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Structures Based on TiO₂ and TiO₂:Co Nanotubes: Electrical and Magnetic Behavior for Resistive Memories.



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ABSTRACT

TiO₂ and TiO₂:Co nanotubes were synthesized via electrochemical anodization using high-purity Ti and Co-sputtered Ti foils. The ~300 nm nanotubes showed well codes and anisotropic phase with an amorphous halo (XRD). Two MSM configurations (transverse and coplanar) were used to study bulk and surface conduction. AFM and KPFM analyses revealed surface topography and potential. All devices exhibited asymmetric I-V behavior, with higher conduction under positive bias. The Au/TiO₂/Ti structure showed the lowest resistance and Schottky-like behavior. Magnetic measurements confirmed ferromagnetic behavior in TiO₂:Co nanotubes, highlighting their potential for multifunctional spintronic applications.

INTRODUCTION

In spintronics, where both electron charge and spin are harnessed, Co-doped TiO₂ has gained attention for its combined semiconducting and magnetic behavior. These nanotubes exhibit resistive switching and operate at room temperature, making them promising for non-volatile memory (NVM) and spintronic applications.

This study focuses on the fabrication and analysis of TiO₂ and TiO₂:Co nanotubes, emphasizing their structural, electronic, and transport properties, with potential for advanced memory and spintronic technologies.

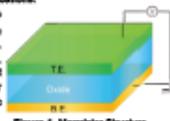


Figure 1. Memristor Structure

METHODOLOGY

Figure 3. Magnetron Sputtering System



Figure 2. Substrate cleaning

Figure 4. Electrochemical Anodization Process



Figure 4. Electrochemical Anodization Process

Figure 5. Heat thermal evaporator



Figure 5. Heat thermal evaporator

PICOAMMETER
XRD
SEM
VSM
AFM

RESULTS

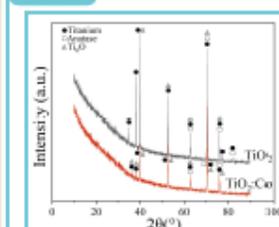


Figure 6. XRD patterns for TiO₂ nanotubes (black line) and TiO₂:Co nanotubes (red line).

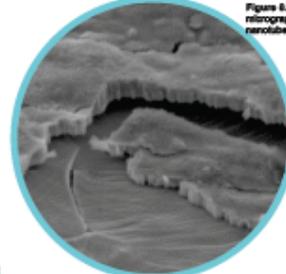


Figure 8. SEM micrograph for TiO₂ nanotubes

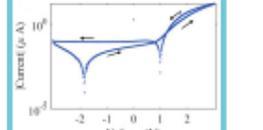


Figure 9. I-V curves of the samples with transversal structure

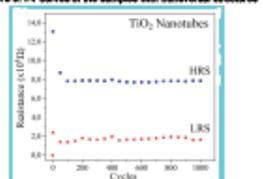


Figure 11. Endurance performance measurements for TiO₂ nanotubes

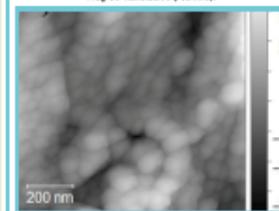


Figure 7. Topography and Kelvin probe force microscopy (KPFM) surface potential maps for TiO₂ and TiO₂:Co samples.

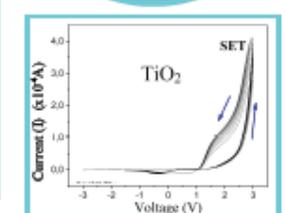


Figure 10. I-V curve for 10 cycles of the TiO₂ and TiO₂:Co nanotubes

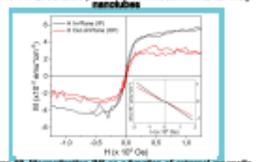


Figure 12. Magnetization (M) as a function of external magnetic field (H) curves

CONCLUSIONS

TiO₂ and TiO₂:Co nanotubes were successfully synthesized via electrochemical anodization, resulting in amorphous and anisotropic structures with oxygen vacancies that promote cobalt incorporation without secondary phases. This method produced diluted magnetic semiconductors with nanotubular morphology. Under oxygen-limited conditions, autochlorination Ti-O phases (e.g., Ti₂O₃) may also form. Electrical characterization revealed two conduction mechanisms: Au top electrodes formed Schottky barriers, while Al introduced a capacitive effect. In surface conduction (AAM configuration), no memristive behavior was observed—only capacitive response. The observed resistive switching is attributed to the formation of conductive filaments from charge carrier migration, allowing transitions between high and low resistance states (HRS/LRS). Devices showed stable switching under 2.0 V (TiO₂) and 0.5 V (TiO₂:Co). Magnetization measurements confirmed ferromagnetic-like behavior in TiO₂:Co nanotubes, supporting their potential for spintronic memory applications.

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- [2] Kimy S. Jaime, Heiddy P. Quiroz, Jorge A. Calderón, A. Dussan, Magnetic-resistive random access memories based on diluted Co: <https://doi.org/10.1016/j.mseb.2024.107890>. Results Phys. 63 (2024) 107890 <https://doi.org/10.1016/j.mseb.2024.107890>.

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