Journal of ELECTRONIC MATERIALS, Vol. 42, No. 8, 2013
DOI: 10.1007/s11664-013-2600-5

Resistive Switching Properties of Sol–Gel-Derived V-Doped $SrTiO_3$ Thin Films

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V-doped and undoped $SrTiO_3$ (V:STO and STO) thin films on Pt/Ti/SiO_2/Si substrates were synthesized using a sol–gel method to form metal–insulator–metal (MIM) structures. Coexistence of the bipolar and unipolar resistive switching (BRS and URS) modes in Pt/STO/Pt and Pt/V:STO/Pt structures was observed as a irreversible transition from BRS to URS on adjustment of the compliance current (I_{comp}). Both states were stable and reproducible over 60 cycles, and the maximum operating voltage of the Pt/STO/Pt was reduced from 10 V to 2 V by doping with V. Linear fitting of current–voltage curves suggests that space-charge-limited leakage was the limiting leakage mechanism for these two devices. Based on these results, a switching mechanism based on filament theory is proposed to explain both resistive switching modes.

Key words: Nonvolatile memory, RRAM, V-doped $SrTiO_3$ thin films, resistive switching

INTRODUCTION

Resistance random-access memory (RRAM) has attracted a great deal of attention in recent years due to its low power consumption, long retention time, small cell size, high operation speed, low cost, high endurance, nondestructive readout, and simple structure. It is well known that reversible switching between a high-resistance state (HRS) and a low-resistance state (LRS) can be achieved by applying a certain voltage. Resistive switching usually occurs in two types: bipolar (BRS) and unipolar resistive switching (URS), whose behavior depends on the polarity and amplitude of the applied voltage.[1–6] The resistive switching (RS) phenomenon has been observed in a wide variety of binary transition-metal oxides such as ZnO, NiO, TiO_2, and ZrO_2, ferromagnetic materials such as $Pr_{1-x}Ca_xMnO_3$, and doped perovskite oxides such as $SrZrO_3$, $BiFeO_3$, and $SrTiO_3$.[7–18] The resistive switching mechanism has been intensively studied and discussed, and various possible physical mechanisms have been proposed in an attempt to explain these behaviors, including alteration of the bulk insulator resistivity by defects or trapped carriers, oxygen vacancies migrating to the electrode interface also with defects or trapped carriers, formation and rupture of filamentary paths by Joule heating, etc.[19–21]

In this study, we report the switching behavior of V-doped and undoped $SrTiO_3$ thin films deposited between Pt electrodes by a sol–gel method. The sol–gel method has advantages including low cost, easy stoichiometric control, and high uniformity. The influence of the process conditions of the thermal treatment on the physical properties of the films

(Received December 24, 2012; accepted April 2, 2013; published online April 30, 2013)