ALD Applications
Room On Demand - Session AA10
Memory Applications: RRAM & Neuromorphic, MIM Capacitors

AA10-1 Li-Nb-O Family Deposited by Atomic Layer Deposition (ALD) for Artificial Neuron and Synapse*, Hyun Seung Choi,* *H. Kim, S. Park, T. Park,* Hanyang University, Korea (Republic of)

Neuromorphic computing, consisting of artificial neurons and synapses, is one of the most promising candidates to resolve the von-Neumann bottleneck because of its in-memory-computing attributes, high efficiency, and parallel signal processing. Recently, artificial neurons and synapses have been studies using the variety of materials to improving device properties. The lithium niobium oxide (Li-Nb-O) family have many desirable multifunctional properties including memory, TS behavior, ferroelectric effect, etc. [1-2] Among these properties, niobium oxide (NbO_2) is well known as metal-insulator-transition selector, and lithium niobate ($LiNbO_x$) as memristor. [3] Especially, lithium niobate can represent superior characteristics due to small ion size of lithium (Li) ion enabling low energy consumption, high mobility, and high endurance. Despite the potential for new and enhanced functional devices and materials, this Li-Nb-O multifunctional family remains relatively unexplored due to the difficulty of precise composition control.

In this study, niobium oxide and lithium niobate deposited by Atomic Layer Deposition (ALD) are proposed for artificial neuron and synapse. Controllable memory and TS behaviors are confirmed by adjusting the composition of Li-Nb-O compound. Niobium oxide represented the volatile property as reported, and lithium niobate showed analog switching memory applicable to artificial synapse. Especially, by understanding the effect of Li-ion concentration on synaptic properties such as potentiation/depression, an optimal composition of lithium niobate is achieved. Consequently, our work can provide an easy yet effective way to construct functional neuromorphic devices by using similar materials in same family.

References [1] IEDM (2013) 268–271 [2] APL Mater. 7, 071103 (2019) [3] Nanotechnology 2020, 31(23):235203

AA10-2 Li Compound-Based Two-Terminal Artificial Synaptic Devices via Atomic Layer Deposition*, Hye Rim Kim,* *H. Choi, S. Park,* Hanyang University, Korea (Republic of)*; G. Kim ,* Korea Research Institute of Chemical Technology (KRICT), Korea (Republic of)*; T. Park,* Hanyang University, Korea (Republic of)

Brain-inspired neuromorphic computing is considered a novel computing paradigm that mimics the human brain, capable of parallel data processing and low power consumption. [1] Memristor devices are potential candidates as a synaptic component for neuromorphic computing especially towards spiking neural networks (SNN) due to their inherent nature. [2] Lithium titanate ($Li_4Ti_5O_{12}$, LTO) as a proposed anode material of lithium (Li) ion batteries, is a zero-strain material capable of reversible Li ion migration. Also, the feasibility of synaptic characteristics in lithium titanate based device has been confirmed through the metallic and insulating phase separation by an electric field. [3] The behavior of Li ions, a key component of synaptic properties, is highly dependent on the Li concentrations inside the LTO active layer [4], but related studies are still insufficient.

In this research, the lithium titanate active layers were grown through atomic layer deposition (ALD) and fine composition control was achieved using super-cycle method. Sequentially, the Li concentration-dependent resistive switching characteristics of the LTO based memristor devices were confirmed. Also, synaptic properties including potentiation and depression were confirmed by applying the identical neuronal spikes. Consequently, we derived an optimized Li concentration of the lithium titanate materials suitable for synapse devices using atomic layer deposition and pulse engineering. The detailed experimental results will be presented.

References list: [1] IEEE Nanotechnol. Mag., Sep., 36-44 (2018). [2] Nat. Commun., 9, 2514 (2018). [3] Adv. Mater., 32, 1907465, 1-12 (2020). [4] Chem. Mater., 27, 1740-1750 (2015)

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