Investigation of Resistive Switching in Pb(Fe_{0.5}Nb_{0.5})O_3: Thin Film Synthesis & Characterization

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Introduction

- Resistive Switching (RS) Effect has a high potential for electronic devices (no scaling limitation)
- RS Effect knows a renewal as a research topic
- PbFe_{0.5}Nb_{0.5}O_3 (PFN) oxide may exhibit this effect due to the change of oxygen vacancy concentration by oxidation reaction

Resistive Switching Effect

- RS Effect consists on the change of resistance of a dielectric to two stable states (Low-RS and High-RS) governed by the external applied voltage and the resulting heating (Joule Effect)
- Process: formation and disruption of conductive filaments (CFs) made of oxygen vacancies in three steps:
  1. Forming process
  2. Re-forming of the CFs by O_2 vacancies migration
  3. Set process

Morphological Characterization

Atomic Force Microscopy

- No conductive filaments (CFs) at V<V_forming
- Whatever the thickness of Pb(Fe_{0.5}Nb_{0.5})O_3, PbFe_{0.5}Nb_{0.5}O_3 films by standard and C-AFM (current IV) measurements using a sweep voltage: Voltage: V=0.5V, f=50mHz

Objectives

- Depositon and characterization of PFN thin film
- Experimental investigation of RS in PFN films by standard and C-AFM current (IV) measurements using a sweep voltage: Voltage: V=0.5V, f=50mHz

Results

C-AFM I-E measurement

- Unipolar RS investigation
  - C-AFM - 60nm film, V_max=20V, A_{RS}=1V, f=60mHz
  - Hysteretic behaviour resulting from unstable filament destroyed soon after the back sequence (2) starts
  - Increase of current with the decrease of voltage resulting from Joule effect heating and leading to a partial switch
  - Thermal contribution too low to obtain stable CFs
  - Ohmic region (J=E) until 1500 kV/cm, then Space charge limited mechanism is activated (J-E^2)

Electrical Characterization

- Bipolar RS investigation
  - Standard - 600nm film, V_{max}=1.2V, A_{RS}=0.1V, f=50mHz
  - Bipolar RS: increase of resistivity of ~10 kΩcm
  - Bipolar Resistive Switching obtained

Prospects

- Resistive Switching obtained in PFN 600nm film
- Unipolar Resistive Switching obtained
  - Change of resistivity of 1 order of magnitude
  - Formation process at 1V during the back sequence

Conclusion

- Resistive Switching obtained in PFN 600nm film
- Hysteretic dependence of the current with the applied voltage attributed to unstable filaments is obtained in PFN 600nm film
- Resistivity of 600nm film of PFN equals to 10^8 Ωcm in agreement with literature
- PFN films synthesized have a grain size lower than 50nm
- Temperature of crystallization of 450°C allows to obtain PFN crystal with few pyrochlore
- Complex permittivity dependence with the thickness at the nano- micro- scale has been observed: difference of 10^3 between 50nm and 600nm films.

References

[1] Data from www.sciedirect.com