New concepts incorporate ferroelectric and piezoelectric properties into semiconductors to make multifunctional architectures for future device technology. Here we introduce a multilayered structure prepared with wurtzite ZnO and perovskite BaTiO$_3$.

The ferroelectric properties of BaTiO$_3$ are influenced by the spontaneous polarization of both ZnO layers ($P_{sp,1}$, $P_{sp,2}$) and the depletion widths of top and bottom ZnO ($w_1$, $w_2$).

The electric properties of ZnO ($\mu$, $\sigma$, $\varepsilon$) are determined by the spontaneous dipole polarization ($P_{sp}$) and its orientation in ZnO-BaTiO$_3$-ZnO heterostructures.

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ZnO-BaTiO$_3$ interfaces: Boundary conditions at right and left ZnO-BaTiO$_3$ interfaces:

$$\begin{align*}
\varepsilon_{NC,1} + P_{sp,1} = E_i z_f + P_d \\
-\varepsilon_{NC,2} + P_{sp,2} = E_i z_f + P_d
\end{align*}$$

where $\delta = E_i \log\left(\frac{1 + P_d/P_{sp,1}}{1 - P_d/P_{sp,2}}\right)$

**ZnO/BaTiO$_3$/ZnO Interface Polarization Hysteresis Model**

** Experimental and Model Calculated Data**

**Effect of ZnO polarity orientation in ZnO-BaTiO$_3$-ZnO**

- Orientation of spontaneous polarization of the ZnO layers controls the ferroelectric properties of the ZnO-BTO-ZnO structure.
- Either positive or negative orientations of both spontaneous polarizations of ZnO layers results an asymmetry in the transport properties (different depletion layer endings in fig. (I) and (II)).
- Asymmetric transport properties of the structure results in an asymmetric shift in the Sawyer-Tower response (shown in fig(I) and (II)).