Resistive Switching of Iron-Doped $SrTiO_3$

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Abstract:

We report on the resistive switching behavior of iron-doped strontium titanate ($SrTiO_3$ or STO), particularly related to electroforming. Epitaxial iron:STO (Fe:STO) thin þlms were deposited on a single crystalline niobium:STO (Nb:STO) substrate with pulsed laser deposition (PLD). Large defect structures were located on the þlm using scanning electron microscopy (SEM). Platinum electrodes were placed over areas both with and without these defects; electroforming and switching behavior were characterized. Results indicated that defect structures have signiþcantly different electroforming behavior than other areas of the þlm.

Introduction:

As the scalability limits of transistor-based memory approach, it is becoming increasingly necessary to þnd alternatives to modern ÿash memory. One such alternative is to utilize resistive switching effects to create resistive random access memory (RRAM). Resistive switching is the phenomena in which certain materials can be switched between high and low resistance states, which at as binary òONó and òOFFó states in memory. In resistive switching devices, a typically insulating layer, generally an oxide, is deposited between two conducting layers. The application of voltage switches the device between high and low resistance states. In some cases, an electroforming step is needed to activate the switching.

In this case, the one-time application of voltage changes the switching device from its initial virgin state and enables resistive switching. STO is often used as a model material for resistive switching. However, there lacks a clear consensus and understanding for the underlying physicochemical processes involved in resistive switching, particularly those for electroformation [1].

Experimental Procedure:

To begin the fabrication process, 0.5 wt.% Nb-doped STO substrates were annealed for three hours to ensure a terrace step topography, which was then veriþed with atomic force microscopy. These substrates also act as the bottom electrode of the switching device. Epitaxial 5 at.% Fe-doped STO thin þlms were deposited using PLD, of thickness either 20 nm or 100 nm. On some samples, a 30 nm platinum thin þlm was then sputtered, patterned with photolithography, and etched using reactive ion etching (RIE) to create arrays of 200 Õm by 200 Õm top electrodes.

Figure 1: A defect structure located on the surface of an Fe:STO thin þlm.

On a 100 nm Fe:STO thin þlm sample, a layer of poly(methyl methacrylate) (PMMA) was spun on top of the Fe:STO thin þlm, marker structures were patterned with e-beam lithography and etched with RIE prior to the sputtering of the 30 nm platinum þlm. The PMMA was then removed, leaving behind platinum marker structures on the Fe:STO thin þlm. Then, using SEM, the þlm was examined and large defect structures were located relative to the marker