Supporting Information

High Photosensitivity Light-Controlled Planar ZnO Artificial Synapse for Neuromorphic Computing

Keywords: photosensitivity, memristor, artificial synapse, persistent photoconductivity, neuromorphic computing

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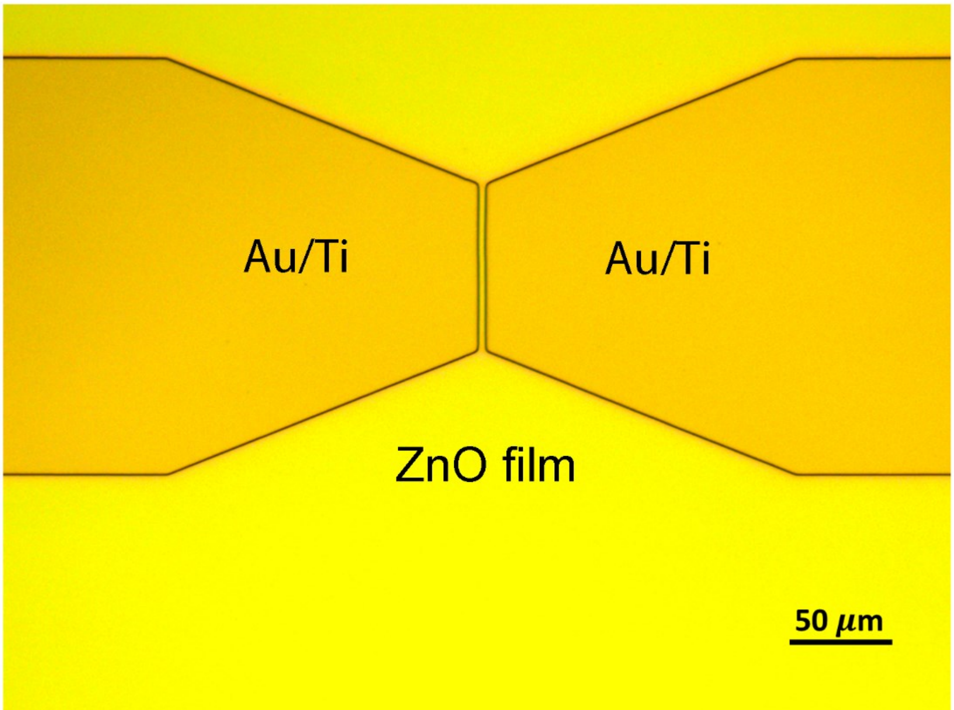

Figure S1. The optical microscope image of the light-controlled planar artificial synapse. A two-terminal Au/Ti/ZnO/Ti/Au planar structure is realized in our light-controlled synapse.

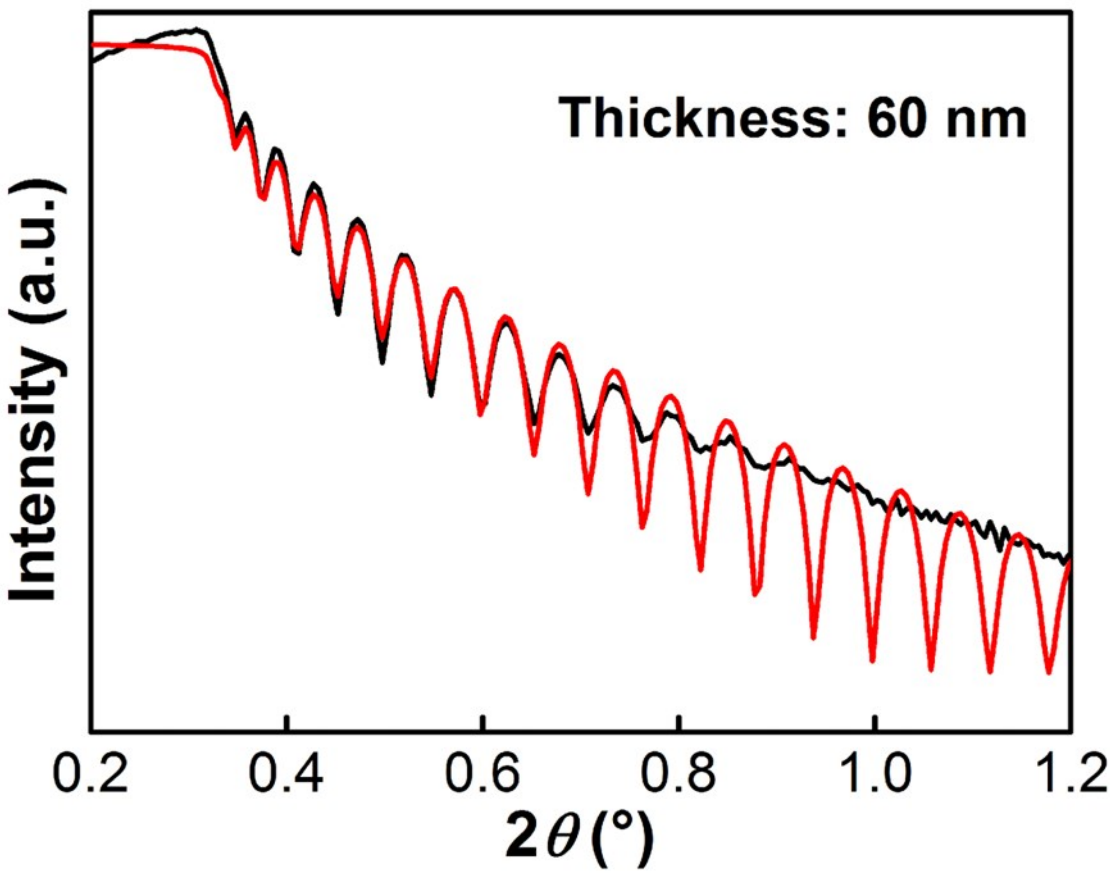

Figure S2. The thickness of the ZnO thin film measured using oscillatory X-ray reflection. All the ZnO thin film thickness used in this study is calculated with reference to this thickness.

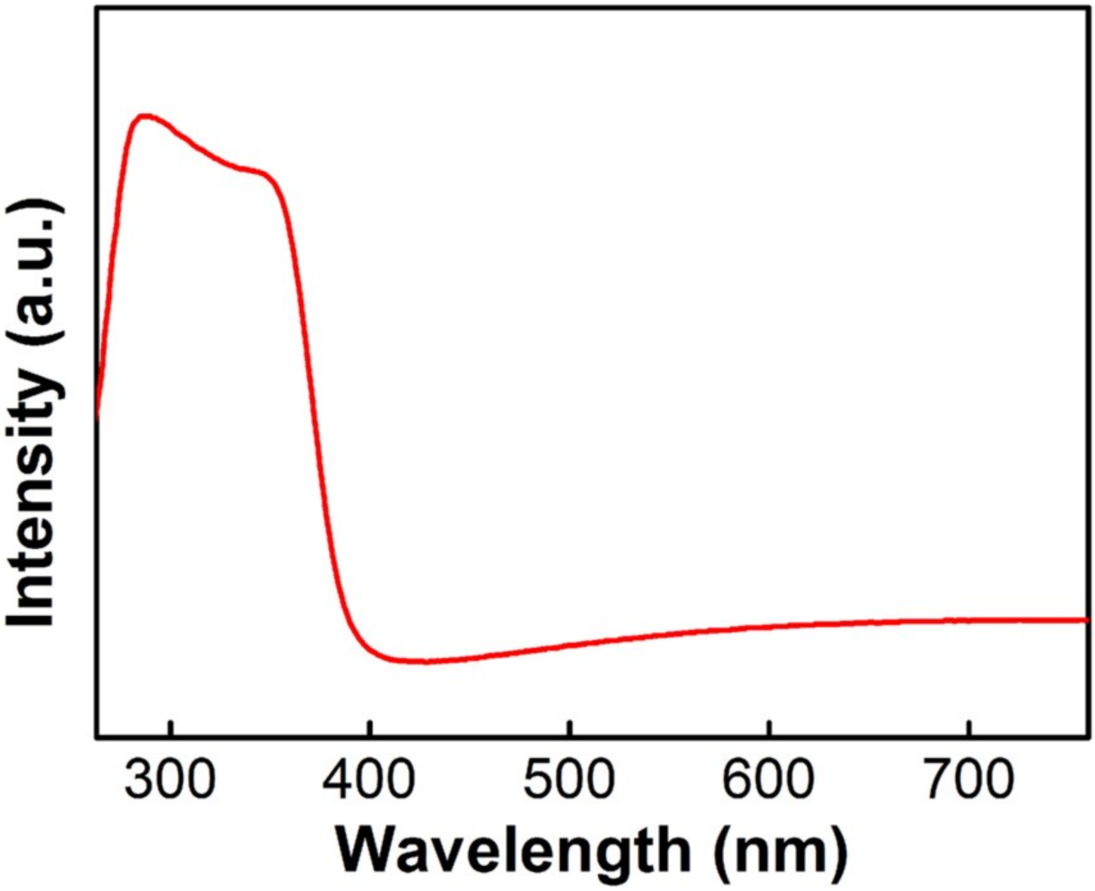

Figure S3. The absorption spectra of ZnO thin film.

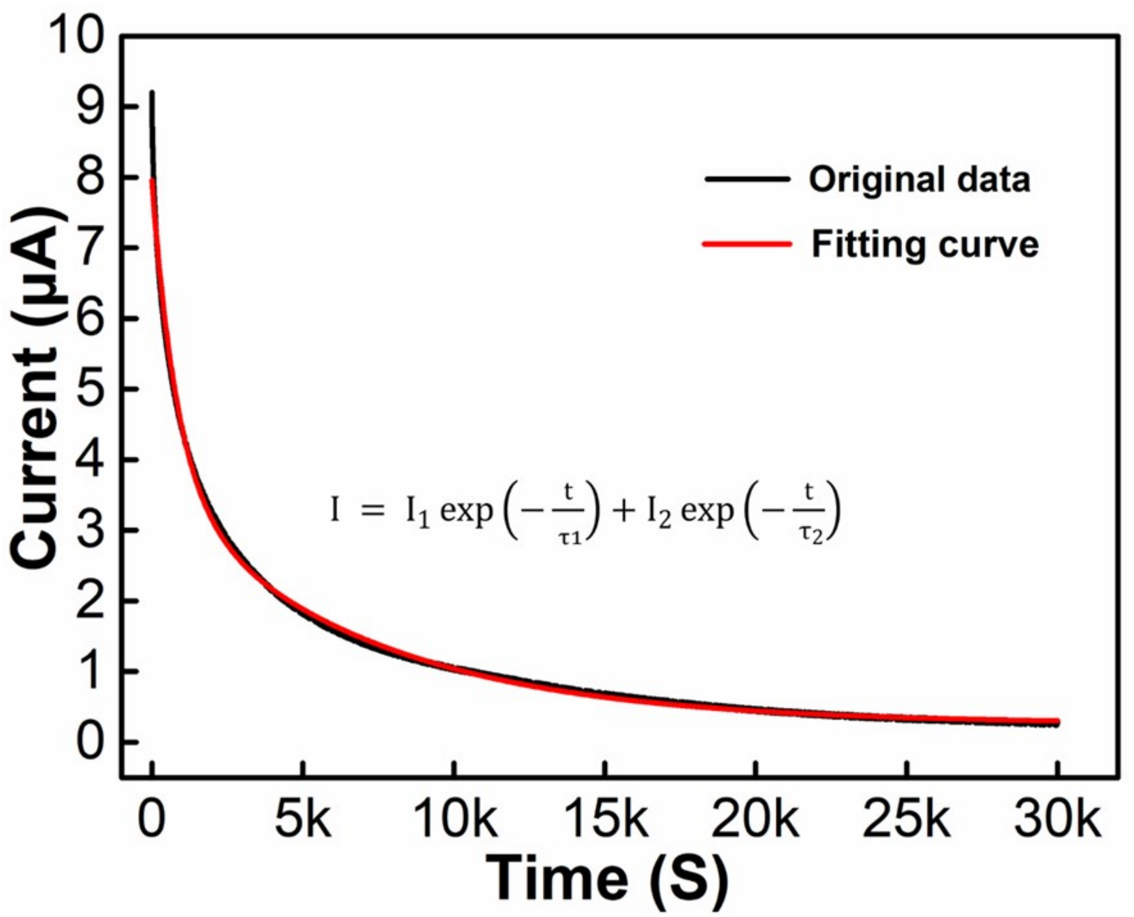

Figure S4. Double exponential relaxation equation fitting of the decay process of the PPC curve.

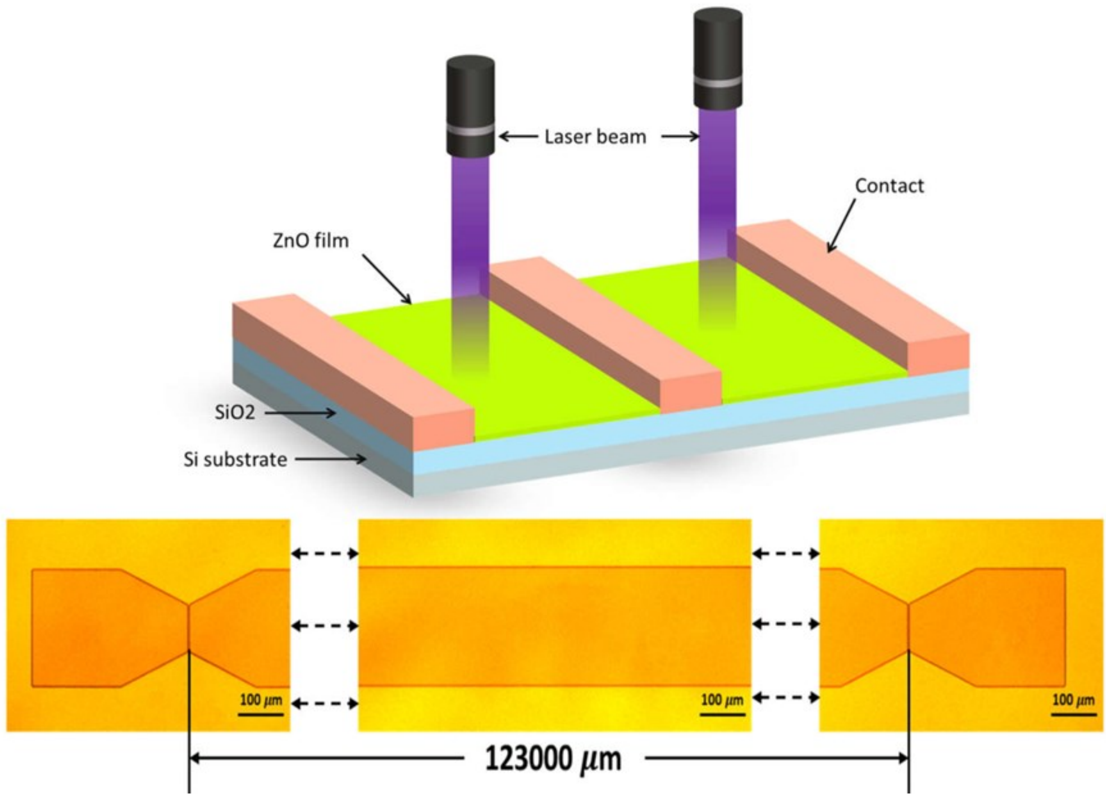

Figure S5. Device structure and optical microscope image of synapse devices for symmetric STDP simulation.

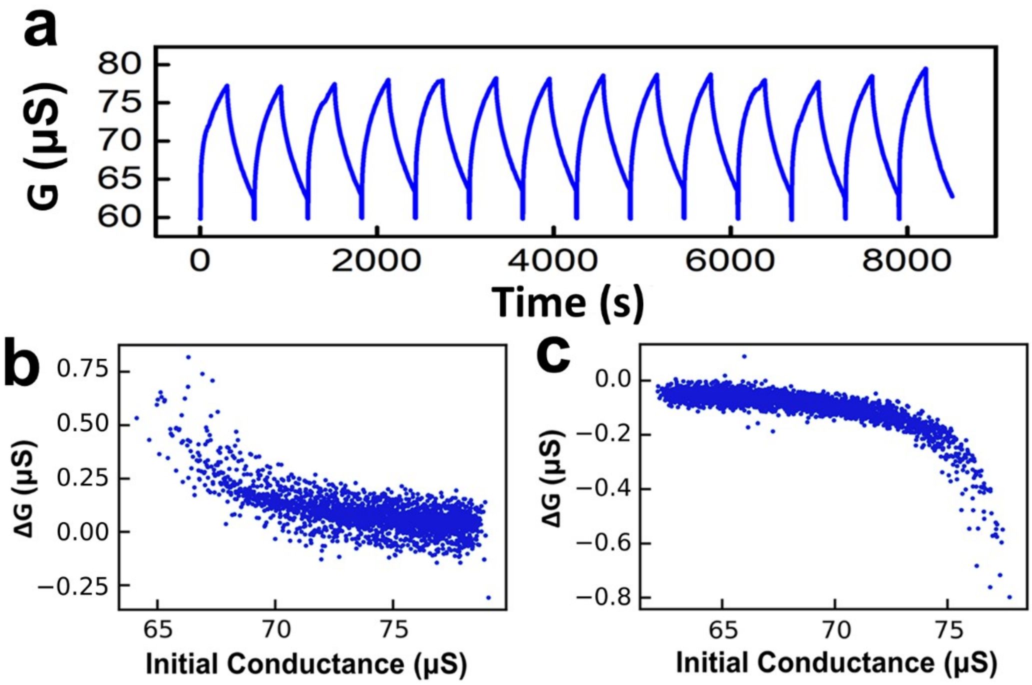

Figure S6. The repeatability and linearity of conductance changes. a) The repeatability of synapse device. The change in conductance, ΔG, against the initial conductance state under b) light exposure and after c) removing light exposure.

Supplementary Text

S1 A discussion on optical system neuromorphic circuits

At present, the research on photo-synapses basically stays at the simulation of biological behavior on a single device [1-3]. The work of integrating photo-synapses neuromorphic circuits still requires a long time of research and effort. By consulting the literature, we have the following ideas for the realization of the photo-synaptic integration neuromorphic circuits system:

1.Large-scale integrated photo-synaptic devices for image recognition acceleration.

We can design a large-scale integrated optical information storage and modulation system with photo-synaptic devices, where the system can directly store optical information and realize the function of optical information modulation due to the memory behavior of photo-synaptic devices [4]. Therefore, the first-stage image information processing such as image contrast enhancement and noise reduction can be realized in this system, which can significantly speed up the image processing and avoid the energy consumption compared with processing in a traditional computer system where the extensive data needs to move between physically separated memory and processor constantly [1].

2. Large-scale integration photo-synaptic devices for processor architecture.

In this processor architecture, each photo-synaptic device needs to participate in logical operations. In this situation, the light exposure is equivalent to the gate electrode of the photo-synaptic device. By introducing the optical interconnection technology in the field of microelectronics, which contains the light emission, light propagation, and light-receiving process[5], the processing speed of the processor can be greatly increased owing to the reason that the data transmission speed of optical interconnection technology is much higher than that of the Cu and Al metal interconnection technology where the speed of the data processing can be limited due to the bandwidth connection density trade-off [1]. Moreover, traditional computer systems can only perform two-state (0,1) operations and are at a disadvantage in solving unstructured problems due to the challenges that originate from the speed bottleneck and huge energy costs associated with constant data movements between physically separated memory and processor. Conversely, the photo-synaptic device processor has the ability of multi-state operations and can be used for high-speed processing of unstructured problems more easily than traditional computer systems [6].

References

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