Haogang Cai

Postdoctoral Researcher
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Research Interests

Nanobiotechnology, mechanobiology, nanophotonics, optical metasurfaces, micro/nanoelectromechanical systems (MEMS/NEMS), nanofabrication

Education

- **Ph. D. in Mechanical Engineering** **2016**
  Columbia University, New York, NY
- **M.S. in Microelectronics and Solid State Electronics** **2009**
  Shanghai Jiao Tong University, Shanghai, China
- **B.S. in Electronic Science and Technology** **2006**
  Xi'an Jiaotong University, Xi'an, Shaanxi, China

Research Experience

- **Postdoctoral research** **2016-present**
  Center for Nanoscale Materials, Argonne National Laboratory
  Supervisor: Dr. Daniel López
  Project: Metasurface-based planar optics for the visible light
- **Postdoctoral research** **2016**
  Biological Sciences, Columbia University
  Supervisor: Prof. Michael P. Sheetz
  Project: Nanoengineered platform for the study of integrin-mediated cell matrix adhesions
  Discovered new geometric effect and mechanism in integrin clustering, which is the key for cells forming adhesion and sensing the environment.
- **Doctoral research** **2010-2016**
  Applied Physics and Applied Mathematics, Columbia University
  Nanomedicine Center for Mechanobiology Directing the Immune Response
  Supervisor: Prof. Shalom J. Wind
  Dissertation: Biomimetic nanoarchitectures for the study of T cell activation with single-molecule control
  Developed a nanoengineered platform to precisely control biological ligand organization at the single-molecule level in all three dimensions. Discovered the geometric underpinnings of T cell receptor triggering, with translational applications in adoptive immunotherapies.
- **Master research** **2006-2009**
  Research Institute of Micro/Nano Science and Technology, Shanghai Jiao Tong University
  Supervisor: Prof. Guifu Ding
  Thesis: Optimized design and fabrication of unidirectional MEMS inertial switches
  Developed novel MEMS inertial switches with improved switch-on time and reliability.

Academic Awards

- Student travel award 2013, 2014, 2015, 2016
  International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication
- Chinese National Scholarship (highest honor for national graduate students, 1%) 2008
- Siyuan Scholarship 2004, 2005
- Outstanding Students Scholarship 2003, 2004

Patents

1. Minitype inertial electrical switch capable of regulating and controlling contact time, 2009, Chinese Patent No. CN100536055 C.

Book Chapter

1. **H. Cai**, D. Depoil, J. Muller, M. P. Sheetz, M. L. Dustin, S. J. Wind. Spatial control of biological ligands on surfaces applied to T cell activation. In **The Immune Synapse. Methods in Molecular Biology**. Humana Press: New York, NY, 1584, 307 (2017).

Journal Publications

ORCID 0000-0003-1700-2531, Google scholar https://scholar.google.com/citations?user=HdYtwWsAAAAJ&hl=en

1. **H. Cai**, J. Muller, D. Depoil, V. Mayya, M. L. Dustin, M. P. Sheetz, S. J. Wind. Full control of ligand positioning reveals spatial thresholds for T cell receptor triggering. **Nature Nanotechnology**, 2018, 13, 610. [**Reported** by EurekAlert!, Phys.org, ecancer, Xinhua, *etc*.]
2. R. Changede*, **H. Cai***, S. J. Wind, M. P. Sheetz. Ligand Geometry Controls Adhesion formation via Integrin Clustering (*These authors contributed equally to this work, **Nature Materials**, ***Under Revision***).
3. **H. Cai**, D. Czaplewski, K. Ogando, A. Martinson, D. Gosztola, L. Stan, D. López. Single-layer transmissive metasurface for multiwavelength optics in the visible. (***Submitted***).
4. **H. Cai**, H. Wolfenson, D. Depoil, M. L. Dustin, M. P. Sheetz, S. J. Wind. Molecular occupancy of nanodot arrays. **ACS Nano**, 2016, 10, 4173.
5. **H. Cai**, S. J. Wind. Improved glass surface passivation for single-molecule nanoarrays. **Langmuir**, 2016, 32, 10034.
6. Y. Jia, **H. Cai**, Q. Lin. Thick-film MEMS thermoelectric sensor fabricated using a thermally assisted lift-off process. **Journal of Micro/Nanolithography, MEMS, and MOEMS**, 2016, 15, 024501.
7. E. Penzo, M. Palma, R. Wang, **H. Cai**, M. Zheng, S. J. Wind. Directed assembly of end-functionalized single wall carbon nanotube segments. **Nano Letters**, 2015, 15, 6547.
8. **H. Cai**, D. Depoil, M. Palma, M. L. Dustin, M. P. Sheetz, S. J. Wind. Bifunctional nanoarrays for probing the immune response at the single-molecule level. **Journal of Vacuum Science and Technology B**, 2013, 31, 6F902. [**Editor's pick**, highlighted in the AVS e-Newsletters *Beneath the AVS Surface*]
9. X. Huang, S. Li, E. Davis, C. Leduc, Y. Ravussin, **H. Cai**, B. Song, D. Li, D. Accili, R. Leibel, Q. Wang, Q. Lin. A MEMS differential viscometric sensor for affinity glucose detection in continuous glucose monitoring. **Journal of Micromechanics and Microengineering**, 2013, 23, 055020.
10. Z. Yang, **H. Cai**, G. Ding, H. Wang, X. Zhao. Dynamic simulation of a contact-enhanced MEMS inertial switch in Simulink. **Microsystem technologies**, 2011, 17, 1329.
11. Z. Yang, G. Ding, H. Wang, **H. Cai**, X. Zhao. Modeling, simulation and characterization of a micromachined acceleration switch with anti-stiction raised strips on the substrate. **IEEE Transactions on Components, Packaging and Manufacturing Technology**, 2011, 1, 1195.
12. Z. Yang, G. Ding, Z. Zhou, **H. Cai**, X. Zhao. Analytical model of squeeze film damping for microelectromechanical systems structures with anti-stiction raised strips. **Micro & Nano Letters**, 2010, 5, 258.
13. **H. Cai**, Z. Yang, G. Ding, H. Wang. Development of a novel MEMS inertial switch with a compliant stationary electrode. **IEEE Sensors Journal**, 2009, 9, 801.
14. Z. Yang, G. Ding, **H. Cai**, X. Xu, H. Wang, X. Zhao. Analysis and elimination of the 'skip contact' phenomenon in an inertial micro-switch for prolonging its contact time. **Journal of Micromechanics and Microengineering**, 2009, 19, 045017.
15. **H. Cai**, G. Ding, Z. Yang, Z. Su, J. Zhou, H. Wang. Design, simulation and fabrication of a novel contact-enhanced MEMS inertial switch with a movable contact point. **Journal of Micromechanics and Microengineering**, 2008, 18, 115033.
16. **H. Cai**, Z. Yang, G. Ding, X. Zhao. Fabrication of a MEMS inertia switch on quartz substrate and evaluation of its threshold acceleration, **Microelectronics Journal**, 2008, 39, 1112.
17. Z. Yang, G. Ding, **H. Cai**, X. Zhao. A MEMS inertia switch with bridge-type elastic fixed electrode for long duration contact", **IEEE Transactions on Electron Devices**, 2008, 55, 2492.

Conference Presentations

1. [Oral] Ultrathin metasurface for the visible light based on dielectric nanoresonators, **SPIE Photonics West**, 2019, San Francisco, CA (accepted).
2. [Oral] Ultrathin metasurfaces based on dielectric nanoresonators for visible light, **62th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication**, 2018, Puerto Rico, PR.
3. [Oral] High-efficiency, low-aspect-ratio planar lens based on Huygens resonators, **International Conference on Optical MEMS and Nanophotonics**, 2017, Santa Fe, NM.
4. [Oral] Out-of-plane spatial control on single-molecule biomimetic surfaces, **60th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication**, 2016, Pittsburgh, PA.
5. [**Invited**] Molecular Occupancy of Nanodot Arrays. **59th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication**, 2015, San Diego, CA.
6. [Poster] Probing the minimum geometric requirements for T-cell stimulation. **Biophysical Society 59th Annual Meeting**, 2015, Baltimore, MD.
7. [Poster] A versatile single-molecule nanoarray platform for T-cell activation. **Gordon Research Conference on Nanostructure Fabrication**, 2014, Biddeford, ME.
8. [Oral] A versatile single-molecule nanoarray platform for T-cell activation. **58th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication**, 2014, Washington, DC.
9. [Oral] Bifunctional nanoarrays for probing the immune response at the single-molecule level. **57th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication**, 2013, Nashville, TN.
10. [Poster] Nanoscale platform for single-molecule control of T-cell receptor organization. **Gordon Research Conference on Nanostructure Fabrication**, 2012, Biddeford, ME.

Research Skills

- **Device fabrication.** 12-year experience of micro/nanofabrication.
  Lithography: e-beam, optical, nanoimprint, soft lithography; *Deposition*: e-beam evaporation, thermal evaporation, sputtering, CVD, MVD, electroplating; *Etching*: wet etching, RIE; *Metrology*: SEM, AFM, mechanical profilometry, optical profilometry, reflectometry; *Back-end and others*: dicing, critical point drying, rapid thermal annealing, laser beam machining, conventional machining.
- **Chemistry.** Surface functionalization/passivation by self-assembled monolayers (SAMs), orthogonal surface chemistry techniques, selective functionalization at single-molecule level, directed self-assembly.
- **Cell and molecular biology.** *Fluorescence microscopy*: quantitative detection of single molecules based on photobleaching, TIRF; *Cell assays*: fixation, fluorescent staining.
- **Optics.** Optical microscopy, optical table-top experiments, CW laser sources.
- **Software.** Design, simulation, data analysis and scientific graphics (CAD software, FEA software, FDTD software, ImageJ, MATLAB, Blender, Photoshop, *etc*.); Script and macro programming.

Teaching and Mentoring

- **Teaching Assistant** **2011-2014**
  Course manager for graduate level "APMA E4204 Functions of a Complex Variable".
  Columbia Video Network (Columbia's online learning program).
- **Graduate Mentor** **2011-2015**
  Mentored two graduate and one undergraduate students at Columbia, and one visiting undergraduate through the Research Program for Undergraduates.
- **Super user** **2011-2015**
  Education, demonstration, training in nanomanufacturing for both academic and industrial users.
  Columbia Nano Initiative, in charge of cleanroom tools: e-beam writer, nanoimprinter, SEM, e-beam evaporator.