OMB No. 0925-0001 and 0925-0002 (Rev. 03/2020 Approved Through 02/28/2023)

BIOGRAPHICAL SKETCH

NAME: Walker, Ross Martin

eRA COMMONS USER NAME: RMWALKER

POSITION TITLE: Associate Professor, Electrical and Computer Engineering, University of Utah

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
University of Arizona	B.S.	08/2005	Electrical Engineering
University of Arizona	B.S.	08/2005	Computer Science
Stanford University	M.S.	06/2007	Electrical Engineering
Stanford University	Ph.D.	09/2013	Electrical Engineering

A. Personal Statement

My group pursues research toward electronic circuits and systems for biomedical applications, with a particular emphasis on neurotechnology. My heritage is integrated circuit design and related disciplines (ASICs). I have worked with the top electronics researchers and companies in Silicon Valley, where I have a wide network of contacts and colleagues. Since the beginning of my career, I have focused on applying electrical engineering techniques to biomedical problems including imaging for cancer detection, neural interfacing, and biochemical sensing. I am experienced with the unique challenges involved in leading the electronic circuits and systems side of multidisciplinary biomedical research and I have over 13 years of experience in neural engineering.

The primary focus of my research group at UofU is innovative neural interface technology and methodologies [1-3]. We design circuits and systems for instrumentation [1-2] and also study the properties of electrodes both in vitro and in vivo [3]. My group performs our own in vivo experimentation in rodents for device characterization [1,3], enabling us to execute iterative cycles of design and in vivo evaluation. We pursue new ideas for high channel count neural recording circuits [1], high speed communication for implantable devices [2], fully implantable microsystems for neural interfacing [2], and other areas. These thrusts stem from my Ph.D. training at Stanford University, where I was the architect and lead designer of the HermesE 96-channel neural recording ASIC. This chip, used in Prof. Krishna Shenoy's lab at Stanford, is the cornerstone of the HermesE and HermesF head-mounted wireless platforms, which enable ground breaking non-human primate (NHP) neuroscience experiments. This device that I designed was used in the first reported study of NHP motor cortical activity during unconstrained quadrupedal walking [4].

1. Sharma, M., Strathman, H.J., Walker, R.M. (2019). Verification of a rapidly multiplexed circuit for scalable action potential recording. IEEE Transactions on Biomedical Circuits and Systems (TBCAS), 16(6), 1655-1663, PMID 31825873, ***Special Issue - Electronic Circuits and Systems Challenge in Large-Scale Neural Recording and Stimulation (NeuralRS19)***.
2. Walker, R.M., Subramanian, I.S., Bajwa, A.A., Rieth, L., Silver, J., Ahmed, T., Tasneem, N., Sharma, M., Gardner, A.T. (2017). Integrated neural interfaces. IEEE Midwest Symposium on Circuits and Systems (MWSCAS), 1045 – 1048, ***Invited Paper****, Oral Presentation*.
3. Gardner, A.T., Strathman, H.J., Warren, D.J., Walker, R.M. (2018). Impedance and noise characterizations of Utah and microwire electrode arrays. IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology, 2(4), 234-241.
4. Foster, J.D., Nuyujukian, P., Freifeld, O., Gao, H., Walker, R., Ryu, S.I., Meng, T.H., Murmann, B., Black, M.J., Shenoy, K.V. (2014). A freely-moving monkey treadmill model. Journal of Neural Engineering, 11(4), 046020 (14pp.), PMID 24995476.

B. Positions and Honors

Positions and Employment

2003-2004	Logic Design Intern, International Business Machines (IBM), Tucson, AZ
2004	Applications Engineering Summer Intern, National Semiconductor (now TI), Tucson, AZ
2004-2005	Research Assistant, Prof. Barton's Biomedical Optics Lab, University of Arizona, Tucson, AZ
2006	IC Design Summer Intern, Linear Technology, Milpitas, CA
2007-2013	Graduate Research Assistant, Prof. Murmann's Lab, Stanford University, Stanford, CA
2013-2019	Assistant Professor, Dept. of Elec. and Comp. Engineering, Univ. of Utah, Salt Lake City, UT
2019-current	Associate Professor, Dept. of Elec. and Comp. Engineering, Univ. of Utah, Salt Lake City, UT

Other Experience and Professional Memberships

2002-current	Member, Tau Beta Pi Engineering Honor Society
2004-current	Member, IEEE
2016-current	Member, IEEE Biomedical and Life Sciences Circuits and Systems Technical Committee
2016-2017	Vice Chair, IEEE Solid-State Circuits Society Utah Chapter
2017-2019	Chair, IEEE Solid-State Circuits Society Utah Chapter
2019-current	Member, Board of Governors, IEEE Circuits and Systems Society
2020-current	Treasurer, IEEE Solid-State Circuits Society Utah Chapter

Honors

2003–2004	Clarence P. Wilson Scholarship
2004–2005	ISS Undergraduate Scholarship
2005	International Engineering Consortium Academic Excellence Award
2005	Electrical Engineering Outstanding Senior Award, University of Arizona
2009	Analog Devices Outstanding Designer Award, ISSCC
2010–2011	Achievement Awards for College Scientists (ARCS) Graduate Fellowship
2015	University of Utah College of Engineering Top 15% Teachers Award
2017	University of Utah Dept. of Electrical and Computer Engineering Outstanding Teacher Award
2018	University of Utah College of Engineering Top 15% Teachers Award
2020	University of Utah Dept. of Electrical and Computer Engineering Outstanding Service Award

C. Contributions to Science

1. Rapid Electrode Multiplexing for Scalable Neural Recording

This project that I directed has produced a revolutionary new approach to neural recording electronics, supported by NIH R21EY027618 (I was the sole PI). Historically, neural recording devices have focused on a simple "one wire per electrode" paradigm where each electrode site is connected to a dedicated electronic circuit (e.g. the >2,800 papers listed under "neural amplifier" in the Engineering Village database as of 10/09/2020). This old paradigm simply cannot scale up to orders of magnitude increases in recording sites in the brain. My ongoing work to invent rapidly multiplexed recording circuits involves rethinking neural interface design both at the electronics level and the system level. For example, this new approach requires a more intimate understanding of the electrode-tissue interface and its implications for recording electronics. My group has published several conference and journal papers on in vivo characterizations to understand electrode-tissue interface characteristics, and we recently published high-impact journal papers reporting the design and testing of an ASIC that achieves more than an order of magnitude reduction in size versus prior art (60x versus Intan chips). I expect this approach to have a key role in the future of large-scale neural interfaces.

a. Sharma, M., Strathman, H.J., Walker, R.M. (2019). Verification of a rapidly multiplexed circuit for scalable action potential recording. IEEE Transactions on Biomedical Circuits and Systems (TBCAS), 16(6), 1655-1663, PMID 31825873, ***Special Issue - Electronic Circuits and Systems Challenge in Large-Scale Neural Recording and Stimulation (NeuralRS19)***.
b. Sharma, M., Gardner, A.T., Strathman, H.J., Warren, D.J., Silver, J., Walker, R.M. (2018). Acquisition of neural action potentials using rapid multiplexing directly at the electrodes. MDPI Micromachines Special Issue: Neural Microelectrodes: Design and Applications, 9(10), PMID 30424410, PMCID PMC6215140, ***Invited Paper***, ***Featured Paper***.

c. Gardner, A.T., Strathman, H.J., Warren, D.J., Walker, R.M. (2018). Impedance and noise characterizations of Utah and microwire electrode arrays. IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology, 2(4), 234-241.
d. Gardner, A.T., Strathman, H.J., Warren, D.J., Walker, R.M. (2018). Signal and noise sources from microwire arrays implanted in rodent cortex. IEEE Life Sciences Conference, 97-100, *Oral Presentation.*

2. Implantable Wireline Communication

This ongoing project that I direct deals with data communication for implantable devices with a relatively unexplored approach. Certainly, neural interfaces must be wireless to achieve their full potential. However, while wireless power and data telemetry is optimal for transcutaneous links, implantable leads and connectors are often used inside the body, e.g. in deep brain stimulation, spinal cord stimulation, and cardiac pacing. This project explores wireline power and data communication over implantable leads and connectors that are used in FDA approved systems. The goal is to enable robust power and data links between multiple implanted modules that contain active devices, which is an emerging system concept in neural interfacing. These wirelines are optimized for chronic implantation, but not for power and data transmission, motivating basic research to understand the limits and special considerations for implantable wireline links. The knowledge produced in this project will be important for future implantable systems of many types, ranging from research to clinical applications.

a. Tasneem, N., Ahmed, T., Walker, R.M. (2019). Design of a 180 nm CMOS transceiver for implantable wireline communication, achieving 800 Mbps at BER<1e-12 with 22.4 dB of channel loss. IEEE Midwest Symposium on Circuits and Systems (MWSCAS), pp. 1155-1158, ***Invited Paper,*** *Oral Presentation*.
b. Ahmed, T., Tasneem, N., Walker, R.M. (2018). High-speed communication up to 600 Mbps over FDA-cleared implantable wirelines. IEEE Biomedical Circuits and Systems Conference (BioCAS), 1-4.
c. Ahmed, T., Tasneem, N., Walker, R.M. (2017). Feedforward-equalized communication link for implantable systems achieving 400 Mbps. Biomedical Engineering Society Annual Meeting (BMES), *Oral Presentation*.
d. Tasneem, N., Ahmed, T., Walker, R.M. (2016). Wireline communication over an implantable lead. IEEE-EMBS Conference on Biomedical Engineering and Science (IECBES), 321-325, *Oral Presentation*.

3. Neural Recording ASIC Design

I have been active in neural recording ASIC design from time of my Ph.D. work to the present day. My Ph.D. research at Stanford (co-advised by Prof. Krishna Shenoy) was focused on new electronics to interface with intracortical microelectrode arrays. At that time, a few multichannel recording ASICs had been created, e.g. by Reid Harrison, but there were not many examples of advanced electronics in the field. I invented a new switched capacitor front-end architecture that decreases size while improving accuracy, reliability, and predictability over electronics that had been used before. I was the architect and lead designer of a 96-channel neural recording ASIC that demonstrated the new electronics, and I worked with Krishna Shenoy's group to deploy the chip in the HermesE and HermesF head-mounted wireless recording platforms. These systems have been used in ground breaking non-human primate experiments (freely behaving, untethered, etc.) in Shenoy's lab at Stanford (e.g. Foster et al. 2014). Publications of the electronics have received about 200 citations, and the designs are still used for comparison in the latest reports of new neural recording ASICs. Recently, I invented a new recording ASIC for peripheral nerve recording that achieved the lowest noise and smallest size among published designs.

a. Liu, J., Walker, R.M. (2018). A compact, low-noise, chopped front-end for peripheral nerve recording in 180 nm CMOS. IEEE Biomedical Circuits and Systems Conference (BioCAS), 1-4.
b. Foster, J.D., Nuyujukian, P., Freifeld, O., Gao, H., Walker, R., Ryu, S.I., Meng, T.H., Murmann, B., Black, M.J., Shenoy, K.V. (2014). A freely-moving monkey treadmill model. Journal of Neural Engineering, 11(4), 046020 (14pp.), PMID 24995476.
c. Gao, H., Walker, R.M., Nuyujukian, P., Makinwa, K.A.A., Shenoy, K.V., Murmann, B., Meng, T.H. (2012). HermesE: A 96-channel full data rate direct neural interface in 0.13μm CMOS. IEEE Journal of Solid-State Circuits (JSSC), 47(4), 1043-1055.
d. Walker, R.M., Gao, H., Nuyujukian, P., Makinwa, K.A.A., Shenoy, K.V., Meng, T.H., Murmann, B. (2011). A 96-channel full data rate direct neural interface in 0.13μm CMOS. Symposium on VLSI Circuits, 144-145, *Oral Presentation*.

4. Quantum Biomolecular Transducers

Toward the end of my Ph.D. work I engaged in research toward quantum chemical sensors that transduce vibrational mode information of solvated analytes. The sensors produce a fingerprint of complex biomolecules through phonon-assisted transport of electrons across a passivated interface. This unique project has roots in inelastic tunneling electron spectroscopy, which is generally performed with solid-state structures at cryogenic temperatures. The current work transduces quantum information in aqueous solutions at room temperature, through ultralow-noise control and readout circuitry that I developed. This research project is still ongoing, and the results are being commercialized as a chemical spectroscopy technique.

a. Fischer, S., Muratore, D., Weinreich, S., Peña-Perez, A., Walker, R.M., Gupta, C., Howe, R.T., Murmann, B. (2019). Low-noise integrated potentiostat for affinity-free protein detection with 12 nV/rt-Hz at 30 Hz and 1.8 pA_{rms} resolution. IEEE Solid-State Circuits Letters (SSCL), 2(6), 41-44.
b. Gupta, C., Walker, R.M., Chang, S., Fischer, S.R., Seal, M., Murmann, B., Howe, R.T. (2017). Quantum tunneling currents in a nanoengineered electrochemical system. The Journal of Physical Chemistry C, 121(28), 15085–15105.
c. Gupta, C., Peña Perez, A., Fischer, S.R., Weinreich, S.B., Murmann, B., Howe, R.T. (2016). Active control of probability amplitudes in a mesoscale system via feedback-induced suppression of dissipation and noise. Journal of Applied Physics, 120(22), 224902 (8pp.).
d. Gupta, C., Walker, R.M., Gharpuray, R., Shulaker, M., Zhang, Z., Javanmard, M., Davis, R.W., Murmann, B., Howe, R.T. (2012). Electrochemical quantum tunneling for electronic detection and characterization of biological toxins. Proc. of SPIE: Micro- and Nanotechnology Sensors, Systems, and Applications, 8373(4), 837303-1-837303-14.

5. Optical Coherence Imaging of Ovarian Tumors

As an undergraduate researcher I developed optical coherence tomography and microscopy systems with off-the-shelf components and discrete electronics. While tomography was a popular technique, microscopy was less common as it was more complex to implement. We developed a highly configurable microscope system that I was responsible for engineering. The team imaged ovarian carcinogenesis in a rodent model, correlated the findings with fluorescence imaging, and developed a framework for early detection of tumors. My work contributed to several optical coherence instruments that supported a number of other researchers in Jennifer Barton's Biomedical Optics Lab at University of Arizona, and I also assisted in surgeries and care of animals.

a. Kanter, E.M., Walker, R.M., Marion, S.L., Brewer, M., Hoyer, P.B., Barton, J.K. (2006). Dual modality imaging of a novel rat model of ovarian carcinogenesis. Journal of Biomedical Optics, 11(4), 41123-1-10, PMID 16965151.
b. Kanter, E., Walker, R., Marion, S., Hoyer, P., Barton, J.K. (2005). Optical coherence tomography imaging and fluorescence spectroscopy of a novel rat model of ovarian cancer. Proc. of SPIE: Biomedical Optics, 5861, 58610P-1-8.
c. Kanter, E., Walker, R., Marion, S., Hoyer, P., Barton, J.K. (2005). Use of multiple imaging modalities to detect ovarian cancer. Proc. of SPIE: Photonic Therapeutics and Diagnostics, 5686, 596-605.
Note: this paper may also appear as published in "Biomedical Optics"

Complete List of Published Work in MyBibliography:
https://www.ncbi.nlm.nih.gov/myncbi/browse/collection/52779616/?sort=date&direction=descending

D. Additional Information: Research Support and/or Scholastic Performance

Ongoing Research Support

NSF 1932602 Mastrangelo (PI) 12/01/2019 – 11/30/2022
Deep Integration of Thin Flexible Microsystems for Vision Correction
This project seeks to address vision loss in the aging population by creating smart contact lenses that correct refractive errors in the eye. My role is to direct research on the electronic circuits and system components of the smart contact lenses.
Role: co-PI

R21EY030710 Fang (PI) 08/01/2019 – 07/31/2021
Massively Multiplexed Gold Microprobe Arrays for Whole-Mouse-Brain Recording

This project will develop a new device concept to enable ultra-large-scale intracortical electrode arrays, which can measure neural signals with high resolution over large areas of the brain. My role is to lead the development of electronic circuits and systems and to direct the in vivo experiments.
Role: PI

Completed Research Support

R21EY027618 Walker (Sole PI) 09/30/2016 – 07/31/2019
Rapid Electrode Multiplexing for Scalable Neural Recording
This project generated the first demonstration of rapidly multiplexed neural recording, directly at high impedance electrodes, without any preamplification or buffering. I directed the overall project including in vivo electrode characterization, ASIC design, and in vivo verification of the electronics.
Role: PI

NSF 1644592 Gaillardon (PI) 08/15/2016 – 06/31/2018
Ultra-High-Performance Terahertz Detection Exploiting Super-Steep-Subthreshold-Slope (S^4) – FinFETs
Under this NSF EAGER project, we executed preliminary research to enable the use of novel nanoscale transistors (S^4-FinFETs) for ultrasensitive terahertz electromagnetic detection. I led the efforts to characterize the S^4-FinFET devices, in order to understand the noise performance and other analog characteristics.
Role: co-PI

DoE DE-SC0010132 Rose (PI) 06/22/2015 – 07/27/2016
A Wireline-Deployed Tool for Monitoring Fluid Flow within an EGS Borehole
This DoE SBIR project supported development of a fluid flow sensor package for geothermal wells, in collaboration with a local University of Utah spinout startup company (FluidTracer). My role was supervision of a MS student who designed custom electronics for a high temperature environment.
Role: co-PI