I^{2}CNER Webinar

International Institute on Carbon-Neutral Energy Research (I^{2}CNER)
Kyushu University

Title **Energy-Efficient Hardware and Materials for Brain-inspired Computing: Artificial Synapses Based on Proton and Oxygen Motion**

Speaker Prof. Bilge Yildiz (Photo by MIT website)

Professor of Nuclear Science and Engineering, and
Professor of Materials Science and Engineering,

Massachusetts Institute of Technology, US

Time& Date 9:00 AM(JST), Wednesday, December 9th, 2020

Abstract

Deep learning is a powerful algorithm for machine learning applications such as computer vision and natural language processing. However, the training of these neural networks is limited by the traditional von Neumann architecture of our current CPUs and GPUs. Shuttling data back and forth between the separate memory and computation units in such architecture results in significant energy consumption; many orders of magnitude greater than the energy consumption in human brain. Our projects focus on designing materials and devices that can instead perform data storage and computation in a single architecture using ions, inspired by the human brain. In one project, we have designed a protonic electrochemical synapse that changes conductivity deterministically by current-controlled shuffling of dopant protons across the active device layer; resulting in energy consumption on par with biological synapses in the brain. In our second project, we demonstrate controlled conducting oxygen vacancy filament formation in resistive memory devices via dopant and microstructure engineering. Through these strategies, we exhibit a path towards neuromorphic hardware that has high yield and consistency, performs data storage and computation in a single device, and uses significantly lesser energy as compared to current systems.

About the Speaker

Bilge Yildiz is a professor in the Nuclear Science and Engineering and the Materials Science and Engineering Departments at Massachusetts Institute of Technology (MIT), where she leads the Laboratory for Electrochemical Interfaces. She received her PhD degree at MIT in 2003 and her BSc degree from Hacettepe University in Turkey in 1999. After working at Argonne National Laboratory as a research scientist, she returned to MIT as an assistant professor in 2007. Her leadership responsibilities at MIT include the Low Carbon Energy Center on Materials in Energy and Extreme Environments, and one of the Integrated Research Groups of MIT's NSF sponsored Materials Research Science and Engineering Center. Her research focuses on laying the scientific groundwork and proof-of-principle material systems for the next generation of high-efficiency devices for energy conversion and information processing, based on solid state mixed ionic-electronic conducting materials, by combining in situ surface sensitive experiments with first-principles calculations and novel atomistic simulations. Her work has made significant contributions to advancing the molecular-level understanding of oxygen reduction and oxidation kinetics on solid surfaces, and of ion and electron transport, under electro-chemo-mechanical conditions. The scientific insights derived from her research guide the design of novel surface chemistries for efficient and durable solid oxide fuel cells, thermo-/electro-chemical splitting of H2O and CO2, high energy density solid state batteries, memristive analog information processing, and corrosion resistant films. Her teaching and research efforts have been recognized by the Argonne Pace Setter (2016), ANS Outstanding Teaching (2008), NSF CAREER (2011), IU-MRS Somiya (2012), the ECS Charles Tobias Young Investigator (2012), and the ACerS Ross Coffin Purdy (2018) awards. She is the Vice President, and President Elect (2021-2023) of the International Society on Solid State Ionics.

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Host Prof. Hiroshige Matsumoto

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