Optoelectronic memory device via electrically controlling phase change material with near-infrared response

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Abstract

In this research, a volatile memory device based on a phase change material (PCM) was demonstrated. Via electrically tuning the temperature of VO_2 thin films, near-infrared optical transmittance is recorded to display the different optoelectronics memory states.

1. Introduction

With the evolution of technologies like artificial intelligence, big data and deep learning, people attach very great importance to the requirement of data transmission and storage. Recently, the concept of integrated optical circuit comes to the fore. Different from electricity, light can provide faster transmission speed and possess wider bandwidth. Therefore, it becomes imperative to develop the novel data storage device, and one of these applications is the optoelectronic memory device. [1]

Vanadium dioxide (VO_2) is a phase change material (PCM) which could be transform from insulator to metal (IMT) at 340 K. [2] Based on its special thermal hysteresis property, the communication wavelength (1550 nm) is used to display the memory operation in this research.

2. Results and discussion

VO_2 thin films were deposited on commercial ITO/glass substrates by RF magnetron sputtering with a VO_2 target (purity:99.99%). After deposited, the sample was annealing at 550°C for 6 hrs in vacuum. Finally, we deposited gold electrodes on top side by E-beam evaporator. The schematic of the device structure was shown in Fig. 1(a). A classic transmittance spectra of VO_2 after phase transition as shown in Fig.1 (b).

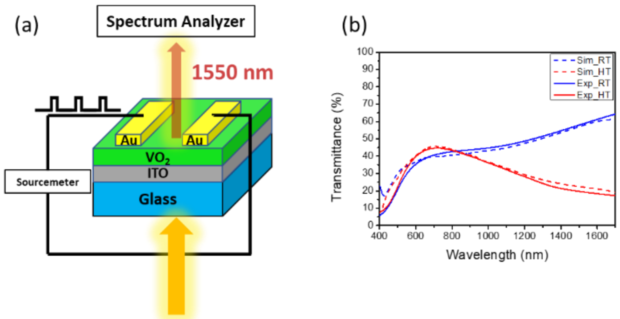

Fig. 1 Schematic of the device structure and sample characterization. (a) Schematic of the device structure. (b) Transmittance spectra of VO_2/ITO/glass samples at the room temperature (RT) state and the high temperature (HT) state. Solid lines correspond to experimental data and dashed lines correspond to simulated data.

As shown in Fig.2 (a), transmittance would exist an abrupt dropping when bias upon to 3.4 V, defined as the threshold voltage. By sweeping the bias voltage with different maximum values, it would form multiple hysteresis loops as shown in Fig.2 (b). In addition, the good stability of VO_2/ITO sample was verified as shown in Fig. 2(c). Finally, we chose 3.5 V to be the base value and two kinds of pulse voltages (4 V/3.4 V) to create two operation modes as shown in Fig.2 (d). According to this operation, two steps-like modes of transmittance had an obvious response with applying bias voltages.

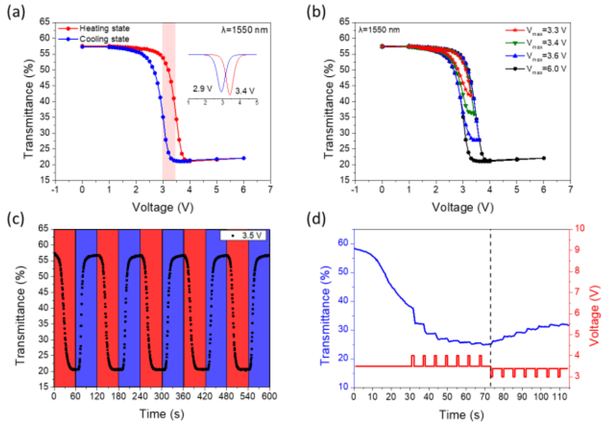

Fig. 2 Memory devices with multiple hysteresis loops and stable repeatability. (a) Transmittance as a function of voltage for VO_2/ITO sample; the inset showed the related differential curves. (b) The multiple hysteresis loops. (c) Dynamically voltage on/off (red area, 60 s/blue area, 60 s) tuning the transmittance (λ=1550 nm) around 5 cycles. (d) Experimental transmittance as a function of different pulsed voltages.

3. Conclusions

In summary, we demonstrated the volatile memory operation with different modes by electrically tuning multiple hysteresis states. Without any complicated lithography technique, is the device could be fabricated economically with low cost. Based on these results, VO_2 is a preferable candidate for memory devices in nanophotonics and advanced optoelectronics.

References

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