World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:14, No:04, 2020

A Low-Cost Memristor Based on Hybrid Structures of Metal-Oxide Quantum Dots and Thin Films

Authors : Amir Shariffar, Haider Salman, Tanveer Siddique, Omar Manasreh

Abstract : According to the recent studies on metal-oxide memristors, researchers tend to improve the stability, endurance, and uniformity of resistive switching (RS) behavior in memristors. Specifically, the main challenge is to prevent abrupt ruptures in the memristor's filament during the RS process. To address this problem, we are proposing a low-cost hybrid structure of metal oxide quantum dots (QDs) and thin films to control the formation of filaments in memristors. We aim to use metal oxide quantum dots because of their unique electronic properties and quantum confinement, which may improve the resistive switching behavior. QDs have discrete energy spectra due to electron confinement in three-dimensional space. Because of Coulomb repulsion between electrons, only a few free electrons are contained in a quantum dot. This fact might guide the growth direction for the conducting filaments in the metal oxide memristor. As a result, it is expected that QDs can improve the endurance and uniformity of RS behavior in memristors. Moreover, we use a hybrid structure of intrinsic n-type quantum dots and p-type thin films to introduce a potential barrier at the junction that can smooth the transition between high and low resistance states. A bottom-up approach is used for fabricating the proposed memristor using different types of metal-oxide QDs and thin films. We synthesize QDs including, zinc oxide, molybdenum trioxide, and nickel oxide combined with spin-coated thin films of titanium dioxide, copper oxide, and hafnium dioxide. We employ fluorine-doped tin oxide (FTO) coated glass as the substrate for deposition and bottom electrode. Then, the active layer composed of one type of quantum dots, and the opposite type of thin films is spin-coated onto the FTO. Lastly, circular gold electrodes are deposited with a shadow mask by using electron-beam (e-beam) evaporation at room temperature. The fabricated devices are characterized using a probe station with a semiconductor parameter analyzer. The current-voltage (I-V) characterization is analyzed for each device to determine the conduction mechanism. We evaluate the memristor's performance in terms of stability, endurance, and retention time to identify the optimal memristive structure. Finally, we assess the proposed hypothesis before we proceed to the optimization process for fabricating the memristor.

Keywords : memristor, quantum dot, resistive switching, thin film
Conference Title : ICMMMDS 2020 : International Conference on Memristors, Memristive Materials, Devices and Systems
Conference Location : New York, United States
Conference Dates : April 23-24, 2020

Open Science Index, Electronics and Communication Engineering Vol:14, No:04, 2020 publications.waset.org/abstracts/124980.pdf