National Institute of Materials Physics (NIMP)

THE BEHAVIOR OF IRIDIUM FILMS AS OXYGEN DIFFUSION BARRIER IN ORIENTED PZT THIN FILMS FOR FERROELECTRIC NONVOLATILE MEMORIES

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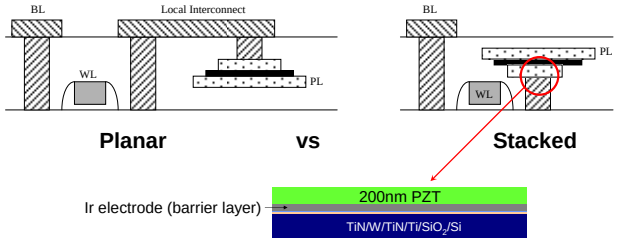
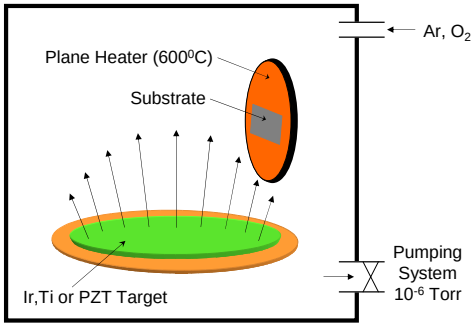
Motivation

An ideal memory should have ultimate properties such as random access, fast read and write operation, as well as unlimited usage with non-volatility. In the last decade only low density FeRAM, or embedded product with low density FeRAM is available. Fabrication of high-density ferroelectric memories requires the growth of ferroelectric materials on the drain contact metal. The structure on top of the drain demands the development of a conductive barrier inhibiting lead and oxygen diffusion down to the contact between capacitor and tranzistor. The purpose of the present investigation is to study the growth of oriented PZT thin films onto Ir layer and to evaluate the behaviour of iridium films as oxygen diffusion barrier.

FERAM Cell Architecture





PZT target, Ir and PZT thin films preparation

PZT target preparation: Mixing 3h in a planetary ball mill using balls of 10 mm diameter and a ball/powder weighted ratio of 2/1. Dried and double calcined at 8500C and 9000C respectively with an intermediate milling of 1 h and a final wet milling of 10 h. Powders were compacted as discs of 55 mm diameter and 7 mm thick. The pressed samples were sintered at 1150-1350⁰C with a dwell time of 4 h. The sintered samples were processed as discs with 50 mm diameters and 5 mm thick.

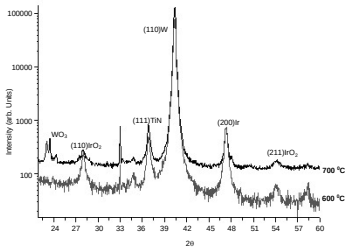
Thin films growth:
TiO_2(10nm)/Ti(2nm) adhesion structure deposited on SiO_2/Si substrate by reactive rf-magnetron sputtering at 10mTorr O_2 pressure, 600⁰C substrate temperature, 50W
Ir thin films were deposited onto TiO_2/Ti/SiO_2/Si and TiN/W/TiN/Ti/SiO_2/Si sbstrates at 30W, 12mTorr Ar pressure, 600⁰C, 200nm.
PZT deposited by rf-magnetron sputtering, off-axis method, onto Ir/TiO_2/Ti/SiO_2/Si substrate at 100W, 15mTorr O_2 pressure, 600⁰C substrate temperature, 200nm

Results for deposited Ir thin film annealed in O_2 atmosphere

Atmosphere	O_2			
Temperature ⁰C	500	575	650	750
Resistivity (μΩ·cm)	9.8	9.7	9.4	8.6

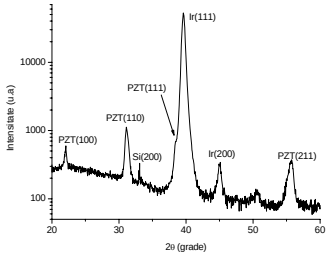
Atmosphere	N_2			
Temperature ⁰C	500	575	650	750
Resistivity (μΩ·cm)	9.8	9.7	8.9	8.2

Electrical resistivity of Ir layer annealed in O_2 and N_2 atmosphere

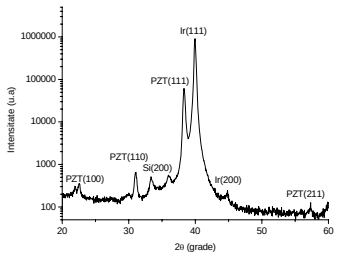


XRD patterns of 200 nm Ir deposited on W/TiN/Ti/SiO_2/Si after annealing at different temperature in O_2 atmosphere.

(111) oriented PZT thin films growth on Ir barrier

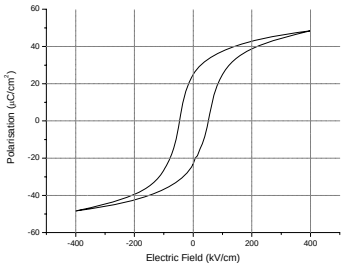


XRD spectra of random PZT thin film deposited on Ir/TiO_2/Ti/SiO_2/Si substrate



XRD spectra of highly oriented (111) PZT thin film deposited on TiO_2/Ti/SiO_2/Si substrate

- The patterns show the perovskite structure.
- Different orientation of PZT can be obtained on Ir(111)
- Few nanometer thick of TiO_2 layer represents a very efficient seed layer for the nucleation of PZT(111)
- dielectric constant = 720
- dielectric loss = 0.03
- remnant polarization = 22μC/cm^2
- coercive field = 48kV/cm.



Conclusions

- Electrical resistivity of Ir film decreases with increasing annealing temperatures due to a better crystallization.
- Iridium layer can be effective as barrier layer against oxygen diffusion up to 650⁰C.
- PZT films deposited by RF sputtering method on Ir(111) by means of a 2nm thick TiO_2 seed layer grow almost perfectly in (111) orientation (98% texture index).
- The remnant polarization of the films is well above the minimum requirements for a non-volatile memory device.

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