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Growth Mechanism and Sensing Behaviour of Sn Doped ZnO Nanoprisms Prepared by Thermal Evaporation Technique

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Abstract : While there’s a perpetual buzz around zinc oxide (ZnO) superstructures for their unique optical features, the versatile material has been constantly utilized to manifest tailored electronic properties through rendition of distinct morphologies. And yet, the unorthodox approach of implementing the novel 1D nanostructures of ZnO (pristine or doped) for volatile sensing applications has ample scope to accommodate new unconventional morphologies. In the last two decades, solid-state sensors have attracted much curiosity for their relevance in identifying pollutant, toxic and other industrial gases. In particular gas sensors based on metal oxide semiconducting (wide Eg) nanomaterials have recently attracted intensive attention owing to their high sensitivity and fast response and recovery time. These materials when exposed to air, the atmospheric O2 dissociates and get absorb on the surface of the sensors by trapping the outermost shell electrons. Finally a depleted zone on the surface of the sensors is formed, that enhances the potential barrier height at grain boundary . Once a target gas is exposed to the sensor, the chemical interaction between the chemisorbed oxygen and the specific gas liberates the trapped electrons. Therefore altering the amount of adsorbate is a considerable approach to improve the sensitivity of any target gas/vapour molecule. Likewise, this study presents a spontaneous but self catalytic creation of Sn-doped ZnO hexagonal nanoprisms on Si (100) substrates through thermal evaporation-condensation method, and their subsequent deployment for volatile sensing. In particular, the sensors were utilized to detect molecules of ethanol, acetone and ammonia below their permissible exposure limits which returned sensitivities of around 85%, 80% and 50% respectively. The influence of Sn concentration on the growth, microstructural and optical properties of the nanoprisms along with its role in augmenting the sensing parameters has been detailed. The single-crystalline nanostructures have a typical diameter ranging from 300 to 500 nm and a length that extends up to few micrometers. HRTEM images confirmed the hexagonal crystallography for the nanoprisms, while SAED pattern asserted the single crystalline nature. The growth habit is along the low index <0001>directions. It has been seen that the growth mechanism of the as-deposited nanostructures are directly influenced by varying supersaturation ratio, fairly high substrate temperatures, and specified surface defects in certain crystallographic planes, all acting cooperatively decide the final product morphology. Room temperature photoluminescence (PL) spectra of this rod like structures exhibits a weak ultraviolet (UV) emission peak at around 380 nm and a broad green emission peak in the 505 nm regime. An estimate of the sensing parameters against dispensed target molecules highlighted the potential for the nanoprisms as an effective volatile sensing material. The Sn-doped ZnO nanostructures with unique prismatic morphology may find important applications in various chemical sensors as well as other potential nanodevices.

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