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# Enhanced electromechanical performance in metal-MgO-ZnO tunneling diodes due to the insulator layers

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## S1 MgO layer thickness dependence

The performance dependence of the MISTDs on the MgO layer thickness are investigated by calculating their I-V characteristics for a series of strains with 1.0nm, 15.nm and 2.0nm thick MgO layers, as shown in Fig. S1. The inserts in Fig. S1 are I-V curves in semilog plots which can show more details on small currents. There are a couple of stages in forwards I-V curves are due to energy barriers in the MISTDs. It is easy to find that the change of I ~ V characterises with strain is similar: the current decrease quickly and the turn-on voltage increase as the strain changes from tensile to compressive.

It is also find that the MgO layer thickness plays an important role in the performance of the MISTDS. First of all, the current of the MISTD decreases remarkably as MgO layer thickness increases and the decrease in current is more than an order of magnitude per 0.5nm. Secondary, turn-on voltage and the width of plateau region in the semilog plots increase as the MgO layer becomes thicker. The electronic structure of the MISTDs are studied in the similar way as in the case of the MISTD with 1.0 nm thick MgO layer. The obtained barrier heights in the ZnO layers ($\Phi_B$) as functions of strain are shown in Fig.S2(a). It is obvious that $\Phi_B$ decreases as the strain increase from -2%(compressive) to 2%(tensile), and the decrease rate increases with MgO layer thickness.

The gauge factor, which describes the performance of a strain sensor, is defined as:

$$\text{gauge factor} = \frac{|I(\varepsilon)-I(0)|}{I(0)} \Big/ \Delta\varepsilon \qquad \text{(S1)}$$

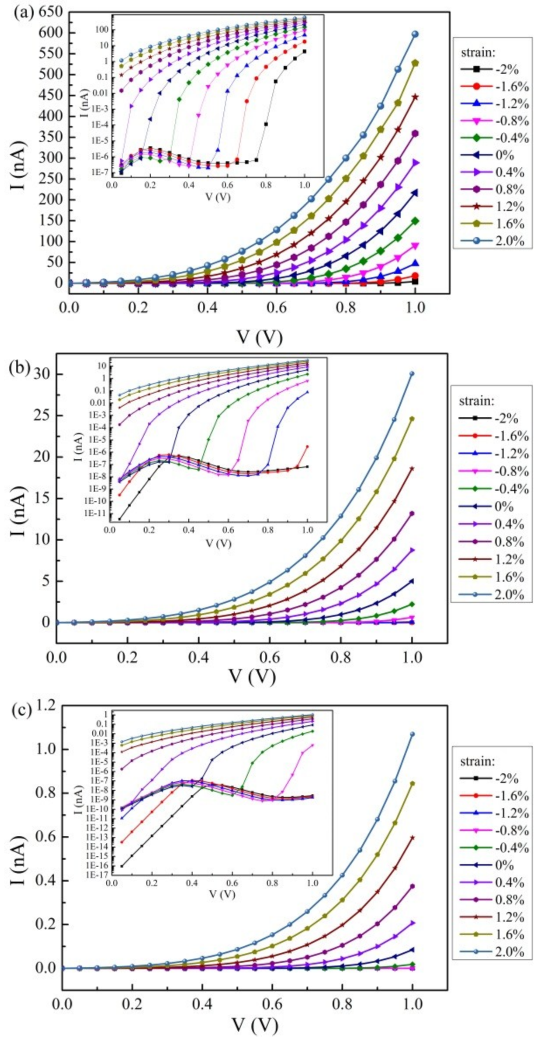


Figure S1 I-V characteristic of MISTDs under a series of strains with MgO layer thickness of (a) 1.0 nm, (b) 1.5 nm, (c) 2.0 nm

The gauge factors of MISTDs at +1V bias for a series of strains are shown in Fig. S2(b). It can be seen that gauge factors of the diodes are larger under tensile strain rather than under compressive strain. Under +2% strain, gauge factor of MSMSD is 10.58, while

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gauge factors of MISTDs with 1 nm, 1.5 nm and 2 nm MgO layer are improved by 8.3, 23.7 and 55.0 times, respectively.

In summary, the MgO layer thickness plays an important role in the performance of MISTDS. As the MgO layer becomes thick, the overall current of the devices decreases rapidly. However, the sensitivity of the device as defined by gauge factor, increases quickly with MgO layer thickness as the energy barrier changes quickly with strain with MgO layer thickness.

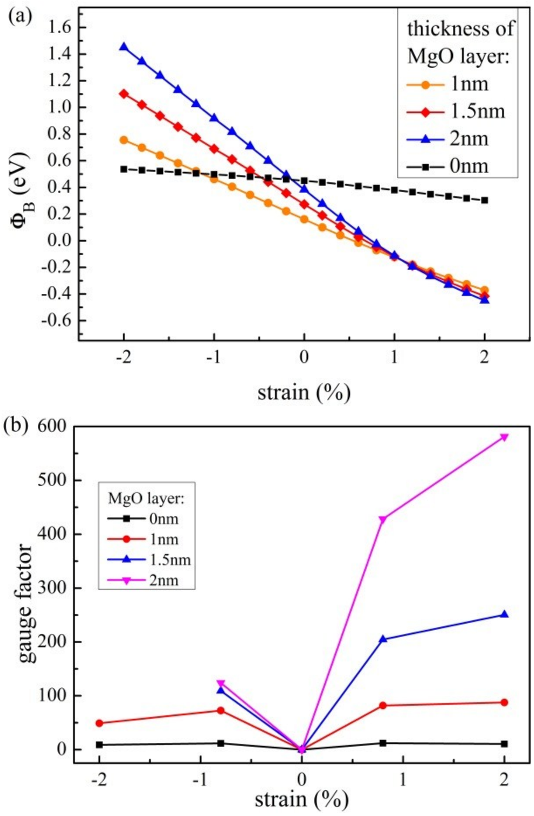


Figure S2 (a) $\Phi_B$ and (b) gauge factors (+1V) as functions of strain for the MISTDs with different thick MgO layers.

 

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