korea, 2015
29. "Nanotechnology for Photovoltaics: Strategies for scalable manufacturing of efficient solar cells", Energy Science Institute, **Yale University**, 2015
30. "Atomic-precision control of nanoscale materials via strain engineering towards scalable manufacturing", Mechanical Engineering, **MIT**, 2015
31. "Material innovations for nanoelectronics: Atomic-precision control of two-dimensional materials", School of Engineering and Applied Science, **Harvard University**, 2015
32. "Atomic-Precision Control of Single-Crystalline 2D Materials & Design Principles of 3D PV Architectures", Electrical and Computer Engineering , **University of Illinois, Urbana-Champaign**, 2014
33. "Atomic-precision Control of Single-crystalline 2D Materials & Recent Progress on Thin Film PV in IBM", Electrical Engineering, **UC Berkeley**, 2014
34. "Atomic-precision Control of Single-crystalline 2D Materials & Recent Progress on Thin Film PV in IBM", Yale Institute for Nanoscience and Quantum Engineering, **Yale University**, 2014
35. "Wafer-scale Single-crystalline Graphene & High-aspect Ratio Three-dimensional PV", Applied Physics and Materials Science, **Caltech**, 2014
36. "Wafer-scale Single-crystalline Graphene and Its applications", Department of Materials Science and Engineering, **UCLA**, 2014
37. "Atomic-precision Control of Two-dimensional Materials & Design Principles of Three-dimensional PV Architectures", Materials Department, **UC Santa Barbara**, 2014
38. "Atomic-precision Control of Two-dimensional Materials & Design Principles of Three-dimensional PV Architectures", Department of Materials Science and Engineering, **MIT**, 2014
39. "Nanocone-based three dimensional thin film silicon solar cells" **SPIE**, San Diego, CA, 2012
40. "Nanostructured 3D Solar cells", Department of Materials Science and Engineering, **UCLA**, 2012
41. "Nanocone-based three dimensional thin film silicon solar cells", Department of Electrical Engineering, **Sungkyunkwan University**, Korea, 2012
42. "Role of Nanostructures on the Performance of a-Si:H Solar Cells", **Optical Society of America**, Austin, TX, 2011
43. "Effect of Work-Function Engineering of p+/TCO interface on the Performance of a-Si:H Solar Cell", IMT, **École Polytechnique Fédérale de Lausanne (EPFL)**, Switzerland, 2011
44. "The role of high work-function metallic nanodots on the performance of amorphous silicon solar cells", Department of Materials Science and Engineering, **Seoul National University**, Korea, 2010
45. "Plasmonics in thin film solar cells", Department of Electrical Engineering, **KAIST**, Korea, 2010

46. “Solar cell and Advanced CMOS research in IBM”, Department of Materials Science and Engineering, **UCLA**, 2010
47. “Plasmonics in thin film solar cells”, Department of Materials Science & Engineering, **Hongik University**, Korea, 2010
48. "n-type Ge MOSFET”, **Korea Advanced Nano Fabrication Center**, Korea, 2010