MICHAEL LEE ROUKES

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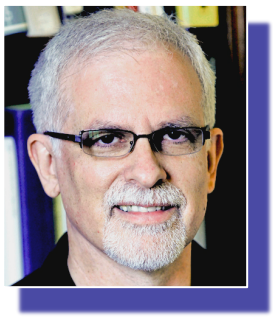

Citizenship: USA

Education:

Ph.D., Physics 1985 Cornell University, Ithaca, NY

- *Doctoral Thesis:* *Hot Electrons and Energy Transport in Metals at mK Temperatures*
- *Thesis Advisor: Prof. Robert C. Richardson, Nobel Laureate, Ultralow Temperature Physics*

B.A., Physics & Chemistry 1978 (**Double Major**) University of California, Santa Cruz

- *Undergraduate Thesis:* *Theory of Path Curvature and Momentum Transfer in Collinear Atom-Diatomic Reactive Scattering*
- *Thesis Advisor: Prof. Eugene Switkes, Theoretical Chemistry*
- *Honors: University Honors, Highest Honors in Physics, Highest Honors in Chemistry, Thesis Honors.*

Scientific Employment:

2018 - present	Frank J. Roshek Professor of Physics, Applied Physics, and Bioengineering, **California Institute of Technology**, Pasadena, CA.
2011-2017	Robert M. Abbey Professor of Physics, Applied Physics, and Bioengineering, **California Institute of Technology**, Pasadena, CA.
2011- present	Co-Founder, **APIX Analytics, S.A.** Grenoble, France
2008 – 2013	Co-Director, **Kavli Nanoscience Institute,** **California Institute of Technology**, Pasadena, CA.
2008 – 2013	Chaire d'Excellence **Fondation Nanosciences, Grenoble, France** **Réseau Thématique de Recherche Avancée (RTRA)**
2003 – 2006	Founding Director **Kavli Nanoscience Institute,** **California Institute of Technology**, Pasadena, CA.
2002 – present	Professor of Physics, Applied Physics, and Bioengineering **California Institute of Technology**, Pasadena, CA.
1995 – 2002	Professor of Physics **California Institute of Technology**, Pasadena, CA.
1992 –1995	Associate Professor of Physics *(tenured)* **California Institute of Technology**, Pasadena, CA.
1985 - 1992	Member of Technical Staff / Principal Investigator **Quantum Structures Research** **Bell Communications Research**, Red Bank, NJ.
1984-1987	Scientific Affiliate (1984), Visiting Scientist (1985-87) **Microkelvin Research Laboratory,** **Cornell University**, Ithaca, NY.

1978-1985	Graduate Research Assistant, Department of Physics **Cornell University**, Ithaca, NY *Advisor:* Prof. Robert C. Richardson
1983-1985	Collaborative Research on Superconducting Electronics **IBM T.J. Watson Research Laboratory**, Yorktown Heights, NY *Sponsor:* Dr. Mark B. Ketchen
1974-1978	Undergraduate Research Assistantships **University of California, Santa Cruz** *Advisors:* Profs. E. Switkes, G. Hammond, R. Hinegardner

Selected Honors & Professional Affiliations:

NIH Director's Transformative Research Award, National Institute of Health (USA), 2023

Chevalier (*Knight*), Ordre des Palmes Académiques, République Française, 2012

NIH Director's Pioneer Award, National Institute of Health (USA), 2010

Invited Contributor, "The Edge of Physics", Scientific American 2005

Fellow, American Physical Society, 1999

Distinguished Lecturer, University of Toronto, Electrical Engineering, 2017

Distinguished Lecturer, Jet Propulsion Laboratory, Electrical Engineering, 2016

Distinguished Lecturer, EPFL, Lausanne, Institut de Microtechnique (IMT), 2016

Director's Lecture, Los Alamos National Laboratory, 2015

Cooper Lecture, Cornell University, 2015

Munushian Lecture, University of Southern California, 2015

President's Lecturer, International Brain Research Organization, 2015

Distinguished Lecturer, National Institute of Nanotechnology & University of Alberta, 2015

Niels Bohr Lecture, University of Copenhagen, 2014

Distinguished Lecture, Lawrence Berkeley National Laboratory, 2014

Distinguished Lecturer, EPFL, Lausanne, Electrical Engineering, 2014

Distinguished Lecturer, Biological Engineering, KAUST, 2014

Llewellyn-Thomas Lecturer, University of Toronto, 2007

Director's Lecture, National Institute of Health, 2007

Lillian Gilbreth Lecturer (selected from all "Frontiers of Engineering" programs), National Academy of Engineering, 2002

Selected Accomplishments:

1990-1992: While a Member of Technical Staff/Principal Investigator at Bell Communications Research in the *Quantum Structures Research* division, I created the ***first nanoelectromechanical systems (NEMS)*** with senior fabrication engineer, Larry Schiavone. While it wasn't until I moved to Caltech in 1992 that I began work with my group to characterize these systems, one of these "world's first NEMS" are pictured in a feature article in *Science*

that contained an interview with me about this nascent line of research and about my early visions of what it could enable (John Travis, ***Building Bridges to the Nanoworld***, *Science* **263** (5154), 1702-1703 (1994).)

1999: I was asked by DARPA to organize what was the ***world's first workshop on NEMS***, held in San Diego from 22-23 April 1999.

2002: I organized the first school (1 day) and first open conference (5 days), the ***First international Conference and School on Nanoscale/Molecular Mechanics*** (n/m^2), held on Maui in May 2002. I raised significant funding to cover the conference itself, as well as full support and travel expenses for 50 graduate students aspiring to enter this field. Many students went on to achieve high recognition in this field of physics.

2001: I authored two early vision papers outlining the potential of nanomechanical systems; both have since been highly cited: M.L. Roukes, ***Nanoelectromechanical systems face the future***, *Physics World* **14** (2), 25 (2001), and M.L. Roukes, ***Plenty of room, indeed***, *Scientific American* **285** (3), 48-57 (2001). The latter was reprinted in Scientific American's *The Edge of Physics* (vol **13**, No. 1, (2003) as *Nanophysics: Plenty of Room, Indeed*.)

2002: I was appointed by the Caltech Administration to organize and lead a pitch to Dr. David Auston, then President of the *Kavli Foundation*, to create a nanoscience institute at Caltech. We competed against two other internal pitches (for centers on Cosmology/Astrophysics and Neuroscience). Our proposal was accepted and awarded by the Foundation in 2003, and the Caltech Administration then named me the nascent center's ***founding Director***. Caltech's ***Kavli Nanoscience Institute (KNI)*** was the first nanoscience institute worldwide in what is now the Kavli Foundation's constellation of funded centers.

2002: Along with three other scientists, I met with, Elias Zerhouni (then Director of the U.S. National Institutes of Health), Andrew von Essenbach (then Director of the National Cancer Institute, Story Landis, (then Director of the National Institute of Neurological Disorders and Stroke), and several other NIH directors to propose what ultimately became the National Cancer Institute's ***Alliance for Nanotechnology in Cancer***.

2003: Science published a feature article entitled ***Researchers Race to Put the Quantum into Mechanics***, which described the friendly competition in research amongst my former postdocs now with labs of their own in various parts of the world (and myself!) to take NEMS to the quantum limit. (A.Cho, *Science* **299**, 36-37 (2003); DOI: 10.1126/science.299.5603.36)

2005: Together with former postdoc, Keith Schwab (at this point a researcher in his own lab at the NSA *Laboratory for Physical Sciences*), I published an article in ***Physics Today*** envisioning the future era of NEMS in the quantum regime entitled, ***Putting mechanics into quantum mechanics*** (*Physics Today* **58**, 36-42 (2005); DOI: 10.1063/1.2012461).

2008: A large-scale print of an electron micrograph showing our suspended NEMS device that first unveiled the quantum of thermal conductance – which was taken by my postdoc Keith Schwab and colorized by me – was acquired for the permanent collection of the ***Museum of Modern Art*** in New York City.

2011: I organized ***TEDxCaltech: Feynman's Vision - The Next 50 Years***, held on January 14, 2011, which celebrated the genius of Caltech physicist Richard Feynman in a series of forward-looking talks in the TED (conference) format. A list of speakers and their talk videos can be found online: http://www.tedxcaltech.com/speakers_2011.html .

2011: I was one of the six scientists to first advocate, first in a white paper and then in-person at several meetings in the White House Office of Science and Technology Policy (OSTP), a large-scale U.S. national neuroscience project to accelerate technology for functional connectomics. Our concept of a ***Brain Activity Map project*** ultimately led to the creation of President Obama's ***BRAIN Initiative***, which was launched in 2013.

2013: I organized ***TEDxCaltech: The Brain***, which was held on January 19, 2013 at Caltech. It featured 23 speakers at the forefront of neuroscience in a series of forward-looking talks in the TED (conference) format, exploring what we know – and importantly, *what we don't*. (See: http://www.tedxcaltech.com/speakers.html)

2016: Founded the multi-institution ***Neurotech Alliance*** to disseminate state-of-the-art neurotechnology to the neuroscience research community. See: https://www.openneurotech.org.

2023: Co-Founded ***NanoSCAn Systems, Inc.*** – with the aim of commercializing Nanosystems-enabled Single-Cell Analysis instrumentation for deep profiling of the single-cell proteome with single-molecule resolution and high throughput.

Other Selected Activities:

- Member, Advisory Committee of the **CPR (*Cluster of Pioneering Research*) of RIKEN**, Sept 2017 – present.
- Chair/Co-Organizer, **International Conference on the *Frontiers of Nanomechanical Systems* (FNS/2019)**, Palm Springs, CA, USA – February 2019.
- Chair/Co-Organizer, **Kavli Futures Symposium: *Next-Gen Neurotechnology for Biology and Medicine***, Santa Monica, CA, October 2017; Santa Monica, CA, October 2018
- Co-Organizer, **International Conference on the *Frontiers of Nanomechanical Systems* (FNS/2017)**, Thiule, Italy – February 2017.
- Chair/Co-Organizer, **Kavli Futures Symposium: *Toward Open-Source Neurotechnology Dissemination***, Santa Monica, CA, October 2017; Santa Monica, CA, October 2018
- Chair/Organizer, **14th International Workshop on Nanomechanical Sensors (NMC/2017)**, Kona, Hawaii, 2017.
- Organizer, **Open Gathering in Support of Caltech's International Scholars**, Caltech, 2017.
- Founder, **Neurotechnology Alliance** (openneurotech.org), 2016.
- Chair, Organizer, **TEDxCaltech: *The Brain***, Caltech, 2013.
- Co-organizer, Working group advocating the ***BRAIN Initiative*, White House Office of Science and Technology Policy**, 2011-2013.
- Chair, Organizer, **TEDxCaltech: *Feynman's Vision—The Next 50 Years***, Caltech, 2011.
- Chair/Co-Organizer, **Kavli Futures Symposium: *Plenty of Room in the Middle: Nanoscience — The Next 50 Years***, Caltech, 2011.
- Co-Founder, ***APIX Analytics, S.A.***, Grenoble, France, 2011.
- Co-Organizer, **Kavli Futures Symposium: *Growing High Performance Computing in a Green Environment***, Tromsø, Norway, 2010.
- Chair/Co-Organizer, **Kavli Futures Symposium: *The Future of Computing, from Extreme to Green***, 2009.
- Founding Director, ***Kavli Nanoscience Institute***, Caltech 2003-2006; Co-Director 2005-2013.
- Panelist, *Fred Friendly Seminar* (***Television Series for PBS***) www.fredfriendly.org "Nanotechnology: The Power of Small", Broadcast on PBS, 2008.
- Co-organizer/Co-Chair (with Prof. Keith Schwab, Cornell U.), ***Second International Workshop on Quantum Electromechanical Systems (QEM-2)***, Morro Bay, CA; 2006.
- Scientific Advisory Board, ***Nanosystems Initiative Munich (NIM),*** Ludwig-Maximilians-Universität München / Technische Universität München, 2006-2011.
- Co-Founder, ***Alliance for Nanosystems VLSI***, Caltech and CEA/LETI-MINATEC, 2006 – present.
- Co-organizer/Co-Chair (with Prof. Stephen Quake, Stanford U.), ***Second International Workshop on Biological Large-Scale Integration (BioLSI-2)***, Caltech, 2006.
- Inaugurual Site Review Committee for the Deutsche Forschungsgemeinschaft (DFG), ***Center for Functional Nanostructures***, University of Karlsruhe, Germany, 2005.

- Featured Interview, ***Leonardo (Science Television Series for RAI)*** www.leonardo.rai.it
  Episode title: "Il "Nano" Che Cura", 2004.
- Chair, ***Research Assessment Committee on the NASA Biophysics Program of Prof. Steven Chu***, Nobel Laureate, Stanford University, 2003.
- ***Research Assessment Committee, Physics and Applied Physics, TU Delft***, The Netherlands, 2003.
- ***Research Assessment Committee, Physics and Applied Physics, Leiden University***, The Netherlands, 2003.
- Chair, External Advisory Board, ***Center for Nanoscale System (CNS)***, Harvard University, 2001-2010.
- Co-organizer, Working group advocating a national roadmap for nanotechnology in cancer research, ***National Institutes of Health / National Cancer Institute***, 2002.
- Founding Co-Editor, "***Virtual Journal of Nanoscale Science and Technology***" (American Institute of Physics)
- Member, ***IEEE Nanotechnology Council***, Committee on Nanofabrication, 2002-2007.
- Chair/Organizer, ***First School and International Conference on Nanoscale and Molecular Mechanics (N/MM-I)***, Kauai, Hawaii, May 2001.
- Member, Steering Committee, ***Nanotechnology Institute, ASME*** (American Society of Mechanical Engineers), 2001-2006.
- Co-Founder, ***NanoSystems Biology Alliance*** with J. Heath & S. Quake, Caltech; L. Hood & A. Aderem, Institute for Systems Biology, Seattle; and M. Phelps, C. Sawyers & O. Witte, UCLA, 2000.
- Co-Director/Co-Founder (with Professor Scott Fraser, Division of Biology, Caltech) ***Caltech Initiative in Computational Molecular Biology***, funded by the Burroughs-Wellcome Foundation, 1998-2003.
- Member, ***Strategic Planning Committee for Physics***, Caltech, Two terms: 1993-1994, 2002-2003.
- Co-Founder, ***Nanokinetics Corporation***, 2002.

Patents (current up to 09/28/2023)

Issued Patents: **59**
Patent Applications in Progress: **6**

***Issued* Patents**

No.	US Pat. No.	Title
1	11,289,319	System to analyze particles, and particularly the mass of particles
2	11,624,715	Highly-multiplexed NEMS-array readout system based on superconducting cavity optomechanics
3	11,621,671	Nanomechanical networks for computation
4	20210311101	Broadband radiation sensor based on a resonantly-coupled graphene SNS junction
5	10,638,933	Brain-machine Interface based on photonic neural probe arrays
6	10,471,273	Implantable, highly collimated light-emitters for biological applications
7	10,381,206	Integrated hybrid NEMS mass spectrometry
8	10,216,698	Analysis device including a MEMS and/or NEMS network
9	10,175,212	System and method for analyzing a gas
10	10,168,292	Nanoscale calorimeter on chip and related methods and devices

11	9,891,382	Optomechanical device with mechanical elements and optical filters for actuating and/or detecting the movement of the elements
12	9,841,408	System for analyzing a gas mixture including at least one chromatography column
13	9,660,654	Synchronization of nanomechanical oscillators
14	9,622,676	Method of making micromachined neural probes
15	9,588,084	Device for detecting gases and/or volatile organic compounds (VOC)
16	9,442,021	Uncooled IR detector arrays based on nanoelectromechanical systems
17	9,423,387	Localized deposition of polymer film on nanocantilever chemical vapor sensors by surface-initiated atom transfer radical polymerization
18	9,347,815	Single-protein nanomechanical mass spectrometry in real time
19	9,291,600	Piezoresistive NEMS array network
20	9,252,731	Passive phase noise cancellation element
21	9,016,125	NEMS comprising AlSi alloy based transducer
22	8,857,275	NEMS sensors for cell force application and measurement
23	8,836,440	Electromechanical oscillators, parametric oscillators, and torsional resonators based on piezoresistive nanowires
24	8,827,548	Polymer NEMs for cell physiology and microfabricated cell positioning system for micro-biocalorimeter
25	8,820,140	System for analyzing a gas mixture including at least one chromatography column
26	8,750,957	Microfabricated neural probes and methods of making same
27	8,487,385	Uncooled IR detector arrays based on nanoelectromechanical systems
28	8,476,005	Microfluidic embedded polymer NEMS force sensors
29	8,378,758	Parametric feedback oscillators
30	8,355,768	Micromachined neural probes
31	8,350,578	Wiring nanoscale sensors with nanomechanical resonators
32	8,329,452	Active NEMS arrays for biochemical analyses
33	8,258,899	Nano-electro-mechanical systems switches
34	8,227,747	Single molecule mass spectroscopy enabled by nanoelectromechanical systems (NEMS-MS)
35	8,115,344	Very low voltage, ultrafast nanoelectromechanical switches and resonant switches
36	8,044,556	Highly efficient, charge depletion-mediated, voltage-tunable actuation efficiency and resonance frequency of piezoelectric semiconductor nanoelectromechanical systems resonators
37	7,989,198	Active NEMS arrays for biochemical analyses
38	7,966,898	Polymer NEMS for cell physiology and microfabricated cell positioning system for micro-biocalorimeter
39	7,959,873	Biological detection based on differentially coupled nanomechanical systems using self-sensing cantilevers with attonewton force resolution
40	7,786,326	Polyacylurethanes based on diisocyanates and polyesterpolyols
41	7,762,719	Microscale calorimeter
42	7,724,103	Ultra-high frequency self-sustaining oscillators, coupled oscillators, voltage-controlled oscillators, and oscillator arrays based on vibrating nanoelectromechanical resonators

43	7,617,736	Metallic thin film piezoresistive transduction in micromechanical and nanomechanical devices and its application in self-sensing SPM probes
44	7,555,938	Thermoelastic self-actuation in piezoresistive resonators
45	7,552,645	Detection of resonator motion using piezoresistive signal downmixing
46	7,449,758	Polymeric piezoresistive sensors
47	7,434,476	Metallic thin film piezoresistive transduction in micromechanical and nanomechanical devices and its application in self-sensing SPM probes
48	7,416,911	Electrochemical method for attaching molecular and biomolecular structures to semiconductor microstructures and nanostructures
49	7,407,814	Active NEMS arrays for biochemical analyses
50	7,375,321	Dynamics bionems sensors and arrays of bionems sensor immersed in fluids
51	7,330,795	Method and apparatus for providing signal analysis of a BioNEMS resonator or transducer
52	7,302,856	Strain sensors based on nanowire piezoresistor wires and arrays
53	7,249,518	Sensors based on giant planar hall effect in dilute magnetic semiconductors
54	7,191,639	On-chip magnetic force actuation of microcantilevers by coplanar coils
55	6,910,382	Sensors based on giant planar hall effect in dilute magnetic semiconductors
56	6,879,012	Giant planar hall effect in epitaxial ferromagnetic semiconductor devices
57	6,722,200	Apparatus and method for ultrasensitive nanoelectromechanical mass detection
58	6,676,813	Technology for fabrication of a micromagnet on a tip of a MFM/MRFM probe
59	6,593,731	Displacement transducer utilizing miniaturized magnet and hall junction

Mentoring (see: http://nano.caltech.edu/people/alumni.html)

	Applied Physics	***Biology***	***Bio-engineer'g***	***Chemistry***	***Electrical Engineer'g***	***Physics***	**Totals**
Senior Staff	-	-	-	-	-	37	**37**
Postdocs	4	2	-	-	-	43	**49**
Graduate Students	12	1	4	1	1	17	**36**

Reviewed Publications (current as of 02/14/2024)

Current Publication Stats (Google Scholar):
total *refereed* publications: **192**
h-index: **90**
total citations: **51,256**

1. Neumann, AP; Gomez, A; Nunn, AR; Sader, JE; Roukes, ML; *Nanomechanical mass measurements throughfeature-based time series clustering*, ***Review of Scientific Instruments*** 95 (2) 025001 (2024).

2. Sader, JE; Stassi, S; Ricciardi, C; Roukes, ML; *Effect of intramodal and intermodal nonlinearities on the flexural resonant frequencies of cantilevered beams*, ***Physical Review B*** 108 (22), 224303 (2023).

3. Jones, J; MacKrell EJ; Wang, T-Y; Lomenick, B; Roukes, ML; Chou, T-F, *Tidyproteomics: an open-source R package and data object for quantitative proteomics post analysis and visualization,* ***BMC Bioinformatics*** 24 (1), Art. 239 (2023). DOI: 10.1186/s12859-023-05360-7

4. Katti, R; Arora, HS; Saira, OP; Watanabe, K; Taniguchi, T; Schwab, KC; Roukes, ML; Nadj-Perge, S; Hot carrier thermalization and Josephson inductance thermometry in a graphene-based microwave circuit, ***Nano Letters***, 23 (10), 4136-4141 (2023). DOI: 10.1021/acs.nanolett.2c04791

5. Sacher, WD; Chen, F-D; Moradi-Chameh, H; Liu, XY; Felts-Almog, I; Lordello, T; Chang, M; Naderian, A; Fowler, TM; Segev, E; Xue, T; Mahallati, S; Valiante, TA; Moreaux, LC; Poon, JKS; Roukes, ML; *Optical phased array neural probes for beam-steering in brain tissue,* ***Optics Letters*** **47** (5) , pp.1073-1076 (2022), DOI: 10.1364/OL.441609.

6. Tjahjono N, Jin Y, Hsu AH, Roukes ML, Tian L; *Letting the little light of mind shine: Advances and future directions in neurochemical detection* (Invited review), ***Neuroscience Research*** 179, 65-78 (2022). DOI: https://doi.org/10.1016/j.neures.2021.11.012.

7. Sacher, WD; Chen, F-D; Moradi-Chameh, H; Luo, XS; Fomenko, A; Shah, PT; Lordello, T; Liu, XY; Almog, IF; Straguzzi, JN; Fowler, TM; Jung, Y; Hu, T; Jeong, J; Lozano, AM; Lo, PGQ; Valiante, TA; Moreaux, LC; Poon, JKS; Roukes, ML; *Implantable photonic neural probes for light-sheet fluorescence brain imaging,* ***Neurophotonics*** **8** *(*2), 025003 (2021), DOI: 10.1117/1.NPh.8.2.025003

8. Wimsatt, G; Saira, OP; Boyd, AB; Matheny, MH; Han, SY; Roukes, ML; Crutchfield, JP; *Harnessing fluctuations in thermodynamic computing via time-reversal symmetries*, ***Physical Review Research*** **3**(3), 033115 (2021), DOI: 10.1103/PhysRevResearch.3.033115

9. Saira, OP; Matheny, MH; Katti, R (Katti, Raj); Fon, W; Wimsatt, G; Crutchfield, JP; Han, SY; Roukes, ML; *Nonequilibrium thermodynamics of erasure with superconducting flux logic*, ***Physical Review Research*** **2**(1), 033115 (2020), DOI: 10.1103/PhysRevResearch. 2.013249

10. Moreaux, LC; Yatsenko, D; Sacher, WD, Choi, J; Lee, C; Kubat, NJ; Cotton, RJ; Boyden, ES; Lin, MZ; Tian, L; Tolias, AS; Poon, JKS; Shepard, KL; Roukes, ML; *Integrated Neurophotonics: Toward Dense Volumetric Interrogation of Brain Circuit Activity-at Depth and in Real Time*, ***Neuron*** **108**(1), 66-92 (2020), DOI: 10.1016/j.neuron.2020.09.043

11. Choi, J; Taal, AJ; Meng, WL; Pollmann, EH; Stanton, JW; Lee, C; Moazeni, S; Moreaux, LC; Roukes, ML; Shepard, KL; *Fully integrated time-gated 3D fluorescence imager for deep neural imaging*, ***IEEE Transactions on Biomedical Circuits and Systems*** **14**(4), 636-645 (2020), DOI: 10.1109/TBCAS.2020.3008513

12. Saira, OP; Matheny, MH; Roukes, ML; *Modification of electron-phonon coupling by micromachining and suspension*, ***Journal of Applied Physics*** **127**(2), 024307 (2020); DOI: 10.1063/1.5132948

13. Wesley D. Sacher, Xianshu Luo, Yisu Yang, Fu-Der Chen, Thomas Lordello, Jason C. C. Mak, Xinyu Liu, Ting Hu, Tianyuan Xue, Patrick Guo-Qiang Lo, Michael L. Roukes, and Joyce K. S. Poon, *Visible-light silicon nitride waveguide devices and implantable neurophotonic probes on thinned 200mm silicon wafers,* ***Optics Express*** **27**(26), 37400-37418 (2019), DOI: 10.1364/OE.27.037400

14. M.I. Dykman, G. Rastalli, M.L. Roukes, E.M. Weig, *Resonantly-induced friction and frequency combs in driven nanomechanical systems,* ***Physical Review Letters*** **122**(25): 254301 (2019), DOI: 10.1103/PhysRevLett.122.254301

15. Hao Jia; Matthew H. Matheny; Michael L. Roukes; Philip X.-L. Feng, *Imaging Multimode Vibrations in High-Frequency Aluminum Nitride Piezoelectric Nanomembrane Resonators*, Proceedings of the 20th International Conference on Solid-State Sensors, Actuators and Microsystems & Eurosensors XXXIII, ***Transducers and Eurosensors XXXIII*** (2019), DOI: 10.1109/TRANSDUCERS.2019.8808643

16. J.J. Whiting, E.B. Myers, R.P. Manginell, M.W. Moorman, J. Anderson, CS Fix, C. Washburn, A. Staton, D. Porter, D. Graf, D.R. Wheeler, S. Howell, J. Richards, H. Monteith, K.E. Achyuthan, M.L. Roukes, R.J. Simonson, *A high-speed, high-performance, microfabricated comprehensive two-dimensional gas chromatograph,* ***Lab On A Chip*** **19**(9): 1633-1643, (2019).

17. M.H. Matheny, J. Emenheiser, W. Fon, A. Chapman, A. Salova, M. Rohden, J. Li, M. Hudoba de Badyn, M. Posfai, L. Duenas-Osorio, M. Mesbahi, J.P. Crutchfield, M.C. Cross, R.M. D'Souza, M.L. Roukes, *Exotic states in a simple network of nanoelectromechanical oscillators,* ***Science*** **363**(6431): 1057+, eaav7932 (2019).

18. W.D. Sacher, X.Y. Liu, F.D. Chen, H. Moradi-Chameh, I.F Almog, T. Lordello, M. Chang, A. Naderian, T.M. Fowler, E. Segev, T.Y. Xue, S. Mahallati, T.A. Valiante, L.C. Moreaux, J.K.S. Poon, M.L. Roukes, *Beam-steering nanophotonic phased-array neural probes,* ***2019 Conference on Lasers and Electro-Optics (CLEO),*** San Jose, CA, 2019, pp. 1-2. doi: 10.23919/CLEO.2019.8749967

19. WD Sacher, X Liu, IF Almog, A Fomenko, T Lordello, F-D Chen, H Moradi-Chameh, A Naderian, M Chang, TM Fowler, TA Valiante, AM Lozano, LC Moreaux, JKS Poon, ML Roukes, *Nanophotonic neural probes for light-sheet imaging in vivo,* ***2019 Conference on Lasers and Electro-Optics (CLEO),*** San Jose, CA, 2019, pp. 1-2. / doi: 10.23919/CLEO.2019.8749967

20. C. Lee, A.J. Taal, J. Choi, K. Kim, K. Tien, L.C. Moreaux, M.L Roukes, K.L Shepard, *A 512-Pixel 3kHz-Frame-Rate Dual-Shank Lensless and Filterless Single-Photon-Avalanche-Diode CMOS Neural Imaging Probe,* 2019 ***IEEE International Solid State Circuits Conference*** (ISSCC), Volume: 62, Pages: 198+ (2019).

21. H.X. Wang, R.B. Dewell, M.U. Ehrengruber, E. Segev, J. Reimer, M.L. Roukes, F. Gabbiani, *Optogenetic manipulation of medullary neurons in the locust optic lobe,* ***Journal of Neurophysiology*** **120**(4): 2049-2058, (2018), DOI: 10.1152/jn.00356.2018

22. E. Sage, M. Sansa, S. Fostner, M. Defoort, M. Gely, A.K. Naik, R. Morel, L. Duraffourg, M.L. Roukes, T. Alava, C. Masselon, S. Hentz, *Single-particle mass spectrometry with arrays of frequency-addressed nanomechanical resonators*, ***Nature Communications*** **9**, Art. No. 3283 (2018), DOI: 10.1038/s41467-018-05783-4

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