Growth and application of low-dimensional SnO_2

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Tin oxide (SnO_2) nanostructures (NSs) have attracted immense interests in key technological applications, e.g., gas sensors, optical devices, catalysis, energy storage, biosensors, because of its biocompatibility, chemical stability and environmentally friendly nature. Importantly, the physicochemical properties of this oxide can be tuned by creating different morphologies of NSs like 0 to1D and manipulation of different types of defects such as cationic (Sn) and anionic (O) vacancies along with the interstitial defects. Moreover, the truncation of the octahedral arrangement at the surfaces gives rise to a reduced coordination number from six to five to the outermost cation (Sn^{5c}). Hence, the most stable surface (110) contains both five (Sn^{5c}), and six-folded (Sn^{6c}) co-ordinate Sn. The equidistant oxygen connected to Sn^{6c} cation forms a row in the [001] direction and is termed as 'bridging oxygen. Its removal creates a bridging oxygen vacancy (V_B). Similarly, removal of the in-plane oxygen found in the direction of [001] and $[1\bar{1}0]$ gives rise to in-plane oxygen vacancy (V_P). Such vacancies can act as 'self-doping' and immensely contribute the electronic applications. For instance, V_P creates shallow donor states and influences electrical conduction based applications, like gas sensors. Similarly, other defects created away from the conduction band level may not directly impact the conduction process like cationic defects. However, they can play a pivotal role in optical property. Moreover, these defects being abundant in quantity in NSs, may have a stronger impact on various applications. However, controlled creation of defects and their characterization pose huge challenges. The presentation, therefore, focuses on the understanding of the multi-functional role of defects which are probed by various spectroscopic techniques like Raman, photoluminescence (PL), Fourier transforms infrared (FTIR), electron energy loss spectroscopy (EELS), X-ray absorption spectroscopy (XAS), FTIR, and lifetime measurement. For structural and morphological interpretation, XRD, FESEM, and TEM are employed. With a comprehensive understanding of defects, unique correlated applications such as PL based gas sensor, waveguide, electrochemical hybrid capacitor, photocatalytic dye degradation, resistive based gas sensor and observation of unusual high dielectric values are presented.