Zirconia quantum dots for a nonvolatile resistive random 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/ZrO₂/Ti device
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)

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

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

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).
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.