SYFS 4.2

UNIVERSITÄT LEIPZIG

Exchange polarization coupling in wurtzite-perovskite oxide interfaces: New concepts for electronic device heterostructures?

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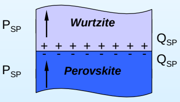
Ellipsometry Workgroup

Interface: $BaTiO_3$/Zn(Mg)O

Is there a polarization exchange coupling??
What is it?

Interaction of the wurtzite polarization (surface ionic charge) with the switchable ferroelectric perovskite polarization. This coupling should influence:



(I) Ferroelectric refractive index change Δn
(II) Ferroelectric phase transition
(III) Electrical properties of junctions
...

(I): Ann. Phys. 13, 61 - 62 (2004)
(II): Appl. Phys. Lett. 86, 091904 (2005)
B. Mbenkum, M.Sc. Thesis, Universität Leipzig Oct. 2004

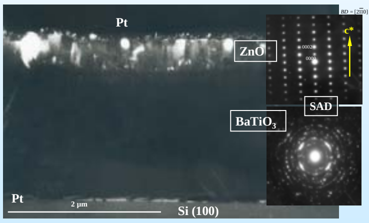
(III): Metal-Ferroelectric-Semiconductor-Metal
Metal-Semiconductor-Ferroelectric-Semiconductor-Metal
This Poster !!

Growth

DC-Magnetron Sputtering:
Top and bottom Metal (Pt)-contacts

Pulsed Laser Deposition:
ZnO/BTO/Pt/Si and ZnO/BTO/ZnO/Pt/Si heterostructures

TEM dark field-image: Pt/ZnO/BTO/Pt/Si



ZnO: poly-crystalline, c-axis texture; the column-like grains are always oriented with the c-axis parallel to the growth direction.
$BaTiO_3$: poly-crystalline, (111) texture

Experiment

Room-Temperature Electrical Propreties

DC Current-Voltage Characteristics:
Agilent 4156C
(Precision Semiconductor Parameter Analyzer)

Polarisation-Electric-Field Characteristics :
Sawyer-Tower Circuit

Capacitance-Voltage Characteristics :
Fluke PM6306-LCR Meter

Results

I-V Characteristics

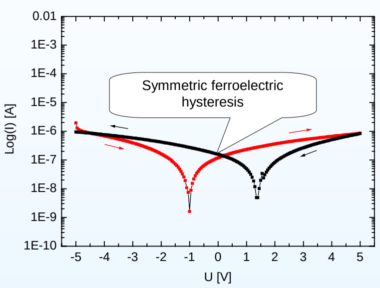
P-E Characteristics

C-V Characteristics

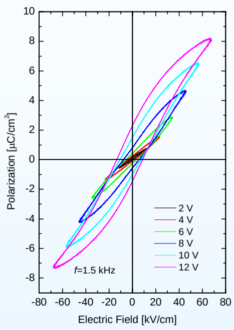
Summary

Pt/BaTiO3/Pt/Si

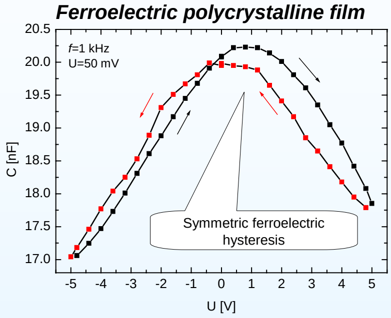
Typical ferroelectric hysteresis



Ferroelectric



Ferroelectric polycrystalline film



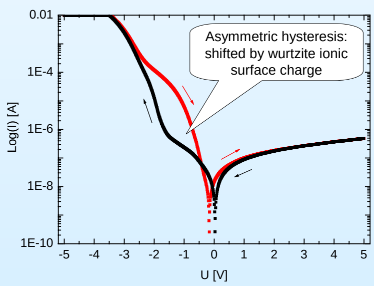
Perovskite reference

Results typical for $BaTiO_3$ low-quality polycrystalline films:

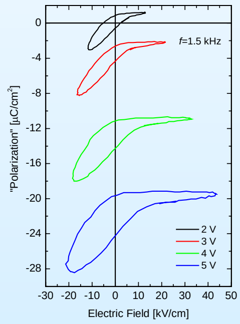
P_r= 2 µC/cm², P_c=11 kV/cm (E=67 kV/cm):
P_r is much lower and P_c are much larger than the values typical for bulk $BaTiO_3$; attributed to small grain sizes, non-ferroelectric grain boundaries, porosity, and space charges.
Small P-E offset along the E-axis, and the asymmetry in the C-V curve: attributed to asymmetric distribution of the space charges and built-in electric field in the film.

Pt/ZnO/BaTiO3/Pt/Si

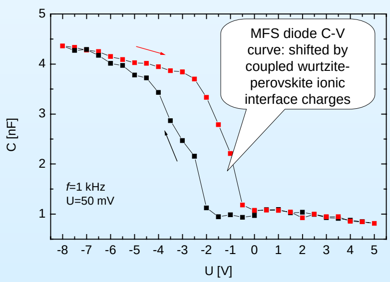
Polarization exchange coupling: switchable-threshold thin film diode ?



Ferroelectric+rectifying

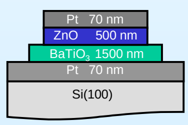


Ionic-surface-charge controlled MI(=F)S C-V characteristics



Single wurtzite-perovskite-interface

Free carrier transport controlled by the ZnO/$BaTiO_3$ interface:
U>0, reverse bias:
formation of a depletion layer in ZnO, rectification
U<0, forward bias:
depletion layer removal, free-carrier injection from ZnO into $BaTiO_3$

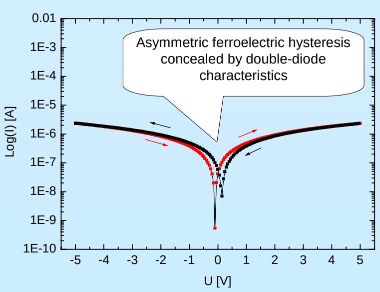


Depletion layer width depends on ferroelectric domain orientation and can be switched! Possible use as electric detector for polarizatin fields!

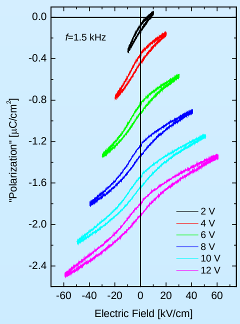
„Giant electric resistance": sensor for polarization fields?

Pt/ZnO/BaTiO3/ZnO/Pt/Si

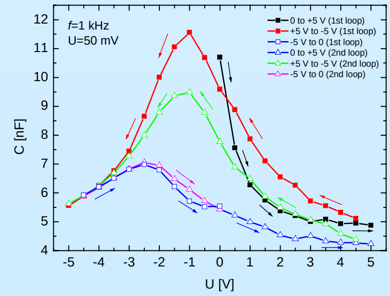
Highly resistive, small DC hysteresis



Voltage-dependend capacitance

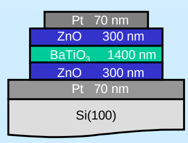


Polarization exchange coupling: Bistable capacitance with memory



Double wurtzite-perovskite-interface

Free carrier transport controlled by both the ZnO/$BaTiO_3$ interface and the $BaTiO_3$/ZnO interface :
formation of depletion layers in both ZnO layers for both voltages and highly resistive behaviour for DC currents;
However: capacitance changes observable for AC voltages!



Bistable ferroelectric domain orientation, switched by external bias voltage, causes large capacitance hysteresis with bistable magnitudes! Possible use in addressable capacitance structures (memory)!

Huge capacitance modulation: memory applications?

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