

# Tzeno Galchev

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## Professional profile

Over nine years of in-depth experience in the semiconductor and MEMS fields, with extensive design, layout, and fabrication know-how of mixed-signal integrated microsystems, commercial foundry manufacturing, flexible and polymer technologies, and post-CMOS process integration and packaging. Numerous successful development cycles (concept/design/fabrication/testing) of implantable tools and bio-sensors for neuroscientific research and therapeutics, energy harvesting/inertial transducers for body-worn and implantable applications, ultra-low-power analog interfaces, and power management systems. Extensive hands-on experience of most standard microfabrication techniques and processes.

## Education

### University of Michigan, Ann Arbor, USA

Ph.D. in Electrical Engineering

08/2010

Thesis Title: “*Energy Scavenging From Low Frequency Vibrations*”

Advisor: Khalil Najafi

## Professional experience

### University of Freiburg, Freiburg, Germany

Department of Microsystems Engineering (IMTEK)

*Marie Curie Research Fellow*

01/2014 - present

*Alexander von Humboldt Research Fellow*

01/2012 - 12/2013

- Researching integrated microsystems for medicine, energy harvesting for wearable devices, analog interface electronics for electrophysiology, and power management. Authored 8 papers (1 more in review)
- Invented new technology for harvesting multi-axial motion for body-worn and implantable applications. Won 3 Best Paper awards at international conferences
- Secured 1.4 M€ worth of funding by writing and budgeting 4 competitive national and international grants (5<sup>th</sup> in review), 2 as principle investigator (PI) and 2 as co-PI
- Coordinated wafer manufacturing with commercial foundry and in-house post-processing of MEMS on CMOS wafers
- Managed students directly (average of 5 at any given time) and their projects (lab. assistants, M.S. and Ph.D. dissertations)
- Held lectures on CMOS process technology, test, and characterization methods
- Gave more than 11 invited talks worldwide on renewable energy sources for mobile and wearable devices

### Entrepreneurship and Consulting, USA, Germany

Enertia Energy Systems LLC, Ann Arbor, USA

2010 - present

- Co-founded start-up based on technology developed during doctoral thesis
- Defined product, market and commercialization strategy and received 12 national and international business development awards
- Developed financial model and raised \$168,000 in seed funding

Technology consulting

2010 - present

- Advised technical clients on demanding engineering challenges. Served as expert consultant for legal firms with respect to IP matters

### University of Michigan, Ann Arbor, USA

Department of Electrical and Computer Engineering

Center for Wireless Integrated Microsystems (WIMS)

*Research Fellow*

9/2010 - 10/2011

- Led team of 2 in developing a 3D wafer-level packaging technology with integrated vibration isolation for an automotive OEM
- Managed NIST sponsored effort on developing autonomous structural health monitoring (SHM) sensors while supervising a PhD student and continuing research in the area of low-frequency energy harvesting. Resulted in 8 papers, 1 best paper award, and the longest published field test of an energy harvester to date

*Graduate Student Research Assistant*

01/2005 - 8/2010

- Researching MEMS, inertial sensors, fabrication, and energy harvesting
- Invented and patented a new technology for harvesting non-periodic and low-frequency motion. Demonstrated efficiency is still state-of-the-art, many years later.
- Developed a commercialization strategy for my research and raised over \$130k in cash by winning 4, and finishing as finalist in 5 other business plan competitions
- Assisted in the teaching of the MEMS curriculum
- Authored 11 publications and won a Best Paper award
- Elected as president of student council 2 years in a row (additional year as vice-president). Duties involved, fundraising, acting as liaison between students and faculty, and organizing networking events

**General Dynamics**, Advanced information systems, Ypsilanti, USA

5/2003 - 8/2003

*Intern*

**Lockheed Martin**, Information Systems & Global Solutions, Rockville, USA

5/2001 - 8/2001

*Intern*

**Honors and awards**

- EU FP7 Marie Curie research fellowship (international acceptance rate < 13.2%) 2013
- Best Student Paper Award “Circuits” Track, IEEE Sensors Conference 2013
- Top 10 outstanding oral presentations, IEEE MEMS Conference 2013
- Best Student Paper Award, PowerMEMS Workshop 2012
- Alexander von Humboldt research fellowship (international acceptance rate < 25%) 2012
- Outstanding Student Leadership Award, University of Michigan 2009
- Business development awards (four 1<sup>st</sup> place and five 2<sup>nd</sup> place) from national and international business plan competitions including the DTE Clean Energy Prize, Colorado Clean Tech Venture Challenge, Wake Forrest Elevator Pitch and others 2007 - 2010
- John Atanasoff Certificate, annual national recognition given to a young scientists under the age of thirty-six for significant contributions in the development of information technologies by the President of the Republic of Bulgaria 2008
- Best Paper Award, Int. Conference on Commercialization of Micro and Nano Systems 2008
- Sandia National Laboratories/U. of Michigan Excellence in Engineering Fellowship 2006
- 2<sup>nd</sup> Place Analog Devices/UM Analog Circuit Design Contest 2004

**Skills and languages**

*Legend: 4 - expert; 3 - advanced; 2 - proficient; 1 - beginner*

**Operating systems**

Windows - 4, Mac - 4, Unix - 3, Linux - 3

**Desktop apps**

Office - 4, MS Project - 2, Adobe Illustrator - 3, Photoshop - 3

**Engineering apps**

Matlab - 4, Labview - 3, Solidworks - 3, AutoCAD - 2,

**EDA**

Cadence - 4, Spice - 3, Mentor Graphics - 2, EAGLE - 2, Target - 3, L-Edit - 4

**FEM**

ANSYS - 4, COMSOL - 4

**Languages**

English - 4, Bulgarian - 4, German - 1, French - 1

**Patents**

- T. Galchev, H. Kim, K. Najafi “Increased Frequency Power Generation Using Low Frequency Ambient Vibrations,” US Patent No: US 8,796,907

## Volunteer activities

- Technical Program Committee: IEEE Conf. on PhD Res. in Microelectr. & Electronics (PRIME), 2011, 2013
- Journal reviewer: IEEE/ASME J. of Microelectromechanical Systems, IEEE J. of Solid-State Circuits, IEEE Trans. on Circuits and Systems II, IEEE Trans. on Magnetics, Sensors and Actuators

## Publications

h-index = 9, total citations = 354 (Google Scholar, August 2015)

### *Books and book chapters*

1. M. Maharbiz, R. Borno, M. Lam, and **T. Galchev** (equal contribution by authors), "Chapter 12. Implantable and Non-implantable NanoBiosystems," in NNIN Nanotechnology Open Source Textbook, K. Najafi, Editor, 2006, [http://www.nano.umn.edu/assets/pdf/textbook/ch\\_12.pdf](http://www.nano.umn.edu/assets/pdf/textbook/ch_12.pdf).

### *Journal publications*

2. A. Herbawi, F. Velarde, O. Paul, and **T. Galchev**, "An efficient self-powered synchronous rectifier suitable for sub-600 mV operation." (*submitted*)
3. J. McCullagh, **T. Galchev**, R. L. Peterson, R. Gordenker, Y. Zhang, J. Lynch, and K. Najafi, "Long-term testing of a vibration harvesting system for the structural health monitoring of bridges," in *Sensors & Actuators A: Physical*, vol. 217, p. 139-150, 2014.
4. **T. Galchev**, E. Aktakka, and K. Najafi, "A piezoelectric frequency increased generator for harvesting low-frequency vibrations," in *IEEE/ASME Journal of Microelectromechanical Systems*, vol. 21, p. 1311-1320, 2012.
5. **T. Galchev**, J. McCullagh, R. Peterson, and K. Najafi, "Harvesting traffic-induced vibrations for structural health monitoring of bridges," in *IOP Journal of Micromechanics and Microengineering*, vol. 21, p. 104005, 2011
6. **T. Galchev**, H. Kim, and K. Najafi, "Micro power generator for harvesting low-frequency and non-periodic vibrations," in *IEEE/ASME Journal of Microelectromechanical Systems*, vol. 20, p. 852-866, 2011
7. **T. Galchev**, W.C. Welch III, and K. Najafi, "A new low temperature high aspect-ratio MEMS process using plasma activated wafer bonding," in *IOP Journal of Micromechanics and Microengineering*, vol. 21, p. 045020, 2011

### *Refereed conference publications with proceedings*

8. M. Tom, O. Paul, and **T. Galchev**, "A fully autonomous power management interface for frequency up-converting harvesters using load decoupling and inductor sharing." (*Submitted to Eurosensors 2015*)
9. F. Pothof, **T. Galchev**, M. Patel, A. Herbawi, O. Paul, and P. Ruther, "Heterogeneous integration of analog CMOS chips on flexible substrates for high resolution deep brain epilepsy diagnosis." (*Accepted to Eurosensors 2015*)
10. A. Herbawi, B. Mildemberger, F. Larramendy, T. Holzhammer, **T. Galchev**, O. Paul, and P. Ruther, "CMOS-based high-density neural probes with improved scheme for addressing recording and stimulation channels." (*Accepted to Eurosensors 2015*)
11. F. Pothof, **T. Galchev**, M. Patel, A. Herbawi, O. Paul, and P. Ruther, "128-Channel deep brain recording probe with heterogeneously integrated analog CMOS readout for focal epilepsy localization," in *Proceedings of IEEE 18<sup>th</sup> International Conference on Solid-State Sensors and Actuators (IEEE TRANSDUCERS)*, Anchorage, Alaska, pp. 1711-14, June 2015. (*Acceptance rate: 46%*)
12. A. Herbawi, **T. Galchev**, F. Larramendy, T. Holzhammer, O. Paul, and P. Ruther, "CMOS-based neural probe with enhanced electronic depth control," in *Proceedings of IEEE 18<sup>th</sup> International Conference on Solid-State Sensors and Actuators (IEEE TRANSDUCERS)*, Anchorage, Alaska, pp. 1723-26, June 2015. (*Acceptance rate: 46%*)
13. A. E. Aguayo, O. Paul, and **T. Galchev**, "Integrated synchronous electric charge extraction system for piezoelectric energy harvesters," in *Proceedings of IEEE International Symposium on Circuits and Systems (ISCAS)*, p. 1090-93, May 2015. (*Oral presentation; Oral acceptance rate: ~30%*)

14. **T. Galchev**, D. Barutçu, and O. Paul, "A gap-varying electrostatic transducer utilizing ferrofluid-based actuation for motion harvesting," in *Proceedings of IEEE International Conference on Micro Electro Mechanical Systems (IEEE MEMS)*, San Francisco, USA, p. 350-353, January 2014. (Acceptance rate: 36%)
15. A. S. Herbawi, O. Paul, and **T. Galchev**, "An ultra-low-power active AC-DC CMOS converter for sub-1V integrated energy harvesting applications" in *Proceedings of IEEE Sensors Conference*, Baltimore, USA, p. 1912-1915, November 2013. (Oral presentation; Acceptance rate for oral: 26%; Overall: 54%) (**Best Student Paper Award "Circuits" Track**)
16. **T. Galchev**, R. Raz, and O. Paul, "An electrostatic springless inertial harvester for converting multi-dimensional low-frequency motion," in *Proceedings of IEEE International Conference on Micro Electro Mechanical Systems (IEEE MEMS)*, Taipei, Taiwan, p. 102-105, January 2013. (Oral presentation; Acceptance rate for oral: 8.5%; Overall: 40%) (**Top 10 Outstanding Oral Papers**)
17. **T. Galchev**, R. Raz, and O. Paul, "A new multi-dimensional low-frequency springless proximity inertial harvester for converting human and environmental motion," in *Proceedings of PowerMEMS 2012 Workshop*, Atlanta, USA, p. 117-120, December 2012. (Oral presentation; Acceptance rate for oral: 32%; Overall: 78%)
18. J. McCullagh, R. L. Peterson, **T. Galchev**, R. Gordenker, Y. Zhang, J. Lynch, and K. Najafi, "Short-term and long-term testing of a vibration harvesting system for bridge health monitoring," in *Proceedings of PowerMEMS 2012 Workshop*, Atlanta, USA, p. 109-112, December 2012. (Oral presentation; Acceptance rate for oral: 32%; Overall: 78%) (**Best Student Paper Award**)
19. K. Najafi, **T. Galchev**, E. Aktakka, R.L. Peterson, and J. McCullagh, "Microsystems for energy harvesting," in *Proceedings of IEEE International Conference on Solid-State Sensors and Actuators (IEEE TRANSDUCERS)*, Beijing, China, p. 1845-48, June 2011. (*invited*)
20. **T. Galchev**, J. McCullagh, R.L. Peterson, and K. Najafi, "Harvesting traffic induced bridge vibrations," in *Proceedings of IEEE International Conference on Solid-State Sensors and Actuators (IEEE TRANSDUCERS)*, Beijing, China, pp. 1661-1664, June 2011. (Acceptance rate: 45%)
21. **T. Galchev**, J. McCullagh, R.L. Peterson, K. Najafi, A. Mortazawi, "Energy harvesting of radio frequency and vibration energy to enable wireless sensor monitoring of civil infrastructure," in *Proc. SPIE Smart Structures/NDE*, San Diego, CA, v 7983, p 798314, March 2011. (Oral presentation)
22. **T. Galchev**, J. McCullagh, R.L. Peterson, and K. Najafi, "A vibration harvesting system for bridge health monitoring applications," in *Proceedings of PowerMEMS 2010 Workshop*, Leuven, Belgium, pp. 179-182, December 2010. (Oral presentation; Acceptance rate for oral: 35%)
23. M. Kurata, J.P. Lynch, **T. Galchev**, M.P. Flynn, P. Hipley, V. Jacob, G. van der Linden, A. Mortazawi, K. Najafi, R.L. Peterson, L.-H. Sheng, D. Sylvester, E. Thometz, "Two-tiered self-powered wireless monitoring system architecture for bridge health management," in *Proc. of the SPIE Smart Structures and Materials*, San Diego, CA, v 7649, p 76490K (12 pp.), March 2010. (Oral presentation)
24. **T. Galchev**, E. Aktakka, H. Kim, and K. Najafi, "A piezoelectric frequency-increased power generator for scavenging low-frequency ambient vibration," in *Proceedings of IEEE International Conference on Micro Electro Mechanical Systems (IEEE MEMS)*, Hong Kong, China, pp. 1203-6, January 2010. (Acceptance rate: 34%)
25. **T. Galchev**, H. Kim, and K. Najafi, "A parametric frequency increased power generator for scavenging low-frequency ambient vibrations," in *Proceedings of Eurosensors XXIII*, Lausanne, CH, pp. 1439-1442, September 2009. (Oral presentation)
26. **T. Galchev**, H. Kim, and K. Najafi, "Non-resonant bi-stable frequency-increased power generator for low-frequency ambient vibration," in *Proceedings of IEEE 15<sup>th</sup> International Conference on Solid-State Sensors and Actuators (IEEE TRANSDUCERS)*, Denver, Colorado, pp. 632-5, June 2009. (Oral presentation; Acceptance rate for oral: 17%)
27. E. Romero, **T. Galchev**, E. Aktakka, N. Ghafouri, M. Neuman, R. Warrington, H. Kim, and K. Najafi, "Micro energy harvesters," in *Proceedings of 13th International Commercialization of Micro and Nano Systems Conference*, Puerto Vallarta, Mexico, September 2008. (Oral presentation) (**Best Paper Award**)
28. **T. Galchev**, W. C. Welch III, and K. Najafi, "Low-temperature MEMS process using plasma activated Silicon-On-Silicon (SOS) bonding," in *Proceedings of IEEE International Conference on Micro Electro Mechanical Systems (IEEE MEMS)*, Kobe, Japan, pp. 309-312, January 2007. (Acceptance rate: 37%)

29. **T. Galchev**, W. C. Welch III, and K. Najafi, " Silicon-On-Silicon (SOS): A new CMOS compatible low-temperature MEMS process using plasma activated fusion bonding," in *Proceedings of Solid State Sensor, Actuator and Microsystems Workshop (Hilton Head)*, Hilton Head, SC, pp. 100-102, June 2006. (*Oral presentation; Acceptance rate for late-news oral: 10%*)

*Refereed conference publications without proceedings*

30. O. Paul, **T. Galchev**, A. Herbawi, F. Larramendy, and P. Ruther, "Active Neural Probes in CMOS Technology with Dense Electrode Arrangement for High-resolution Intracerebral Recording," in *48<sup>th</sup> Annual Conference of the German Society of Biomedical Engineering*, Hannover, 2014.
31. **T. Galchev**, J. McCullagh, R.L. Peterson, and K. Najafi, "Energy harvesting from low frequency and arbitrary vibrations," in *High Efficiency Energy Conversion, Energy Management, and Low Power Systems for Aerospace/Military Electronics Workshop*, Redstone Arsenal, AL, September 2010. (*Oral presentation*)