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Ellipsometry Workgroup

Polarization coupled response of ZnO-BaTiO$_3$: Determination of ZnO Spontaneous Polarization

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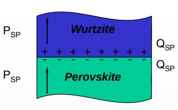
Polarization coupled interfaces



Is there a charge polarization exchange coupling in BTO/ZnO?? Can this be used to determine the amount of the spontaneous polarization in ZnO??

ZnO is a wurtzite structure typically n-type semiconductor with ionic interface charge (spontaneous polarization P_{sz}). This charge interacts with the switchable (ferroelectric) perovskite structure polarization P_s in BTO. This coupling influences the BTO index of refraction [1], the ferroelectric phase transition [2], and the rectifying electrical properties of ZnO/BTO heterostructures. We previously predicted that this coupling can be used to determine P_{sz} of ZnO. Here we report on electrical measurements of Pt/BTO/ZnO/Pt heterostructures, and our new model approach, in which we included the effect of a charge depletion layer in ZnO.

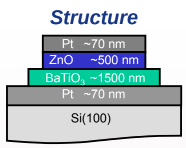
We obtain the first experimental value for the spontaneous polarization in ZnO: $P_{sz,\,ZnO}$ = - 4 μC/cm².

Previous theory calculation:
$P_{sz,\,ZnO}$ = - 5 ... - 5.7 μC/cm² [4]

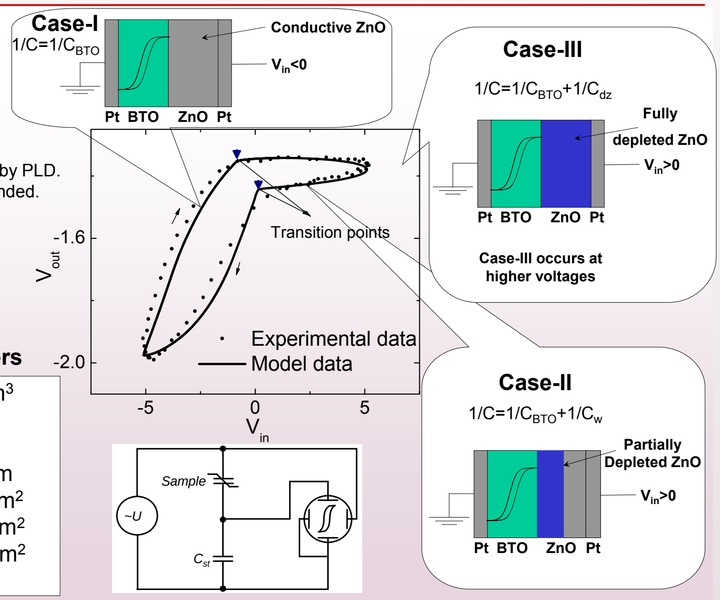
[1] Ann. Phys. 13, 61 (2004); [2] APL 86, 091904 (2005); [3] Thin Solid Films 486 (2005) 153; [4] PRB 56, R100024 (1997)

Sawyer-Tower circuit: Experiment and Model

Structure



BTO and ZnO are grown by PLD. Bottom Metal (Pt) is grounded.



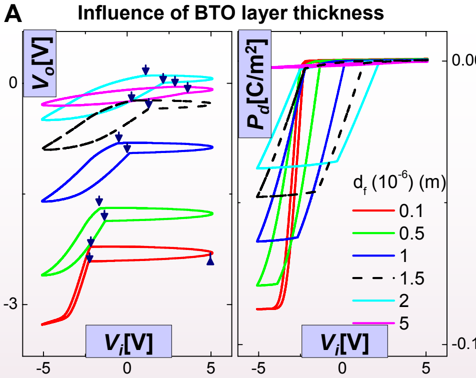
Sawyer-Tower circuit

Best fit parameters

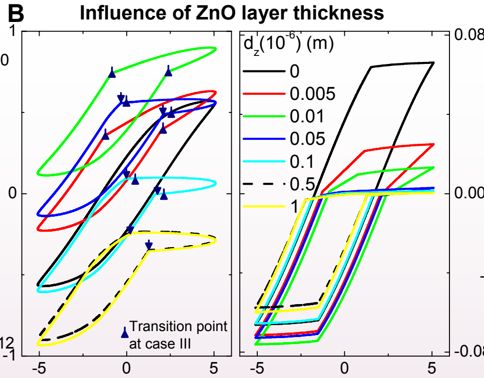
N_c	= 5.5×10^{22} /m³
ε_{BTO}	=250
ε_{ZnO}	=8
E_c	=1.2×10^6 V/m
P_s	=14.1×10^{-2} C/m²
P_r	=6.35×10^{-2} C/m²
P_{sz}	=-4.0×10^{-2} C/m²
R_s	=13 kΩ

Influence of model parameters on calculated Sawyer-Tower response

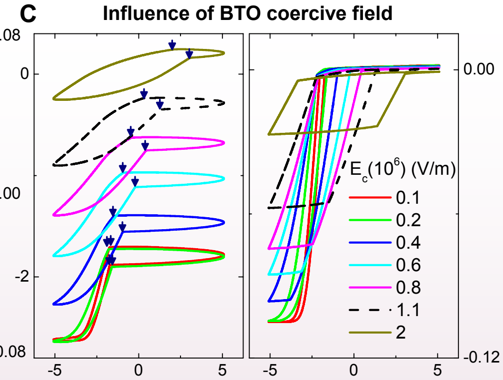
A Influence of BTO layer thickness



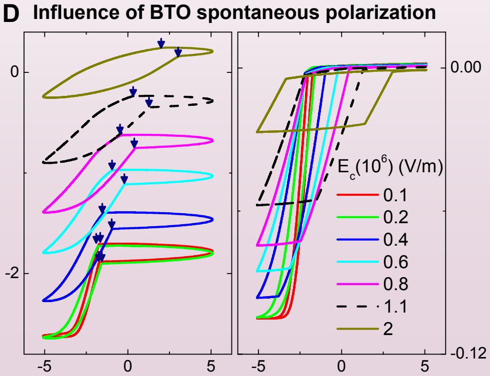
B Influence of ZnO layer thickness



C Influence of BTO coercive field



D Influence of BTO spontaneous polarization



A: Asymmetric loop and polarization saturation with d_f ↑.

B: Quenching of hysteresis for positive voltages with d_z ↑. Full depletion reached in ZnO for small d_z.

C: Similar to A, separation between transitions between I-II (on forward cycle) and II-I (on back cycle) ↑ with E_c ↑.

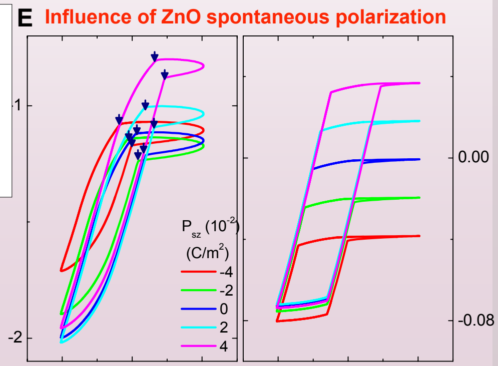
D: Asymmetry ↑ with P_s ↑. Negative charging of sample.

E: Points I-II and II-I shift parallel with P_{sz}. Asymmetry ↓.

Center parameters for model calculations (dotted lines)

d_z	=0.5×10^{-6} m
d_f	=1.5×10^{-6} m
E_c	=1.1×10^6 V/m
P_s	=10.5×10^{-2} C/m²
P_{sz}	=0

E Influence of ZnO spontaneous polarization



DPG, Regensburg, March 2007

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