Fabricating and Testing a Novel Memristive Device for Optimized Neuromorphic Vision Applications

Alshehry, Adeeb (School: Al-Hussan High School)

This study presents a novel back-end-of-line compatible optoelectronic device specifically engineered for neuromorphic computing and visual processing applications. As the foundation of modern computers, the von Neumann architecture is inherently limited by its sequential processing design and communication bottleneck, hindering computational efficiency, scalability, and resulting in high energy consumption. This novel memristor performs voltage-activated synaptic properties, such as short-term and long-term plasticity, while also exhibiting impressive light-sensitive characteristics that enable a range of light-triggered synaptic functions. By concurrently applying both optical and electrical voltage pulses, we can achieve light-enhanced/electrically erased behavior and light-initiated paired-pulse facilitation (PPF). Moreover, advanced synaptic features, including long-term memory (LTM) and short-term memory (STM), could be implemented simply by modulating light intensity and time duration. The novel structure (ITO/ZnO/HfOx/Pt) for the device marked excellent results such as stability for one million endurance cycles, great data retention at 100°C for 104 seconds, and a 96.8% accuracy when the linearity of the switching mechanism was tested on recognizing the MNIST handwritten digits dataset. The electrical and optical synaptic plasticity of the device makes it a promising candidate for furthering the development of neuromorphic computing systems. The real-time image processing and object recognition with minimal energy consumption makes it applicable in many fields, including self-driving cars, augmented/virtual reality, industrial automation, security, surveillance, and overall marks a significant advancement in the field.