Design of Fault-Tolerant Neuromorphic Computing Systems

講者： Prof. Krish Chakrabarty, Duke University

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地點：台大博理館201演講廳

摘要： The performance of today's computing infrastructure is limited by the energy consumption involved in processing, storing, and moving data. In addition, the exponential increase in the volume of data must be be handled by our computational infrastructure is driven in large part by machine-learning applications such as deep neural networks. Conventional computing architectures are unable to deal effectively or efficiently with this data volume or with the requirement to transform data into actionable information. Moreover, a major showstopper towards energy efficient computing is the high error rate associated with traditional techniques. There is a pressing need to incorporate fault tolerance in emerging computing architectures and circuit designs.

This talk will first introduce the audience to the exciting and emerging area of brain-inspired neuromorphic computing systems for machine-learning hardware. The presenter will describe RRAM-based crossbars and their role in neuromorphic computing systems. Following this, the need for testing and fault tolerance will be motivated in light of imperfect fabrication technologies, as well as technology limitations such as write endurance in RRAM cells. The speaker will present a physics-based classification and analysis of memristor fault origins. These faults origins will be systematically attributed to process variations and manufacturing defects. This study of memristor fault origins and the resulting conclusions provides valuable feedback for the fabrication and the design of memristor-based circuits and systems. Fault models, test solutions, and the architecture of a novel processing element to tolerate stuck-at and undefined-state faults in binary RRAM cells will be presented. Subsequently, techniques for online testing and fault-tolerant training will be described. Finally, time permitting, the speaker will describe an efficient fault tolerance method inspired by algorithm-based fault tolerance (ABFT), and referred to as extended-ABFT (X-ABFT), for fault detection and error correction.

簡介： Krish Chakrabarty has been at Duke University since 1998. His current research is focused on: testing and design-for-testability of integrated circuits (especially 3D SOC); microfluidic biochips; hardware security; neuromorphic computing. His research projects in the past have also included digital print and enterprise system optimization, chip cooling using digital microfluidics, wireless sensor networks, and real-time embedded systems.

Prof. Chakrabarty is a Fellow of ACM, a Fellow of IEEE, a Fellow of AAAS, and a Golden Core Member of the IEEE Computer Society. He is a Hans Fischer Senior Fellow at the Institute for Advanced Studies, Technical University of Munich, Germany. He is also an Invitational Fellow of the Japan Society for the Promotion of Science (JSPS), 2009 and 2018 (Short Term S, at the "Nobel Prize Level"). He is a recipient of two IBM Faculty Awards, the Semiconductor Research Corporation Technical Excellence Award (2018), the IEEE Circuits and Systems Society Charles A. Desoer Technical Achievement Award (2017), the IEEE Test Technology Technical Council Bob Madge Innovation Award (2018), the IEEE Computer Society Technical Achievement Award (2015) and the Meritorious Service Award. Prof. Chakrabarty is currently serving as an ACM Distinguished Speaker. He served as Editor-in-Chief of IEEE Design & Test of Computers during 2010-2012, ACM Journal on Emerging Technologies in Computing Systems during 2010-2015, and IEEE Transactions on VLSI Systems during 2015-2018.

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