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JHEN-YONG HONG

Tamkang University
New Taipei City, Taiwan

Stochastic Nature of Charge Dynamics in AlO_x Magnetic Tunnel Junctions

ABSTRACT

Magnetic tunnel junctions (MTJs), which rely on stabilized magnetization and resistance, have been vital components in the processing and memory blocks of traditional computing systems for the past two decades. Recently, innovative approaches such as probabilistic bits and neuromorphic computing have emerged as potential solutions for next-generation memory and logic devices aimed at unconventional computing.

In this presentation, I will explore examples of unconventional characteristics, particularly focusing on charge stochastics in traditional magnetic tunnel junctions. Our study investigates the random telegraph noise (RTN) associated with charge fluctuations in MTJs. By analyzing bias-dependent noise results using the partition function and conducting theoretical calculations based on the tight-binding model, we reveal the mechanisms that govern the relaxation time of stochastic charge fluctuations in these junctions.

Our findings indicate that random telegraph noise is highly sensitive to external voltage perturbations, providing a valuable opportunity to investigate the stochastic nature of charge transport dynamics.

These results can be understood through the concept of modulating the energy landscape with external stimuli. Our work highlights the potential of magnetic tunnel junctions as essential elements for understanding charge stochasticity from a practical standpoint.

In this talk, I'll also introduce you the resources of synchrotron radiation facilities, available from my institute in Taiwan, and from my personal cooperations in the worldwide. These are featured by X-ray Magnetic Circular Dichroism (XMCD), Momentum Microscope (MM), Scanning transmission X-ray microscopy (STXM) and X-ray Holography.

References:
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2. Sci. Rep. 14, 13664 (2024); "Bias polarity dependent low-frequency noise in ultra-thin AlOx-based magnetic tunnel junctions"
3. Electronics 15, 2525 (2021); "Low-Frequency 1-f Noise Characteristics of Ultra-Thin AlOx-Based Resistive Switching Memory Devices with Magneto-Resistive Responses"
4. Sci. Rep. 11, 6027 (2024); "Electrically programmable magnetoresistance in AlOx-based magnetic tunnel junctions"

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