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Improved Long-Term Stability and Reduced Humidity Effect in Gas Sensing: SiO_2 Ultra-Thin Layered ZnO Columnar Films

Postica Vasile, Lupan Oleg, Gapeeva Anna, Hansen Luka, Khaledialidusti Rasoul, Mishra Abhishek Kumar, Drewes Jonas, Kersten Holger, Faupel Franz, Adelung Rainer, Hansen Sandra

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Abstract

The undoped and metal-doped zinc oxide columnar films (ZnO:Sn, ZnO:Fe, ZnO:Ag, and ZnO:Cu) are covered with an ultra-thin layer of SiO2 (10–20 nm). The electrical, UV, and volatile organic compounds (VOCs) sensing properties are evaluated under different ambient conditions for ≈7 months to investigate the impact of the top SiO2-layer on the long-term stability of samples. The obtained results show a high immunity of sensing properties of SiO2-coated samples to humidity. Furthermore, gas sensing measurements show that the loss in response after 203 days is significantly lower for coated samples indicating higher stability of sensing performance. For ZnO:Fe the gas response is reduced by about 90% after 203 days, but for SiO2-coated ZnO:Fe columnar films the gas response is slightly reduced by only 38%. The density functional theory (DFT) calculations show that water species bind strongly with the surface SiO2 layer atoms with a −0.129 e− charge transfer, which is, much higher compared to the interaction with ethanol and acetone. Calculations show strong binding of water species on the SiO2 layer indicating preferential absorption of water molecules on SiO2. The obtained results demonstrate an important role of the top SiO2 ultra-thin layer in order to produce humidity-tolerant sensitive devices.

Keywords: *zinc oxide columnar films, columnar films, ultra-thin layers*

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