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Neuromorphic Computing and Proton-Toggling of Topology in Magnetic Multilayers



For two decades, magnetic tunnel junctions (MTJs) have been vital in traditional computing memory and processing. Recently, innovative paradigms like probabilistic bits and neuromorphic computing have emerged as promising solutions for next-generation, unconventional computing devices. Driven by the pursuit of advanced functionalities, recent research has pivoted toward exploiting quantum phenomena—such as skyrmions—within diverse heterostructures and multilayers.

Bridging these foundational concepts to implementations, this presentation first explores unconventional characteristics within magnetic systems. Specifically, we focus on charge stochasticity in traditional MTJs by analyzing bias-dependent noise data through the partition function, complemented by tight-binding model calculations [1-4]. This highlights the potential of MTJs as platforms for understanding charge stochasticity from a practical, device-level standpoint.

Building upon these microscopic insights, the second part of this talk shifts focus to macro-level control, demonstrating how we can dynamically manipulate the magnetic properties and topology of ferromagnetic multilayers and synthetic antiferromagnets via voltage-free proton toggling.

Finally, I will introduce state-of-the-art resources at synchrotron radiation facilities, both at my home institute in Taiwan and through worldwide collaborations. I will discuss how cutting-edge techniques—X-ray Magnetic Circular Dichroism (XMCD), Momentum Microscopy (MM), Scanning Transmission X-ray Microscopy (STXM), Angle-Resolved Photoemission Spectroscopy (ARPES), and X-ray Holography—serve as powerful tools to unveil the hidden magnetic and electronic structures of next-generation spintronic devices.

References

1. [Nano Letters 25, 11776 \(2025\)](#); Featured on the [Journal Cover](#). “Stochastic Nature of Voltage-Controlled Charge Dynamics in AlO_x Magnetic Tunnel Junctions”
2. [Sci. Rep. 14, 13664 \(2024\)](#); “Bias polarity-dependent low-frequency noise in ultra-thin AlO_x-based magnetic tunnel junctions”
3. [Electronics 15, 2525 \(2021\)](#); “Low-Frequency 1-f Noise Characteristics of Ultra-Thin AlO_x-Based Resistive Switching Memory Devices with Magneto-Resistive Responses”
4. [Sci. Rep. 11, 6027 \(2021\)](#); “Electrically programmable magnetoresistance in AlO_x-based magnetic tunnel junctions”

Short Bio

Education:

Ph.D. in Physics, National Taiwan University (2012)

Career:

Postdoctoral Fellow, National Taiwan University, Taiwan (2012.08 - 2015.09)

Postdoctoral Fellow, University of California, Riverside (2015.10 - 2016.07)

Assistant Professor, Tamkang University, Taiwan (2016.08 - 2021.01)

Associate Professor, Tamkang University, Taiwan (2021.02 - present)