

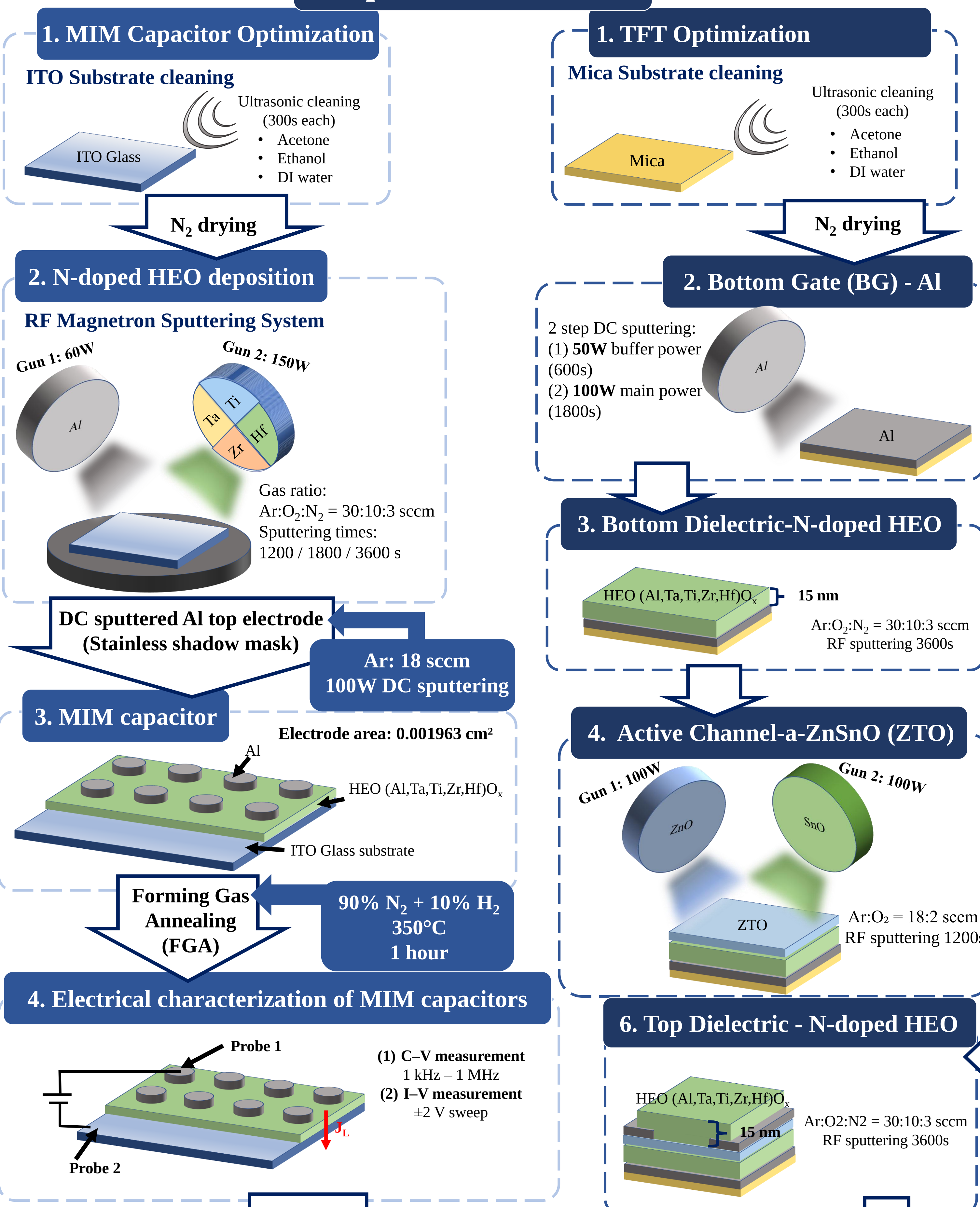
Abstract

In this study, we developed a dual-gate ZnSnO thin-film transistor (TFT) on Mica substrate. We used a 15 nm thick, nitrogen-doped (Al,Ta,Ti,Zr,Hf)O_x high-entropy oxide (HEO) as the gate dielectric layer. To improve the device's performance, the device was subjected to forming gas annealing (FGA) at 350°C in a mix of nitrogen and hydrogen. Our results show that the HEO dielectric has a high dielectric constant (k) of about 64. After the FGA treatment, the leakage current dropped significantly from 10^{-7} ~ 10^{-11} A/cm². This improvement is attributed to the passivation of defects (dangling bonds) at the interface by hydrogen atom. The TFT achieved excellent performance metrics, with a sharp subthreshold swing (S.S.) of 0.09 V/dec, a threshold voltage (V_T) of 0.16V and a mobility (μ) of 54 cm²·V⁻¹·s⁻¹. For UV sensing applications, the device showed excellent performance. It reached a very high sensitivity of 6.6×10^6 and a responsivity of 9524 A/W. With a wide bandgap of 4.8 eV, this research proves that using high-entropy oxides and FGA is a very effective way to build high-performance optoelectronics for light-sensing.

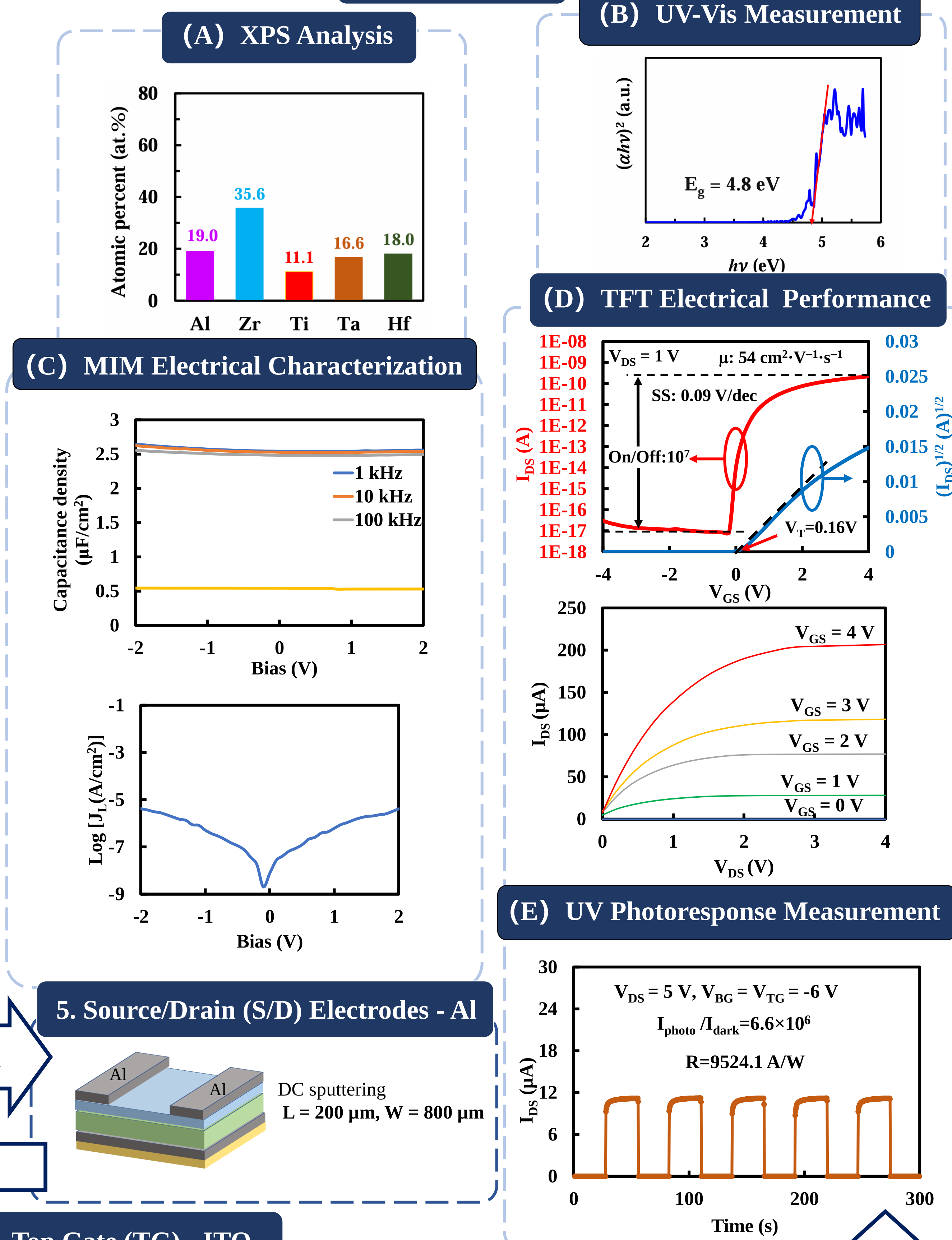
Motivation

As next-generation transparent electronics grow rapidly, ZnSnO semiconductors show great promise due to their high carrier mobility, high transparency and wide bandgap. However, traditional oxide semiconductors easily suffer from interface defects, which cause hysteresis and instability—major bottlenecks for device performance. In addition, traditional single-metal oxide dielectrics struggle to simultaneously achieve both a high dielectric constant and low leakage current. To overcome these limitations, this study employs the high-entropy oxides (HEOs) as gate dielectrics. By incorporating multiple elements in (Al,Ta,Ti,Zr,Hf)O_x, the configurational entropy stabilizes the amorphous structure, effectively suppressing leakage paths and boosting dielectric performance. Furthermore, to mitigate oxygen vacancies and dangling bonds generated during low-temperature fabrication, we used interface engineering through nitrogen doping and forming gas annealing (FGA) to let hydrogen atoms passivate the defects. By integrating a thermally stable and transparent Mica substrate with a dual-gate design, this research aims to realize a high-performance ultraviolet (UV) photodetector with great potential for future flexible applications, featuring high stability, low power loss, and superior photoresponse performance.

Experiment Process



Analysis



Conclusion

In this study, we successfully developed a dual-gate ZnSnO thin-film transistor on a Muscovite mica substrate, using a nitrogen-doped (Al,Ta,Ti,Zr,Hf)O_x high-entropy oxide (HEO) as the dielectric layer. The HEO film exhibited a high dielectric constant ($k \approx 64$) and a wide bandgap ($E_g = 4.8$ eV). After forming gas annealing (FGA) at 350°C, hydrogen atoms effectively passivated interface defects, dropping the leakage current density down to the 10^{-11} A/cm² range and greatly reducing frequency dispersion. The dual-gate structure provided strong electrical control, achieving a very sharp subthreshold swing (S.S. = 0.09 V/dec) and a stable threshold voltage ($V_T = 0.16$ V). Our dual-gate TFT based UV sensors showed massive photoresponse under UV illumination. It achieved an ultra-high sensitivity of 6.6×10^6 and a responsivity of 9524 A/W.

