

Nd-Doped ZnO Nanorod-Based Self-Powered Gas Sensor Integrating Energy Harvesting and Ammonia Detection

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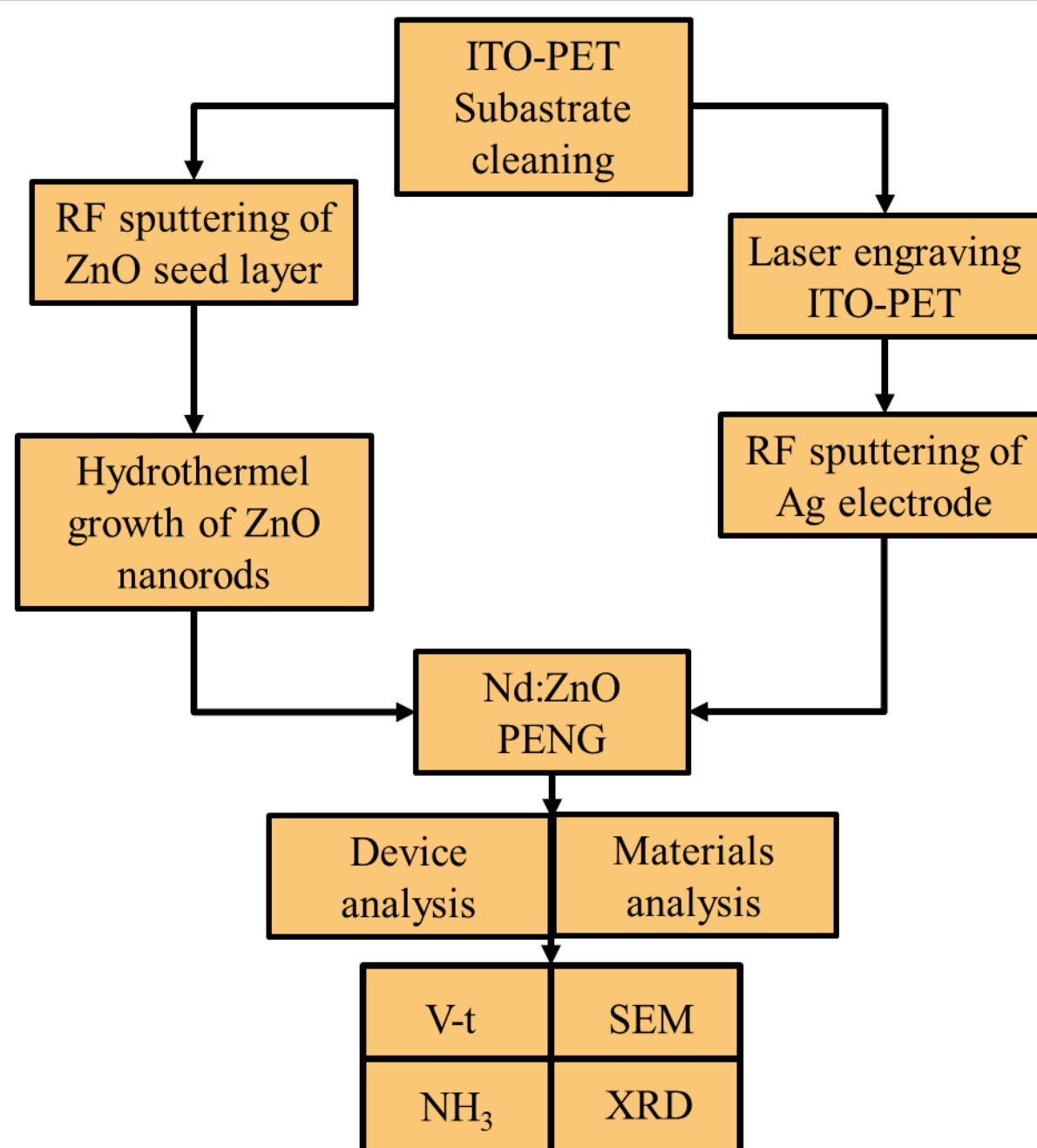
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Abstract

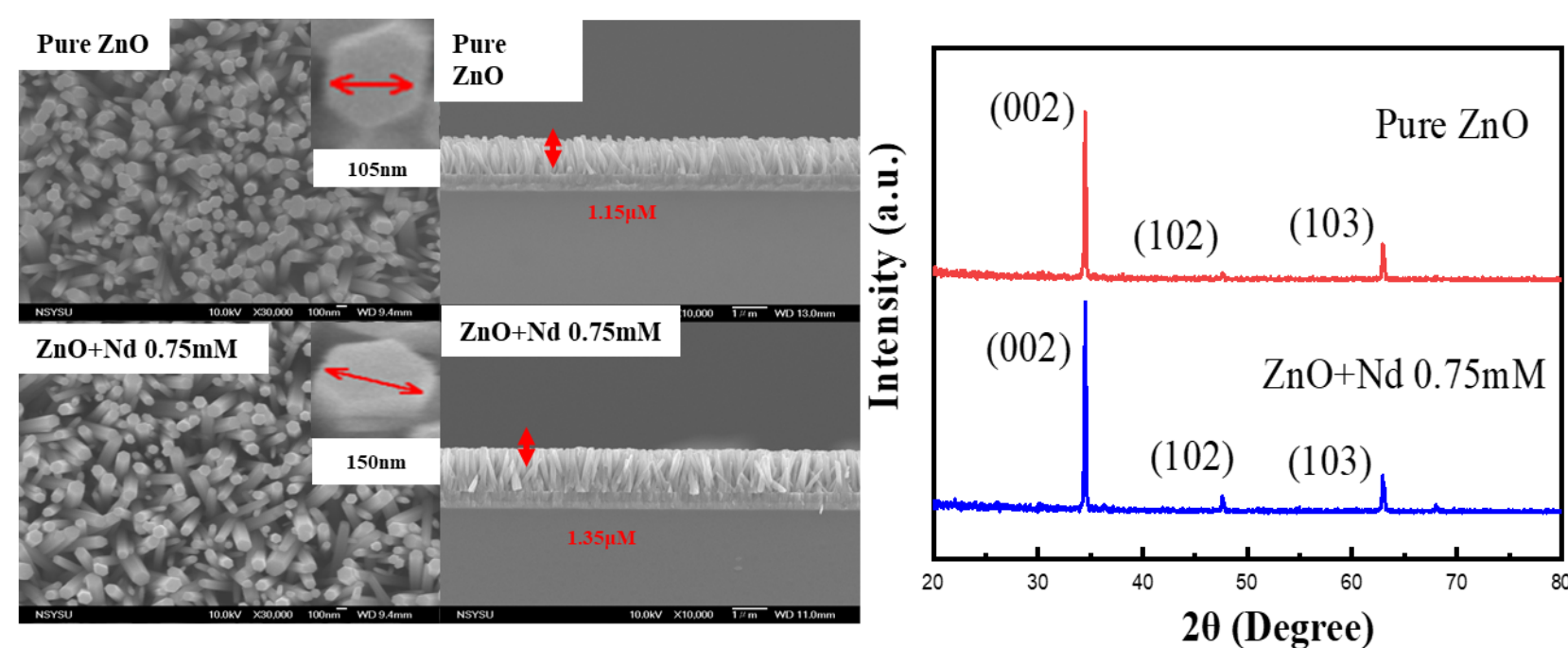
Traditional self-powered sensors usually rely on external power sources. In this study, neodymium (Nd)-doped zinc oxide (ZnO) nanorod arrays were synthesized using the hydrothermal method, and a self-powered gas sensor based on a piezoelectric nanogenerator (PENG) was fabricated and analyzed. XRD results confirmed that the samples maintained a hexagonal wurtzite structure, and the (002) diffraction peak was significantly enhanced due to Nd doping. During device fabrication, the top electrode pattern was defined by laser engraving, followed by RF sputtering of a silver (Ag) layer onto an ITO-PET substrate. The bottom electrode was composed of Nd-doped ZnO nanorods. When driven by a tapping system, the pure ZnO device without gas exposure generated a voltage of about 0.25 V, which increased to 0.72 V after Nd doping. Upon exposure to 75 ppm of ammonia (NH₃), the output voltage further increased to 1.19 V. These results demonstrate that the proposed device possesses self-powered characteristics and exhibits a clear response to NH₃ gas.

Research Methods and Experimental Procedure

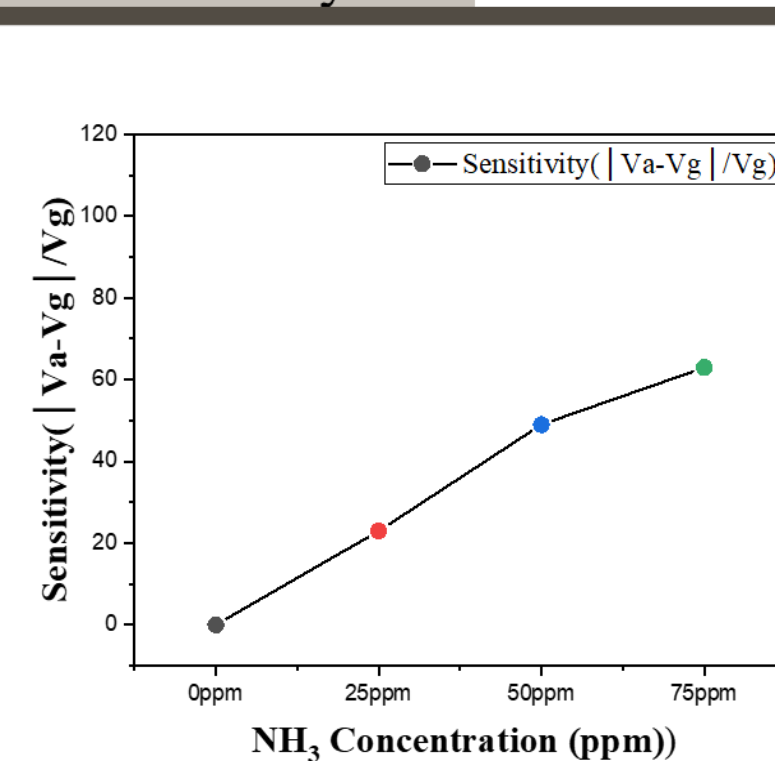


Results and Discussion

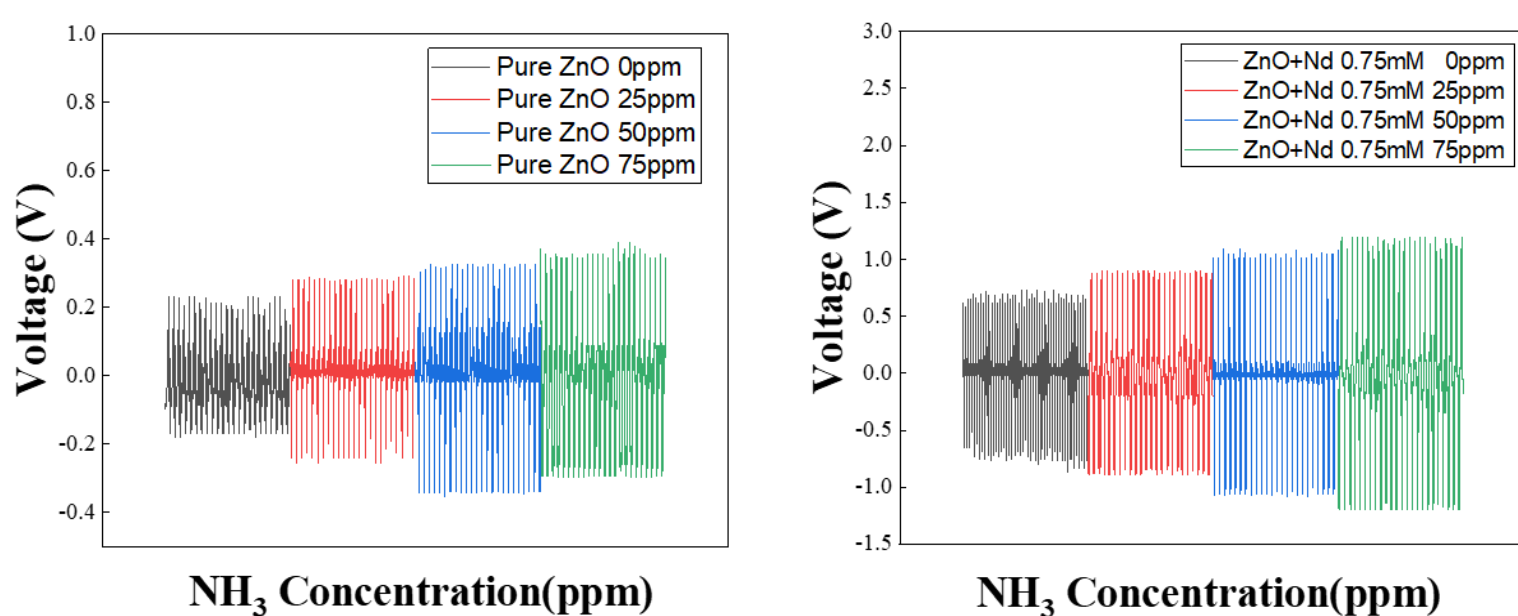
SEM&XRD



Device analysis



NH₃ Gas detection



Conclusion

The self-powered Nd-doped ZnO PENG exhibits enhanced piezoelectric and NH₃ gas-sensing performance due to improved nanorod morphology and crystallinity. SEM and XRD analyses confirm denser vertical alignment and stronger c-axis orientation. The output voltage increases from 0.25 V (pure ZnO) to 0.72 V at 0.75 mM Nd, reaching 1.19 V under 75 ppm NH₃ with 63% sensitivity. These results demonstrate that Nd doping effectively boosts piezoelectric energy harvesting and gas-sensing capabilities for next-generation self-powered sensor systems.