Electronic Supporting Information

Dynamic band alignment modulation of ultrathin WO_x/ZnO stack for high on/off ratio field-effect switching applications

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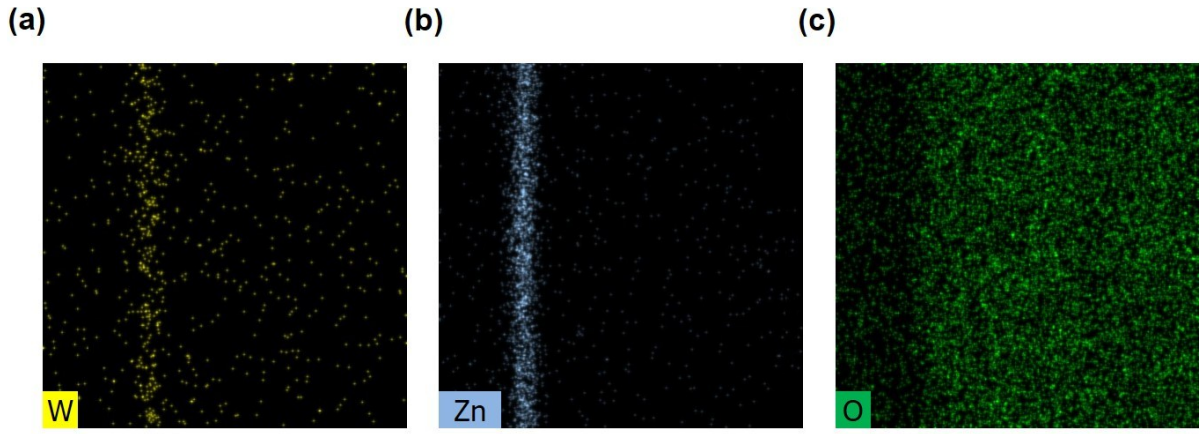

Figure S1. (a)-(c) EDS analysis of WO_x/ZnO stacked structure (a) W (b) Zn (c) O.

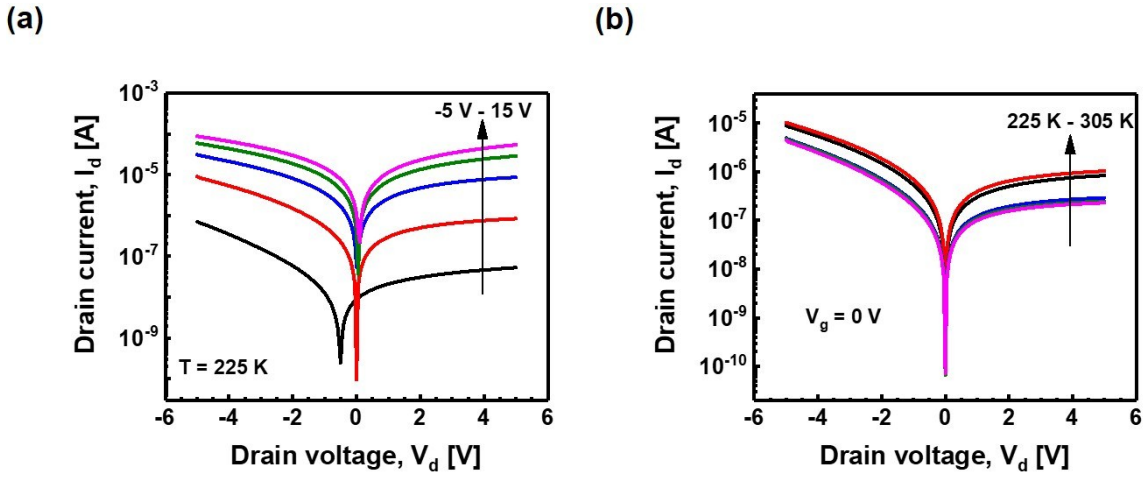

Figure S2. (a)-(b) I_d-V_d characteristics of WO_x/ZnO FET. (a) Varying V_g from -5 V to 15 V at T = 225 K. (b) Varying temperature from 225 K to 305 K at V_g = 0 V.

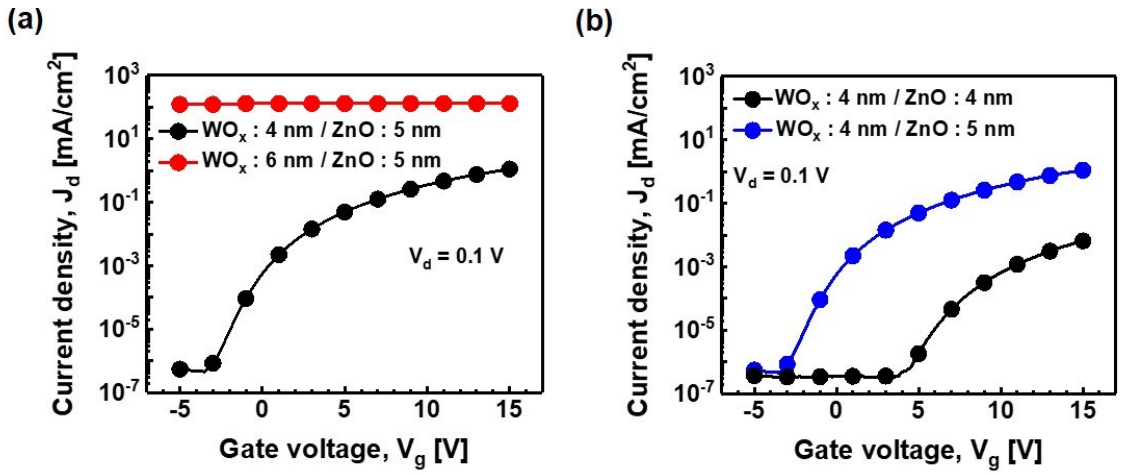

Figure S3. J_d-V_g characteristics of WO_x/ZnO FET with different thickness of (a) WO_x and (b) ZnO measured at V_d = 0.1 V.

When WO_x is 6 nm, metallic conduction was observed as shown in Figure S3 (a). On the other hand, WO_x is not uniform for the process condition targeting below 4 nm. Thus, somewhat narrow window around 4 nm was chosen to observe the unique conduction behavior.

In the similar way, the thickness below 5 nm ZnO showed deteriorated property as shown in Figure S3 (b). As a result, 5 nm was chosen to obtain a uniform conduction behavior at the thin film limit.

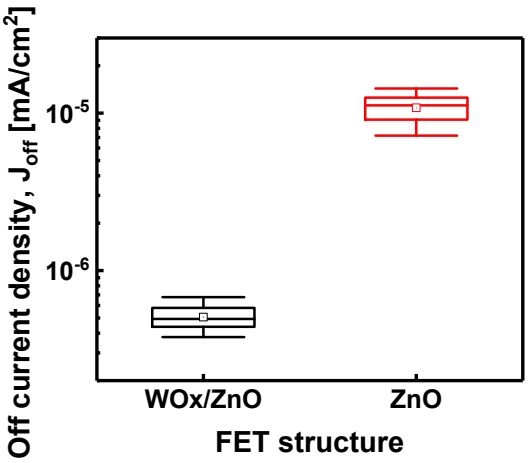

Figure S4. Static variations of off current density for overlapped WO_x/ZnO and ZnO FET. The eighteen devices for each of WO_x/ZnO and ZnO FET were measured.