Topic for a

Project Work / Studienarbeit

Modeling of a molecular memristor

At the Chair of Fundamentals of Electrical Engineering various applications with memristive memory elements are investigated to enable non-conventional and low-power analog computing systems [1]. Memristive devices have internal memory functions like a RAM and can be used in crossbar structures for highly parallel computations, especially for matrix multiplications, as they are massively used in Artificial Neural Networks (ANN) [2]. In a current collaboration, a circuit model of a molecular memristor device as described in [3] is developed. In this context, the fundamental investigation of the molecular switching mechanism and the possible integration into a mathematically efficient compact model are being researched. Within the scope of a scientific work, the equations described in [3] are analyzed in depth and implemented in a suitable environment such as Matlab or Python. Based on this, mathematical methods are used to obtain the form of a compact memristor model with the scope of a SPICE-compatible implementation.

The student research project should include, but not be limited to, the following:

- Literature research on the molecular memristor described in [2] and [3]
- Implementation of molecular memristor equations as a set of current and state equation in a suitable environment such as Matlab or Python
- Application of mathematical methods to modify the equations towards a compact memristor model
- Optional: Full implementation of a SPICE-compatible compact memristor model for the molecular memristor
- Documentation of the results

For this work, a very good understanding of physical equations and the basics of electrical engineering are required. In-depth knowledge of the molecular memristor model and the compact modeling approach can be acquired in the course of the student research project.

References:

[1] Tetzlaff, Ronald. *Memristors and Memristive Systems*. Springer, 2014
[2] Sharma, Deepak, et al. "Linear Symmetric Self-Selecting 14-Bit Kinetic Molecular Memristors." Nature, vol. 633, no. 8030, Sept. 2024, pp. 560–66, https://doi.org/10.1038/s41586-024-07902-2
[3] Kundu, Bidyabhusan, and Sreetosh Goswami. Molecular Mechanism Enabling Linearity and Symmetry in Neuromorphic Elements. arXiv:2501.01729, arXiv, 3 Jan. 2025, https://doi.org/10.48550/arXiv.2501.01729

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