ABSTRACT

The research work embodied in this thesis reports a comprehensive piece of experimental work of a surface modified compound $CaIn_2O_4$ of the small core-shell crystallites so as it delineates multifunctional properties useful for optical, photocatalytic electronic and other applications. An optical doping of Eu^{3+} and Cr^{3+} ions of selective dosages varied up to 10 mol% is used in finely tailoring light absorption/emission in the UV-visible regions in the doped samples in harvesting their photocatalytic and electronic properties as demanded for the multifunctional applications. A synergetic eco-friendly biogenic synthesis method using a natural green aloe-vera gel (which offers hydrolysis of the metal salts in small tissues in a biogenic complex) has been explored to produce these synergetic materials of finely tailored physical properties in a tunable core-shell structure. As-prepared samples (after burning the mixed precursor gels in a flame in camphor in air) were annealed over 400-600 °C in air for 1-2 h in finely tuning a core-shell structure, wherein part of a grafted-C-sp^2 surface layer desorbs off and the bare crystallites grow over reactive facets in a refined core-shell structure so as it finely tunes the optical bandgap and associated optical/electronic properties. So obtained results are presented in seven chapters as follows. Chapter-1 provides a general introduction to the basic research interest and overview of materials science of $CaIn_2O_4$ types of mixed valence oxides. This includes a statement of the problem, review of the literature, motivation behind choosing this research work, intriguing properties, and applications of such materials. Chapter-2 describe so obtained results of characterizing small core-shell C-$CaIn_2O_4$ crystallites with tailored X-ray diffraction, microstructure, XPS bands, and phonon bands. Chapters-3, 4 describe the results of the data analyses of the phase formation with XRD patterns and microstructure of the Eu^{3+}/Cr^{3+} doped C-$CaIn_2O_4$ of selective chemical compositions. Novel results of light absorption/emission, photocatalytic and dielectric properties obtained in finely tuned core-shell C-$CaIn_2O_4$ crystallites are described in Chapter-5. Tailored optical properties so obtained in the doped samples are described in Chapter-6. The phonon and XPS bands illustrate how surface species, oxygen vacancies and twins vary in a C-sp^2 surface layer bonding on the crystallites and when it is etched out selectively by annealing at successively increased temperatures. A summary and conclusion of the major findings of this work are briefed in Chapter-7 along with a further scope of the work in this series.

Keywords: A biogenic synthesis, Core-shell $CaIn_2O_4$ crystallites, Hybrid nanocomposites, Hierarchical nanostructure, Dielectrics, Optical properties