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Zirconia quantum dots for a nonvolatile resistiverandom access memory device

Key words: Zirconia quantum dot; Resistive switching; Memory device; Spin coating

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Motivation

- The speed and capacity of central processing units (CPUs) and memories are increasing rapidly, but the increase in bus speed for transferring data and instructions is very limited. Memristors or resistance random access memory (RRAM) can be used to not only store data but also implement logic calculations.
- However, the preparation methods for RRAM devices are complex, as they usually involve a magnetron sputtering method.

Main idea

- ZrO_2 has been widely applied for preparing a variety of optical devices and electronic devices. Recently, due to the various advantages of ZrO_2, the RRAM devices based on ZrO_2 active layer offer a facile approach for future electronic applications.
- Compared with the magnetron sputtering method, the spin-coating method is a relatively simple operation process.

Method

Experimental setup

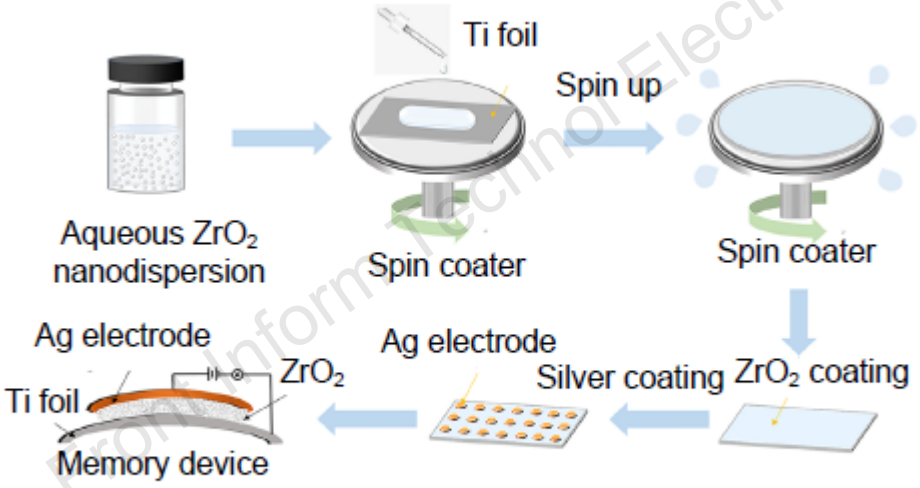

Fig. 1 Manufacturing process of the Ag/ZrO_2/Ti device

Major results

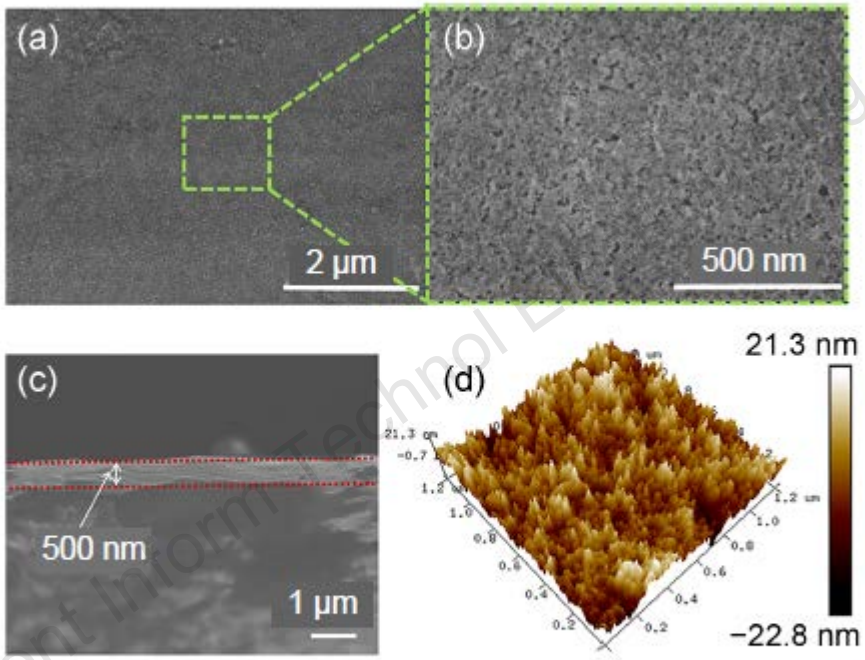

Fig. 3 SEM images (a and b), the cross sectional SEM image (c), and an AFM image (d) of ZrO_2 coating on the titanium foil

The hydrophilic ZrO_2 coating clearly shows a film formed by stacking a dense oxide on the titanium sheet. The thickness of the ZrO_2 coating is observed by SEM at around 500 nm.

The average surface roughness (Ra) of the ZrO_2 surface coating is 4.49 nm, which is close to the size of a single ZrO_2 QD.

Major results (Cont'd)

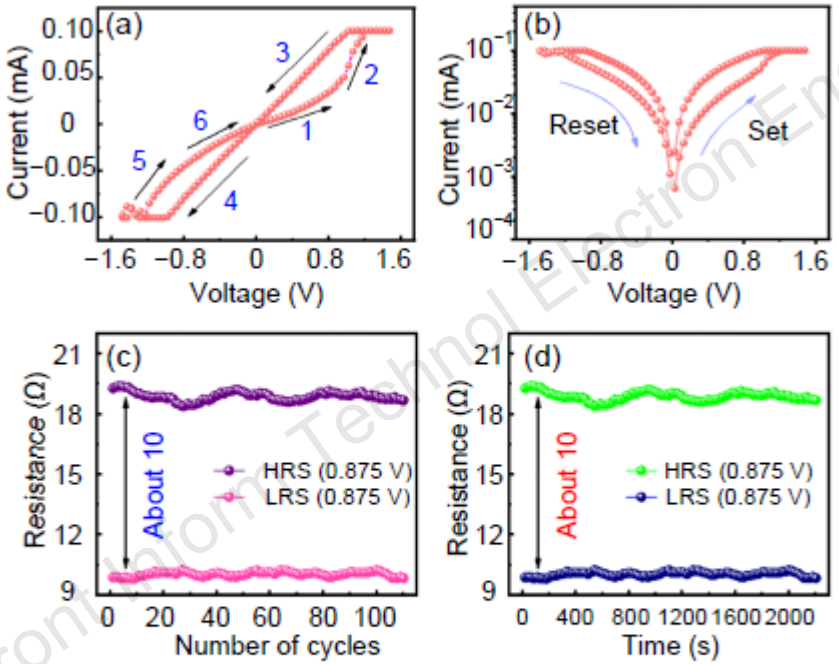

Fig. 4 *I-V* **curves of a single cycle when the voltage changes from 0→1.5→0→−1.5→0 V (a and b), and resistance curves vs. the number of cycles and time under a positive voltage of 0.875 V (c and d)**

Results show that the device has a quick response even in very short time and a relatively low switching current (about 1 μA).

Considering the practical application of memristors, a stable cycle performance and a large HRS/LRS resistance difference are necessary.

Conclusions

- Nonvolatile resistive random access memory devices using ZrO_2 QDs as an active layer have been devised by a simple spin-coating process.
- The resistive switching memory devices based on Ag (top)/ZrO_2 (active layer)/Ti (bottom) showed an HRS/LRS resistance difference (about 10 Ω), a good cycle performance (the number of cycles larger than 100), and a relatively low conversion current (about 1 μA).
- The Ag ions and oxygen vacancies are organized as conducting filaments inside the ZrO_2 coating.