DEMONSTRATION OF SYNAPTIC CHARACTERISTICS OF Ti/BaO_x/n^+-Si DEVICE

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Abstract - Recently, there has been an increasing requirement for computing performance and efficiency. Traditional Von Neumann architecture, whose principle is to separate the central processing unit (CPU) and memory, not only limits the performance of the computer but also causes a large amount of energy consumption. Artificial synaptic device has been widely recognized as a solution to solve theVon Neumann bottleneck. Among semiconductor devices, resistive random-access memory device is considered suitable for realizing artificial synapses. In this study,a barium oxide (BaO_x)synaptic device is proposed. The BaO_xactive layer was deposited on a n^+-Si substrate using a sol-gel process.Then, theBaO_x/n^+-Si sample was annealed at 500 °Cin vacuum for 30 min.The BaO_x was cured and densified because of the high-temperature annealing.After that,a thermal evaporator with a shadow mask was used to deposit and patternTi metal on the BaO_x active layer as top electrodes. Theartificial synaptic behavior of the Ti/BaO_x/n^+-Si device was evaluated using DC voltagesweeps and voltage pulses.Fig. 1 shows current-voltage characteristics of the Ti/BaO_x/n^+-Si device measured with a DC voltage cycle of 0 → -6 V → 0→ 6 V → 0.When the first negative voltage sweep is applied to the Ti electrode, oxygenions in the BaO_x layer are gradually repelled, resultingin generation ofoxygen vacancies.The conductance of theBaO_x synaptic device gradually increases. Therefore, when the voltage sweeps backward from -6 V to 0, the device shows a higher conduction current. In contrast, when a positive voltage is applied to the Ti electrode, oxygen ions in the BaO_x layer are attractedto fill the oxygen vacancies, leading to a decrease in oxygen vacancy content of the device. The conductance of the BaO_x synaptic device gradually decreases. Hence, the device shows a lower current when the voltage sweeps back from 6 V to 0. The conductance modification of the BaO_x device is dominated by oxygen vacancy content in the BaO_xactive layer.Fig. 2 revealssynaptic characteristics of the BaO_x device. The device conductance can gradually increase with increasing pulse number, demonstrating a synapticpotentiation behavior.Synaptic depression function can also be successfully obtained when successive positive voltage pulses are applied to the device.Satisfactory linearitiesin potentiation and depression characteristicsare observed.Moreover, paired pulse facilitation effect and spike-timing-dependent-plasticity (STDP) behavior can also be mimicked by the Ti/BaO_x/n^+-Si device.This study demonstrates synaptic functionsof the Ti/BaO_x/n^+-Si device.Artificial synapses are crucial to advancement of artificial intelligence and neuroscience. The proposed BaO_xsynaptic device will contribute to the development of future neuromorphic computing systems.

Keywords - Barium Oxide(BaO), Artificial Synapse, Neuromorphic Computing

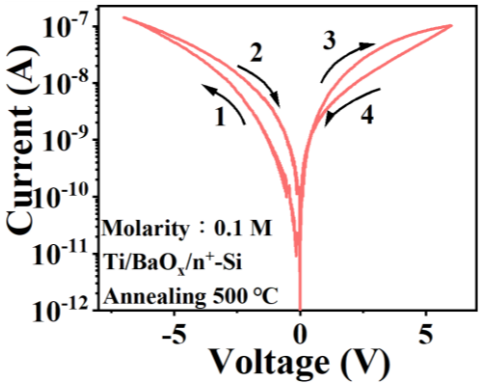


Fig. 1 Gradual conductance transition behavior of the Ti/BaO_x/n^+-Sidevice.

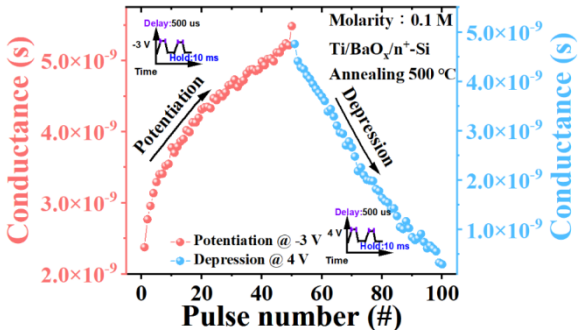


Fig. 2 Potentiation and depression characteristics of the Ti/BaO_x/n^+-Sidevice.

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