ADVANCED OPTICAL MATERIALS

Supporting Information

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Resistive Switching-based Electro-Optical Modulation

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Supporting Information - Resistive Switching based Electro-Optical Modulation

Supporting Figure 1

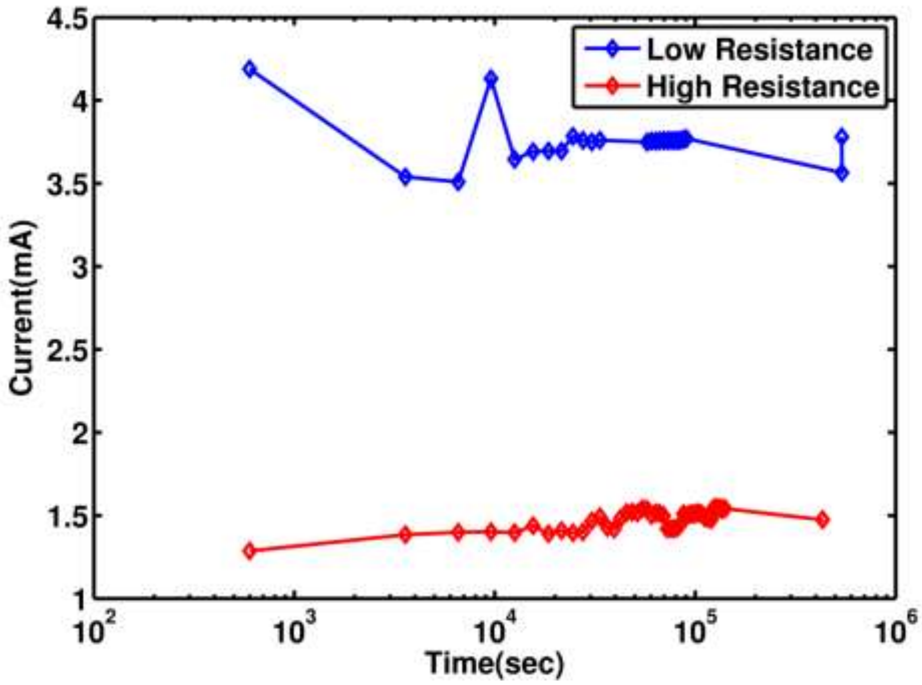

Figure S1 – Retention time measurements of the resistive switching memory. The states of the devices are read with 0.1V bias at each 60s continuously for one day and then measured consecutively a week after in a room temperature environment. Devices maintain their states HRS and LRS individually and reach retention times more than 10^5 seconds.

Supporting Equation 1

$$\varepsilon(\omega) = \varepsilon_\infty + A_{Lorentz}\frac{\Gamma\hbar\omega_n}{(\hbar\omega_n)^2-(\hbar\omega)^2-j\Gamma\hbar\omega} - \frac{\hbar^2 N(\frac{q}{m^*})^2}{\varepsilon_o((\hbar\omega)^2+j(\frac{q}{\mu m^*})\hbar\omega} \quad (1)$$

where $\hbar$ is the Planck's constant, ε_∞ is the static dielectric permittivity, $A_{Lorentz}$ is the amplitude of the Lorentz oscillator, Γ is the broadening, ω_n is the center frequency of the oscillator, ω is the frequency, q is the elementary charge, m* is the effective electron mass in ZnO (0.24), μ is the mobility and N is the doping concentration.

Supporting Table 1 Fit parameters for optical constants of ZnO layers with different doping levels

Doping Level	ε_∞	A	Γ (cm^{-1})	ω_n (cm^{-1})	N (10^{19} cm^{-3})	μ (cm^2/V.s)
Low Doping	3.71	51.2	48.3	397.3	3.84	4.6
High Doping	3.65	51.6	52.74	397	4.4	19.2

Supporting Figure 2

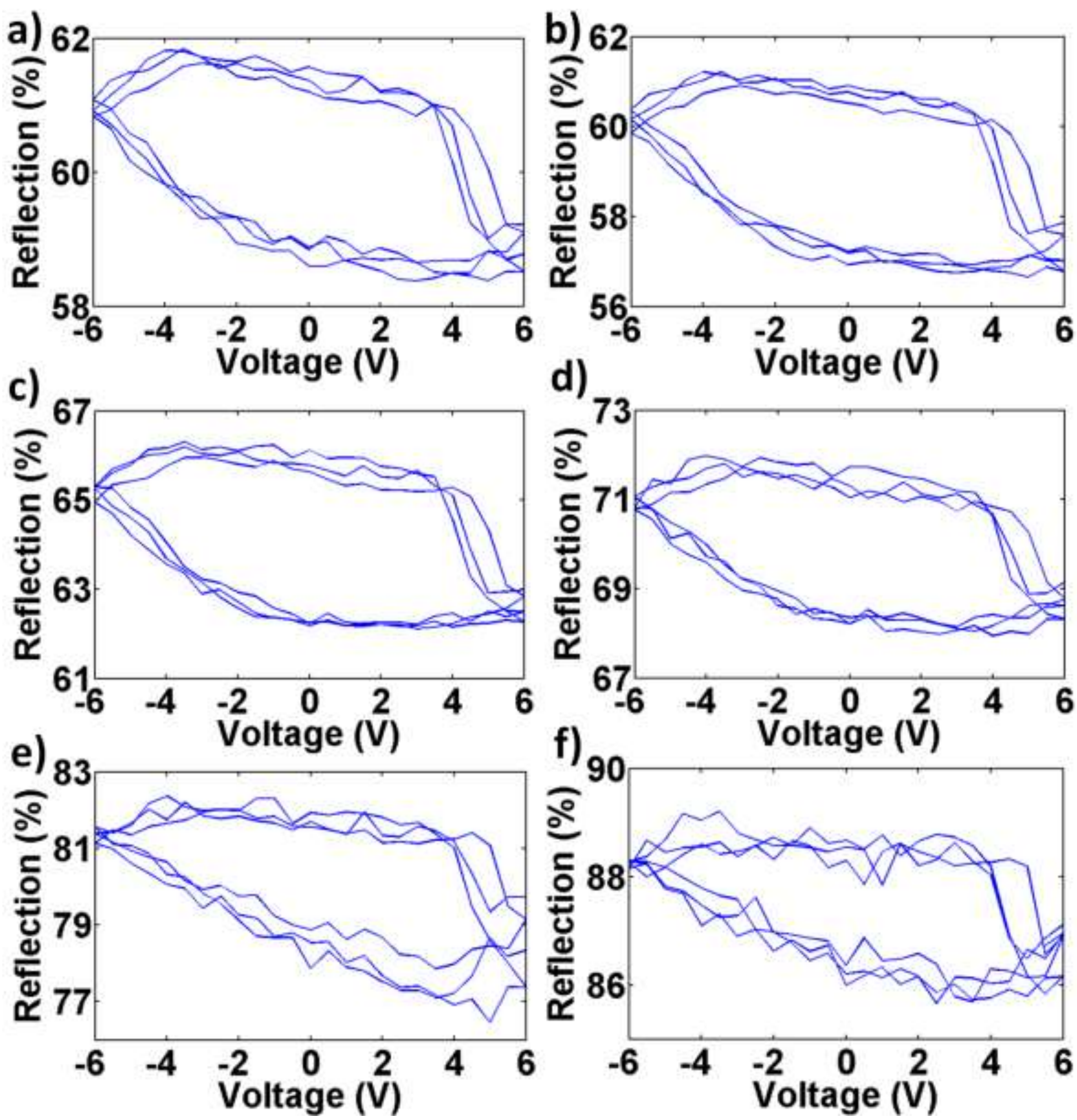

Figure S2 – Optical hysteresis in reflection as a function of voltage for different wavelengths a)6μm b)7μm c)10μm d)12μm e)15μm and f)18μm. Reflection loop depend on the difference of level of light localization inside ZnO layer for HRS and LRS. Highest contrast in the reflection is observed at 8μm.

Supporting Figure 3

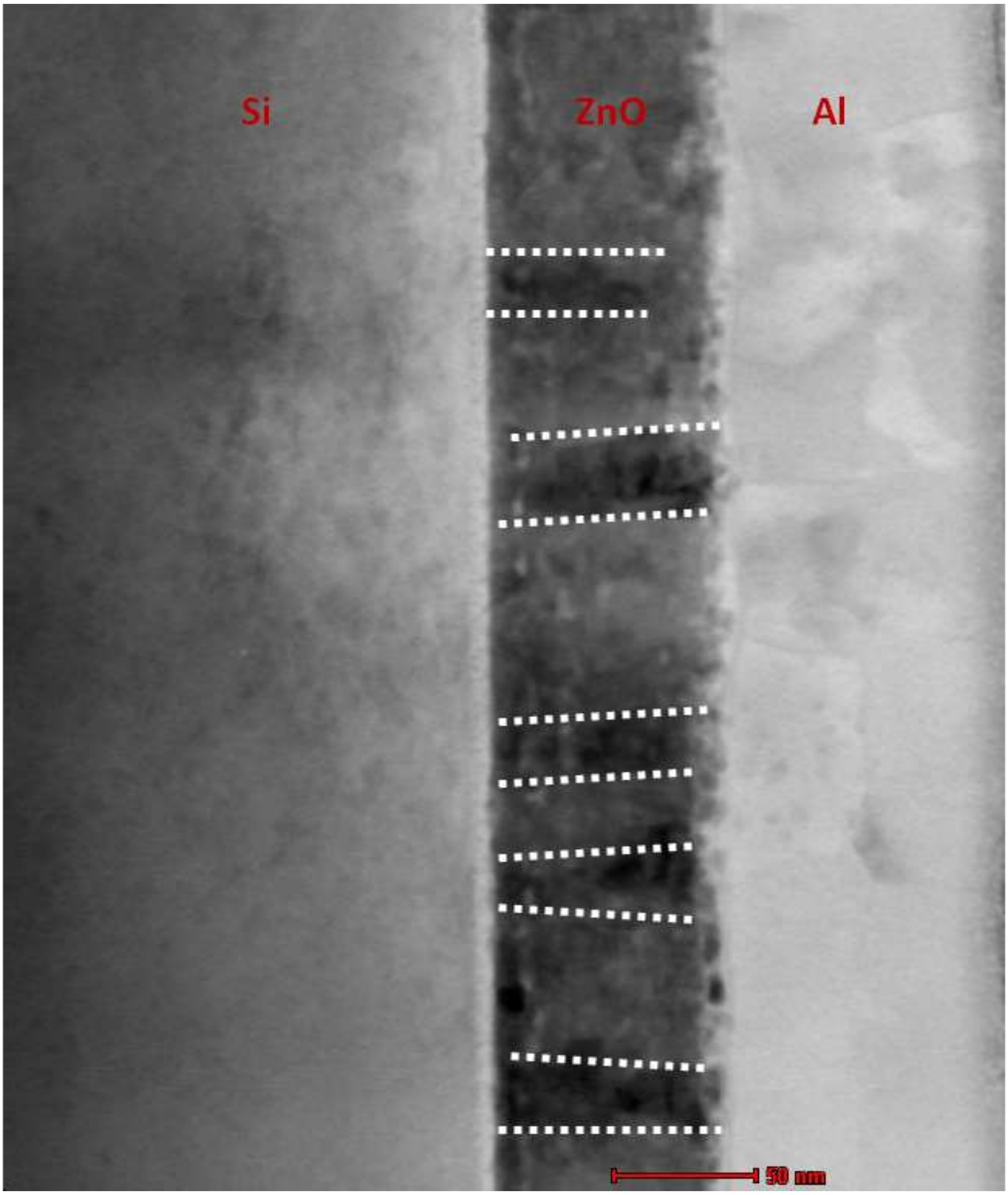

Figure S3 – Low magnified STEM image of device showing filamentary regions. While, a precise determination of the concentration of the filaments requires further investigations, we can predict the filament concentration from low magnified STEM image as shown in Figure S3 for a 370-nm-wide and 100-nm-thick film. There are 7 filamentary regions that estimate the filament density on the order of 10^{10} filaments/cm^2.

Although resistive switching is shown to be feasible at ultra-small feature sizes such as 20 nm, we estimate that a minimum device area on the order of the wavelength of light used is required to obtain optical switching.