Tuning of Conductance Values by Si Doping in GeTe for Artificial Synapse Characteristics

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Chalcogenides are materials that contain chalcogen atoms, such as sulfur, selenium, and tellurium, in their chemical structure. Chalcogenides are of great interest for various applications such as data storage, neuromorphic computing, and thermoelectric applications.[1] Among the GeTe-Sb_2Te_3 tie line, GeTe is widely studied because of its fast switching and large resistance contrast. Although GeTe has been steadily studied through electrical characteristics between amorphous and crystalline, its application to neuromorphic computing has not been studied much so far. This is because it is difficult to implement artificial synaptic properties that require a gradual decrease or increase in resistance because GeTe rapidly decreases or increase in resistance. To solve this problem, fascinating fundamental properties may be realized by doping pristine-GeTe with Si. In general, doping of some elements or compounds in GeTe affects the electrical and optical transport behavior of phase change materials.[2]

In this study, it was revealed that the Si dopant influences a change in the crystal structure environment of the existing rhombohedral structure of pristine GeTe. It was also confirmed through the Resistance-Temperature measurements and X-ray diffraction that Si-doped GeTe exhibits gradual resistance change with temperature due to the unique characteristic. The presence of Si atoms at Ge sites or Ge vacancies reduces the carrier concentration and hinders crystallization. Such results imply that Si-doped GeTe device shows gradual resistance reduction characteristics, and long-term potentiation (LTP) and long-term depression (LTD), which are one of the characteristics of artificial synapses. [3] We investigated the artificial synaptic characteristics of devices using Si-doped GeTe to mimic the LTP/LTD properties. In presentation, we will discuss on synaptic functionalities in the Si-doped GeTe device.

[Reference]

[1] Zuliani, Paola, et al. "Engineering of chalcogenide materials for embedded applications of Phase Change Memory." Solid-State Electronics 111 (2015): 27-31.

[2] Liu, Wei-Di, et al. "High-performance GeTe-based thermoelectrics: from materials to devices." Advanced Energy Materials 10.19 (2020): 2000367.

[3] Huh, Woong, Donghun Lee, and Chul-Ho Lee. "Memristors based on 2D materials as an artificial synapse for neuromorphic electronics." Advanced Materials 32.51 (2020): 2002092.

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