Pattern Recognition using Pulsed-Laser-Deposited $BiFeO_3$ Neuromorphic Devices for Advanced Artificial Intelligence.

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ABSTRACT

The advent of neuromorphic technology marks a pivotal adaptation in modern computational hardware, addressing the evolving demands of artificial intelligence systems. This thesis underscores the importance of neuromorphic technologies in enhancing the interaction between software advancements and hardware capabilities, particularly how they can be immediately beneficial to society. The research presented here explores the use of Bismuth Iron Oxide (BFO), a multiferroic material, for developing neuromorphic devices due to its favourable material properties. A reactive pulsed laser deposition system, designed and assembled in our laboratory, was employed for the deposition of BFO thin films, which were then optimized for quality and consistency.

The core of this thesis revolves around the fabrication of neuromorphic devices using a straightforward metal-insulator-metal configuration, with Fluorine-doped tin oxide as the bottom electrode and gold as the top electrode. Comprehensive studies were conducted on the neuromorphic properties of these devices, with a specific focus on the nonlinearity of synaptic weight updates, which is crucial for real-world applications such as pattern recognition. Additionally, we investigated the impact of varying oxygen vacancy levels on the synaptic responses, revealing significant implications for device performance.

Furthermore, the practical applications of these neuromorphic devices were demonstrated through pattern recognition tasks, showcasing enhanced operational efficiency and accuracy when employing multiple devices simultaneously. This thesis not only presents the development and characterization of BFO-based neuromorphic devices but also exemplifies their potential integration into existing CMOS technology, offering a substantial leap towards advanced neuromorphic applications.