BIOGRAPHICAL SKETCH

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NAME: Wang, Shan X.

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POSITION TITLE: Edwards Chair Prof., Stanford University

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Science and Technology of China, Hefei, China	B.S.	07/1986	Physics
Iowa State University, Ames, IA	M.S.	07/1988	Physics
Carnegie Mellon University, Pittsburgh, PA	Ph.D.	12/1993	Electrical and Computer Engineering

A. Personal Statement

Professor Shan Wang, PhD, is the Leland T. Edwards Professor in the School of Engineering, Stanford University, and a Professor of Radiology, by courtesy, in Stanford School of Medicine. Shan is a leading expert in cancer diagnostics, biosensors, and information storage. His research and inventions span from biochips, in vitro diagnostics, cancer biomarkers, to magnetoresistive random access memory. Shan has over 300 publications and over 70 issued/pending patents. He has cofounded 6 companies including Curve Biosciences, which is commercializing a liver cancer blood test, and Magic Lifescience, which is commercializing genotyping POCT based on GMR biosensors. He is an elected Fellow of the National Academy of Inventors (NAI), American Physical Society (APS), and IEEE. Over the past 15 years the Shan Wang lab made distinctive contributions to magneto-nanosensors and has been considered among the select few pioneers in the use of magnetic nanoparticles (MNP) and giant magnetoresistive (GMR) sensors for bio-detection of circulating proteins and nucleic acids. The Wang lab reported attomolar to femtomolar sensitivities for protein biomarkers, and versatile assays of DNA, RNA, and small molecules. The magneto-nanosensors have spurred many collaborative clinical studies in lung cancer, prostate cancer, liver cancer, colorectal cancer, myocardial infarct, inflammation, autoimmunity, radiation exposure, hepatitis, HIV, Covid-19, marijuana DUI, pain medicine, and fertility improvement. Recently Dr Wang co-invented protein biomarker panels for more precise detection of malignancy in lung nodules from CT scan, and co-developed Layered Analysis of Methylated Biomarkers (LAMB) method and Next Generation Sequencing (NGS) assays for early detection of cancers and therapy monitoring of solid tumors. Drs. Wang and de la Zerda coauthored a textbook “Biochips and Medical Imaging”, which include the subjects of cancer, cardiovascular diseases and their diagnostics. His strong track record in innovation, technology transfer and commercialization, mentoring (50+ predoctoral and postdoctoral trainees supervised, including many female and underrepresented minority trainees), and cross-disciplinary collaboration (20+ long-time collaborators), and his long-standing dedication to cancer care and education, allow him to contribute actively to the Proposed Program.

Ongoing and recently completed projects that I would like to highlight include:
1R01CA257843 (Shan Wang) 07/01/21 - 06/30/25
National Institutes of Health
Rapid and affordable magneto-nanosensors for ctDNA-guided lung cancer management
The aims of this project are (1) Validate ctDNA EGFR magneto-nanosensor assay accuracy and correlations to clinical outcome on expanded cohort. (2) Develop an extensive ctDNA mutation panel assay on magneto-nanosensor arrays for NSCLC treatment selection, monitoring, and prognosis.

Role: PI

1R21DK131776 (Joseph Liao and Shan Wang) 09/21/21-07/31/23
National Institutes of Health
Title: MagSToNE - a magnetic system for kidney stone fragment elimination
Major Goals: Kidney stones are common, but their surgical treatment is limited by incomplete stone removal, which can lead to recurrence of symptoms. These studies seek to develop a new magnetic technology that will more efficiently remove all kidney stone fragments from the body after surgery. This will improve clinical outcomes and reduce healthcare costs by helping patients avoid recurrent stones and repeat surgeries.
Role: PI

203278SU-Wang (Shan Wang) 07/01/18 - 12/31/22
SRC/University of Notre Dame
Exploring New Topological Materials and Interfaces for Advanced SOT-MRAM
We anticipate to establish spin-orbit torque (SOT) switching behavior with topological materials under various parameters and with minimized SOT switching energy, to demonstrate nano-sized SOT-driven MTJ prototypes at ns to sub-ns timescale, and to interpret and predict experimental results with ab initio calculations.
Role: PI

SPO227309 (Shan Wang) 03/01/21 - 02/28/23
Taiwan Semiconductor Manufacturing Company
Field-free Type-x & Type-z Switching in Nano-device by x/z-direction Spin Polarizations in MnPdx, MnPtx, CoPtx and [Pt/Co]n
The objectives of this project are: (1) Fundamental material physics study on x & z-direction spin polarization generation on MnPd and Pt/Co multilayer with post 400 oC (33% PVD tool time for TSMC own studies). (2) Field-free spin-orbit torque (SOT) feasibility in Type-x/z demonstration on CD 50 nm× 150 nm with 1hr retention at 105 oC and high-speed behaviors (< 10 ns). (3) Angular-dependent spin-torque ferromagnetic resonance (ST-FMR) and differential planar Hall effect (DPHE) device characterization setups (> 50% usage on TSMC own samples).
Role: PI

Citations

1. Adam de la Zerda and Shan X. Wang, *Biochips and Medical Imaging*, Wiley, 2022.
2. Giovanni Rizzi, Jung-Rok Lee, Christina Dahl, Per Guldberg, Martin Dufva, Shan X. Wang, and Mikkel F. Hansen, “Simultaneous Profiling of DNA Mutation and Methylation by Melting Analysis Using Magnetoresistive Biosensor Array,” *ACS Nano*, 11, 8864-8870, 2017. (PMCID: PMC5810360)
3. SM Park, DD Won, BJ Lee, D Escobedo, A Esteva, A Aalipour, TJ Ge, JH Kim, S Suh, EH Choi, AX Lozano, C Yao, S Bodapati, FB Achterberg, J Kim, H Park, Y Choi, WJ Kim, JH Yu, AM Bhatt, JK Lee, R Spitler, SX Wang & SS Gambhir, “A mountable toilet system for personalized health monitoring via the analysis of excreta,” *Nature BME*, 4, 624–635, 2020. (PMCID: PMC7377213)
4. R. S. Gaster, D. A. Hall, C. H. Nielsen, S. J. Osterfeld, H. Yu, K. E. Mach, R. J. Wilson, B. Murmann, J. C. Liao, S. S. Gambhir, and S. X. Wang, “Matrix-insensitive protein assays push the limits of biosensors in medicine,” *Nature Medicine*, 15, 1327-1332, 2009. (PMCID: PMC4165514)

B. Positions, Scientific Appointments, and Honors

2021-present Full Faculty Member, Molecular Imaging Program at Stanford (MIPS)
2012-present Associate Faculty Member, Canary Center for Early Detection of Cancer
2010-present Full Professor by courtesy, Dept. of Radiology, Stanford School of Medicine
2006-present Full Professor, Dept. of Materials Science & Engineering, and jointly with Dept. of Electrical Engineering, Stanford University
2005-present Director, Stanford Center for Magnetic Nanotechnology
2004-present Affiliated Faculty Member, Stanford Cardiovascular Institute
2003-present Affiliated Faculty Member, Stanford Bio-X Program
2014-2019 Associate Chair, Department of Materials Science and Engineering
2002-2005 Director, Stanford Center for Research on Information Storage Materials (CRISM)
2001-2006 Associate Professor, Dept. of Materials Science & Engineering, and jointly with Dept. of

Electrical Engineering, Stanford University
1993-2000 Assistant Professor, Dept. of Materials Science & Engineering, and jointly with Dept. of Electrical Engineering, Stanford University

Honors:

2022-2023 Distinguished Adjunct Professor, Department of Electrical Engineering, Tsinghua University
2021 Fellow of National Academy of Inventors (NAI)
2018 Leland T. Edwards Professor, School of Engineering, Stanford University
2017 Professor in Residence, StartX, Stanford University
2017 XPRIZE Bold Epic Innovator Award (co-winner with Cloud DX)
2015 Faculty Fellow, Center for Innovation and Global Health (CIGH)
2014 XPRIZE Foundation's Nokia Sensing XCHALLENGE Distinguished Award
2013 IBM Faculty Award
2012 Fellow of American Physical Society (APS)
2010 Gates Foundation Grand Challenge Explorations Award
2009 Fellow of the Institute of Electrical and Electronics Engineers (IEEE)
2009 BMEidea Competition 1st Prize; 2009
2007-2008 Obducat Prize 2007 Award (1st Prize)
2006 Co-author of the best student paper of International Electronic Device Meeting (IEDM)
2001-2002 IEEE Magnetics Society Distinguished Lecturer
1999 IBM Partnership Award
1994-1997 Inaugural Frederick Terman Faculty Fellow
1986 CUSPEA Scholarship organized by Nobel Laureate T. D. Lee

C. Contributions to Science

1. Wang's most innovative work is pioneering the development of giant magnetoresistive (GMR) biochips, aka magneto-nanosensors, into an ultrasensitive and multiplex protein assay platform suitable for cancer diagnostics. *More recently, he has extended the chip platform to simultaneous profiling of DNA mutation and methylation*. He has some 50 issued or pending patents in this area. Partly because of these, he was elected a Fellow of the American Physical Society (APS) "for seminal contributions to biomagnetics, nanomagnetics, and magnetic recording" in 2012. His work has attracted wide public interests and media coverage, including ABC News and San Jose Mercury News. The resulting technologies have been out-licensed for clinical translation, including diagnostics of lung cancer, prostate cancer, autoimmunity, infectious diseases, and drug abuses. The representative papers and patents on the magneto-nanosensors are as follows:
   a. Jared C. Nesvet, Katie A. Antilla, Danielle S. Pancirer, Alexander X. Lozano, Jordan S. Preiss, Weijie Ma, Aihua Fu, Seung-min Park, Sanjiv S. Gambhir, Alice C. Fan, Joel W. Neal, Sukhmani K. Padda, Millie Das, Tianhong Li, Heather A. Wakelee, and Shan X. Wang, "Giant Magnetoresistive Nanosensor Analysis of ctDNA EGFR Mutations for Rapid Diagnosis and Therapy Response Monitoring," Clinical Chemistry, hvaa307, 04 January 2021. https://doi.org/10.1093/clinchem/hvaa307 (PMID: 33393992)
   b. S. J. Osterfeld, H. Yu H, R. S. Gaster, S. Caramuta, L. Xu, S.-J. Han, D. A. Hall, R. J. Wilson, S. Sun, R. L. White, R. W. Davis, N. Pourmand, and S. X. Wang, "Multiplex Protein Assays Based on Real-Time Magnetic Nanotag Sensing," *PNAS*, **105**, 20637-20640, 2008. (PMCID: PMC2602607)
   c. E Ng, C Yao, TO Shultz, S Ross-Howe, SX Wang, "Magneto-nanosensor Smartphone Platform for the Detection of HIV and Leukocytosis at Point-of-Care," *Nanomedicine: Nanotechnology, Biology and Medicine* **16**, 10-19, 2019.
   d. L. Xu, H. Yu, M. S. Akhras, S.-J. Han, S. J. Osterfeld, R. L. White, N. Pourmand, S. X. Wang, "Giant magnetoresistive biochip for DNA detection and HPV genotyping," *Biosensors and Bioelectronics*, **24**, 99–103, 2008. (PMCID: PMC2573902)
2. Wang coinvented a 3D portable cell sorter called magnetic sifter (MagSifter) which has been applied to enrich circulating tumor cells (CTCs) in lung cancer patients with unprecedented flow rates and nearly perfect capture yields (Cover article of LabChip, Jan., 2014). The MagSifter has been successfully combined with a Nanowell-based single cell analysis platform with in situ multiplex PCR capability, enabling single-CTC level analysis of molecular signature. This tool is shedding new insights into diagnosis, prognosis, and biology (e.g., mutation, metastasis, and remission) of lung cancer and other lethal diseases. Wang also coinvented MagSToNE (Magnetic System for Total Nephrolith Extraction) technology led by Drs. Gu and Liao. More details can be found in the following publications:

a. T. Jessie Ge, Daniel Massana Roquero, Grace H. Holton, Kathleen E. Mach, Kris Prado, Hubert Lau, Kristin Jensen, Timothy C. Chang, Simon Conti, Kunj Sheth, Shan X. Wang, and Joseph C. Liao, "A magnetic hydrogel for the efficient retrieval of kidney stone fragments during ureteroscopy," Nature Comms., under 4th round review.
b. C. M. Earhart, C. E. Hughes, R. S. Gaster, C. Ooi, R. J. Wilson, L. Y. Zhou, E. W. Humke, L. Xu, D. J. Wong, S. B. Willingham, E. J. Schwartz, I. L. Weissman, S. S. Jeffrey, J. W. Neal, R. Rohatgi, H. A. Wakelee, and S. X. Wang, "Isolation and mutational analysis of circulating tumor cells from lung cancer patients with magnetic sifters and biochips," *Lab on a Chip*, **14**, 78–88, 2014. (**Cover article**, Themed Issue on Circulating Tumor Cells) (PMCID: PMC4144998)
c. Seung-min Park, Dawson J. Wong, Chin Chun Ooi, David M. Kurtz, Ophir Vermesh, Amin Aalipour, Susie Suh, Kelsey L. Pian, Jacob J. Chabon, Sang Hun Lee, Mehran Jamali, Carmen Say, Justin N. Carter, Luke P. Lee, Ware G. Kuschner, Erich J. Schwartz, Joseph B. Shrager, Joel W. Neal, Heather A. Wakelee, Maximilian Diehn, Viswam S. Nair, Shan X. Wang, and Sanjiv S. Gambhir, "Molecular profiling of single circulating tumor cells from lung cancer patients," *Proc. Natl. Acad. Sci. (PNAS),* 113(52): E8379–E8386, 2016. (PMCID: PMC4237466)
d. Ophir Vermesh, Amin Aalipour, T. Jessie Ge, Yamil Saenz, Yue Guo, Israt S. Alam, Seung-min Park, Charlie N. Adelson, Yoshiaki Mitsutake, Jose Vilches-Moure, Elias Godoy, Michael H. Bachmann, Chin Chun Ooi, Jennifer K. Lyons, Kerstin Mueller, Hamed Arami, Alfredo Green, Edward I. Solomon, Shan X. Wang & Sanjiv S. Gambhir, "An intravascular magnetic wire for the high-throughput retrieval of circulating tumour cells in vivo," Nature Biomed. Eng., 2(9): 696–705, 2018. (PMCID: PMC6261517)

3. Biomarker validation and clinical translation is a challenge to the biomedical community because vast majority of biomarkers discovered in research fail in clinical validation phase, the predicament of so called "valley of death". Wang group and collaborators are developing technologies and methods well suited for biomarker validation and clinical translation, including those for emerging mobile health applications. Wang Group's Eigen Diagnosis Platform won a distinguished award in Nokia Sensing XChallenge organized by the XPrize Foundation in 2014, and an Bold Epic Innovator Award in 2017. Immunity status against Hepatitis can be known in 10 min. with a cell phone App. His lab also developed methods to rapidly screen antibody kinetic parameters and cross-reactivity for assay development, multiplex blood test for rapid triage of ionizing radiation exposure, and targeted molecular imaging agent.
   a. Richard S. Gaster, Drew A. Hall, and Shan X. Wang, "nanoLAB: An ultraportable, handheld diagnostic laboratory for global Health," *Lab Chip*. 11, 950-956, 2011. PMID: 21264375.
   b. Jung-Rok Lee, Daniel J.B. Bechstein, Chin Chun Ooi, Ashka Patel, Richard S. Gaster, Elaine Ng, Lino C. Gonzalez, and Shan X. Wang, "Magneto-nanosensor platform for probing low-affinity protein-protein interactions and identification of a low-affinity PD-L1/PD-L2 interaction," Nature Communications, 7, 12220, 2016 (PMCID: PMC4961847)
   c. D. Kim, F. Marchetti, Z. Chen, S. Zaric, R. J. Wilson, D. A. Hall, R. S. Gaster, J.-R. Lee, J. Wang, S. J. Osterfeld, H. Yu, R. M. White, W. F. Blakely, L. Peterson, S. Bhatnagar, B. Manion, S. Tseng, K. Roth, M. Coleman, A. M. Snijders, A. J. Wyrobek, and S. X. Wang, "Nanosensor dosimetry of mouse blood proteins after exposure to ionizing radiation," *Scientific Reports*, **3**, 2234; DOI:10.1038/srep02234, 2013. (PMCID: PMC3715761)
   d. R. S. Gaster, L. Xu, S.-J. Han, R. J. Wilson, D. A. Hall, S. J. Osterfeld, H. Yu, and S. X. Wang, "Quantification of Protein Interactions and Solution Transport Using High-Density GMR Sensor Arrays," *Nature Nanotechnology*, 6, 314-320, 2011. (PMCID: PMC3089684)
4. Wang and his collaborators also developed original chemical synthesis and/or physical fabrication recipes for monodisperse and uniform iron oxide nanoparticles, dumbbell-like multifunctional nanoparticles, and ultra-responsive antiferromagnetic nanoparticles, and magneto-fluorescent nanoparticles. These particles have been used widely in biosensing, imaging, cell sorting, water purification, catalysis, among others.
   a. S. Sun, H. Zeng, D. B. Robinson, S. Raoux, P. M. Rice, S. X. Wang, and G. Li, "Monodisperse MFe2O4 (M = Fe, Co, Mn) nanoparticles", *J. Am. Chem. Soc.*, **126**, 273-279, 2004. (PMID: 14709092)
   b. H. Yu, M. Chen, P. M. Rice, S. X. Wang, R. L. White, and S. Sun, "Dumbbell-like bifunctional Au-Fe3O4 nanoparticles,". *Nano Lett.*, **5**(2), 379-382, 2005. (PMID: 15794629)
   c. M. Zhang, X. Xie, M. Tang, C. S. Criddle, Y. Cui, S. X. Wang, "Magnetically ultra-responsive nanoscavengers for next-generation water purification systems," *Nature Communications*, **4**, 1866, 2013. (PMCID: PMC4123635)

d. W. Cai, D.-W. Shin, K. Chen, O. Gheysens, Q. Cao, S. X. Wang, S. S. Gambhir, and X. Chen, "Peptide-labeled near-infrared quantum dots for imaging tumor vasculature in living subjects," *Nano Lett.* **6**(4), 669-76, 2006. (PMID: 16608262)

5. Wang was elected a Fellow of IEEE for extraordinary contributions to magnetic materials and device in 2009. Some of his non-biological research range from multiferroic materials, soft magnetic materials, spintronics, MRAM, to magnetic information storage. The latter is at the physical foundation of Big Data and Cloud Computing. His representative publications in these areas are as follows, including a textbook on magnetic data storage:
   a. Mahendra DC, Ding-Fu Shao, Vincent D.-H. Hou, P. Quarterman, Ali Habiboglu, Brooks Venuti, Masashi Miura, Brian Kirby, Arturas Vailionis, Chong Bi, Xiang Li, Fen Xue, Yen-Lin Huang, Yong Deng, Shy-Jay Lin, Wilman Tsai, Serena Eley, Weigang Wang, Julie A. Borchers, Evgeny Y. Tsymbal, and Shan X. Wang, "Observation of anti-damping spin-orbit torques generated by in-plane and out-of-plane spin polarizations in MnPd3," *Nature Materials*, published online, April 03, 2023.
   b. Y. H. Chu, L. W. Martin, M. B. Holcomb, M. Gajek, S-J. Han, Q. He, N. Balke, C.-H. Yang, D. Lee, W. Hu, Q. Zhan, P.-L. Yang, A. Fraile-Rodriguez, A. Scholl, S. X. Wang, and R. Ramesh, "Electric-field control of local ferromagnetism using a magnetoelectric multiferroic," *Nature Materials*, **7**, 478-412, 2008. (PMID: 18438412)
   c. S. X. Wang, N. X. Sun, M. Yamaguchi, and S. Yabukami, "Properties of a new soft magnetic material," *Nature*, **407**, 150-1, Sept. 14, 2000. (PMID: 11001044)
   d. S. X. Wang and A. M. Taratorin, Magnetic Information Storage Technology, Academic Press, April, 1999.

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