UCI Samueli School of Engineering

Department of Materials Science and Engineering UCI

UNIVERSITY OF CALIFORNIA, IRVINE

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

IS PROUD TO HOST A SEMINAR BY

"EXPLORING LIGHT AND LIFE: NANOPHOTONICS AND AI FOR SCALABLE MOLECULAR SENSING, SEQUENCING, AND SYNTHESIS"

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Thursday, February 27, 2024

2:00 PM - 3:20 PM

McDonnell Douglas Engineering Auditorium

Abstract: The earth's biosphere is incredibly information-rich, with estimated information transmission rates exceeding those of the technosphere by 9 orders of magnitude. Yet, current methods to extract this information are slow and laborious, hindering our ability to understand the genesis and evolution of biochemical systems, and to optimize their performance. Here, we present nanophotonic methods that may enable unprecedented data about biochemical systems, at rates previously unattainable. First, we describe our lab's Si-photonic "Very-large-scale Integrated high-Q Nanophotonic Pixels" (VINPix). These photonic resonators achieve high-Q factors, subwavelength mode volumes, and dipole-like radiation, simultaneously, with Q-factors from the thousands to millions, and resonator densities exceeding 100M/cm2. By combining VINPix arrays with bioprinting for local chemical functionalization, we develop Si chips that detect multi-omic signatures on the same platform. We discuss integration of these sensors with workflows in Stanford's Clinical Laboratories for label-free interrogation of the tumor-immune microenvironment, as well as with autonomous underwater robots from Monterey Bay Aquarium Research Institute for ocean biodiversity monitoring. Then, we describe how these chips can be used for peptide sequencing. By tailoring each resonator for strong Raman enhancement, we demonstrate high-resolution identification of wildtype and mutated human leukocyte antigens. We also show how VINPix can be converted into reaction sites for DNA molecular synthesis by integrating optically absorbing heating elements. Reactions at each of the nanoantennas can be activated by a unique combination of optical wavelength and polarization, eliminating errors seen in other solid-state synthesis platforms. Further, the high-Q of each VINPix prevents spectral and spatial crosstalk between the nanoantennas, enabling maximum molecular sequence diversity. Collectively, we anticipate that these nanophotonic platforms can shed completely new data on the biosphere - from improved understanding of molecular communication systems, to optimization of novel biochemical sensing and synthesis platforms for sustainability.

Bio: Jennifer (Jen) Dionne is a Professor of Materials Science and Engineering and, by courtesy, of Radiology at Stanford. She is also a Chan Zuckerberg Biohub Investigator, deputy director of Q-NEXT (a DOE National Quantum Initiative), and co-founder of Pumpkinseed, a company developing quantum sensors to understand and optimize the immune system. From 2020-2023, Jen served as Stanford's Inaugural Vice Provost of Shared Facilities, raising capital to modernize instrumentation, fund experiential education, foster staff development, and support new and existing users of the shared facilities. Jen received her B.S. degrees in Physics and Systems Science and Mathematics from Washington University in St. Louis, her Ph. D. in Applied Physics at the California Institute of Technology in 2009, and her postdoctoral training in Chemistry at Berkeley. As a pioneer of nanophotonics, she is passionate about developing methods to observe and control chemical and biological processes as they unfold with nanometer scale resolution, emphasizing critical challenges in global health and sustainability.Her research has developed culture-free methods to detect pathogens and their antibiotic susceptibility; amplification-free methods to detect and sequence nucleic acids and proteins; and new methods to image light-driven chemical reactions with atomic-scale resolution. Jen's work has been featured in NPR, the Economist, Science, and Nature, and recognized with the NSF Alan T. Waterman Award, a NIH Director's New Innovator Award, a Moore Inventor Fellowship, and the Presidential Early Career Award for Scientists and Engineers. She was also featured on Oprah's list of "50 Things that will make you say 'Wow'!". She is especially proud of the many outstanding alumni who have graduated from her lab. Dionne lab members have received awards including HHMI, Beckman, Schmidt and Packard fellowships, and alum now hold faculty positions spanning top academia (eg, professors at MIT, Stanford, Berkeley, Northwestern, Rice, U. Chicago, among others), industry (Apple, Intel, Facebook/Meta, Lockheed Martin, Pacific Biosciences, Tempus), startups (founders of Antora and Arabesque), policy (Congressional Fellows), and communications (including a Pulitzer prize winner). She also perceives outreach as a critical component of her role and frequently collaborates with visual and performing artists to convey the beauty of science to the broader public. Beyond the lab, Jen enjoys long-distance cycling, trail running, singing, and reliving her childhood with her two young sons.