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Structural And Optical Properties Of Core-Shell Tio_2/Mgo Nanostructures At Different Annealing Temperatures

Priyanka Basyach
Dept.of Physics, Tezpur University, Napaam, India
Amarjyoti Choudhury
Dept.of Physics, Tezpur University, Napaam, India

Abstract:
Titanium di Oxide nanostructures are recently in considerable demand as a model material for photovoltaic devices. Dye Sensitized Solar Cell s fabricated with TiO_2 nanoparticles as photo anode have been reported previously in various publications. Recently TiO_2 nanotubes heve been found useful as photo catalyst, photo anode, sensor, and in photoelctrolysis too. Here we report on the synthesis and optical properties of TiO_2 nanostructure as well as core-shell TiO_2/MgO nanostructures with the core annealed at different temperatures. TiO_2 nanoparticles are prepared by a sol-gel method and to the prepared TiO_2 nanoparticles, Mg $(OH)_2$ solution is added to avail the coating of MgO layer on the surface of TiO_2 nanoparticles. A strong UV absorption is observed in case of both TiO_2 and TiO_2/MgO nanostructures. The XRD patterns confirm the presence of both $TiO_2$and MgO in the core-shell structure. Also the TEM inage confirms the core-shell structure of the sample. The effect of varied annealing temperature of the core in the core-shell structure is also investigated via spectroscopic and morphological tools. The prepared core-shell nanostructures are expected to show good performance as photo anode in photovoltaic devices.

Keywords: *Core-shell, UV, XRD, TEM*

Introduction

Dye sensitized solar cells have brought generated enormous interest in the photovoltaic industry due to their low cost fabrication and comparatively high fill factor.

DSSC s fabricated with TiO_2 nanoparticle coated photo anode has been reported previously in various publications [1]. Again coating the surface of a photo electrode with a material of higher energy band gap yields core-shell electrode and these electrodes are in high demand these days as they are found to be very promising in enhancing the photovoltaic efficiency of the DSSC s [2]. Keeping in view the various applications of TiO_2 nanostructures and the use of core-shell nanostructures in fabricating the photo anode while improving the efficiency of DSSC s various workers attempted to make DSSC s with core-shell electrodes. Recently the ZnO/TiO_2 core/shell structure was formed through deposition of a TiO_2 coating layer on the hydrothermally fabricated ZnO nanorod arrays through radio frequency magnetron sputtering[3].One report reveals that core-shell electrodes based on TiO_2 covered with different oxides were applied in gel electrolyte-based dye-sensitized solar cells (DSSC)[4].The optimum performance was achieved by solar cells based on TiO_2/MgO core-shell electrodes with a fill factor of 0.60.In our work, we prepared core-shell TiO_2/MgO nanostructures with core annealed at different temperatures and studied their structural and optical properties as a supporting tool to use them in photovoltaic devices.

Preparation

Core-shell TiO_2/MgO nanostructures are synthesized through a simple sol-gel method [5] and upon them a coating of MgO was obtained through adding Mg $(OH)_2$ solution.

Structural Property Analysis

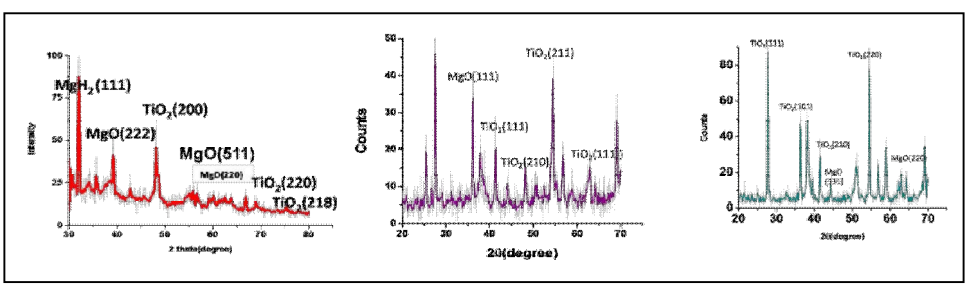

Figure 1: XRD pattern

Figure 1(left to right) shows the XRD pattern of core-shell TiO_2/MgO nanostructures with core annealed at 450^0C, 650^0C and 850^0C respectively. The patterns confirm the presence of both TiO_2 and MgO in the sample and support a phase transition form anatase to rutile at higher annealing temperatures.

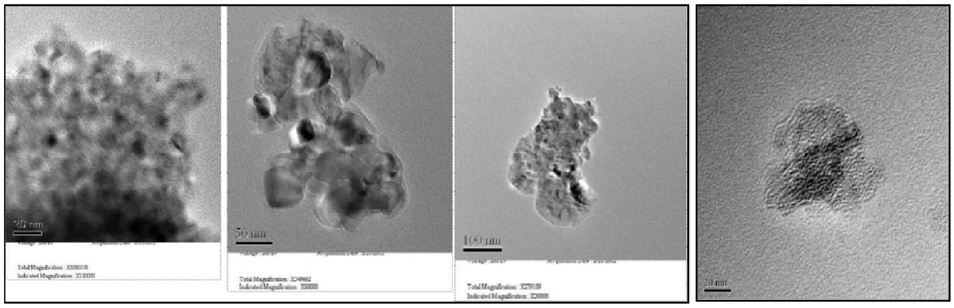

Figure 2: TEM images

Figure 2 shows the TEM images (from left to right) of TiO_2 nanoparticles annealed at temperatures 450^0,650^0,850^0 C and core-shell TiO_2/MgO nanostructure. Increase in size of the particles is observed with increasing annealing temperature.

Optical Proerty Analysis

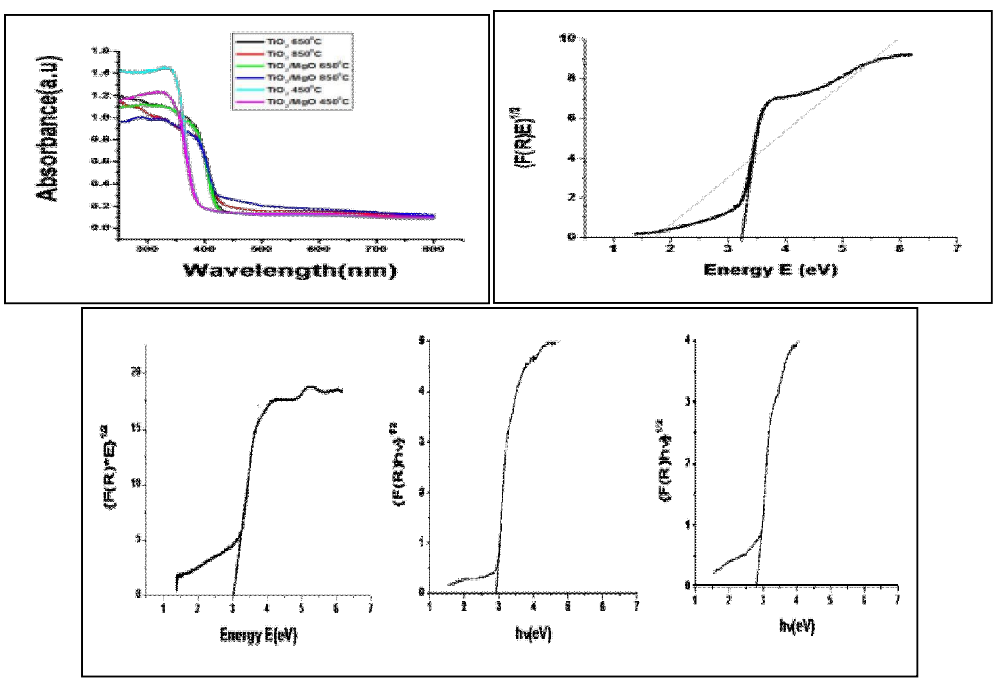

Figure 3: Absorption spectra and band gap calculation

From the UV-Vis absorption spectra,distinct red shift in aborption peak is observed for each increasing annealing temperature. The band gaps are calculated as $E_g(TiO_2)$=3.25 eV,$E_g(TiO_2/MgO$ 450)=3.05 eV, $E_g(TiO_2/MgO$ 650)=2.85 eV, $E_g(TiO_2/MgO$ 850)=2.75 eV.

It shows that all core-shell structures are TYPE 2 core-shell structures which is the most essential criteria for a material to be used in photovoltaic devices. Also the decrease in band gaps suggest that the materials tend to absorb more in the visible region which is another essential criteria for photovoltaic device fabrication.

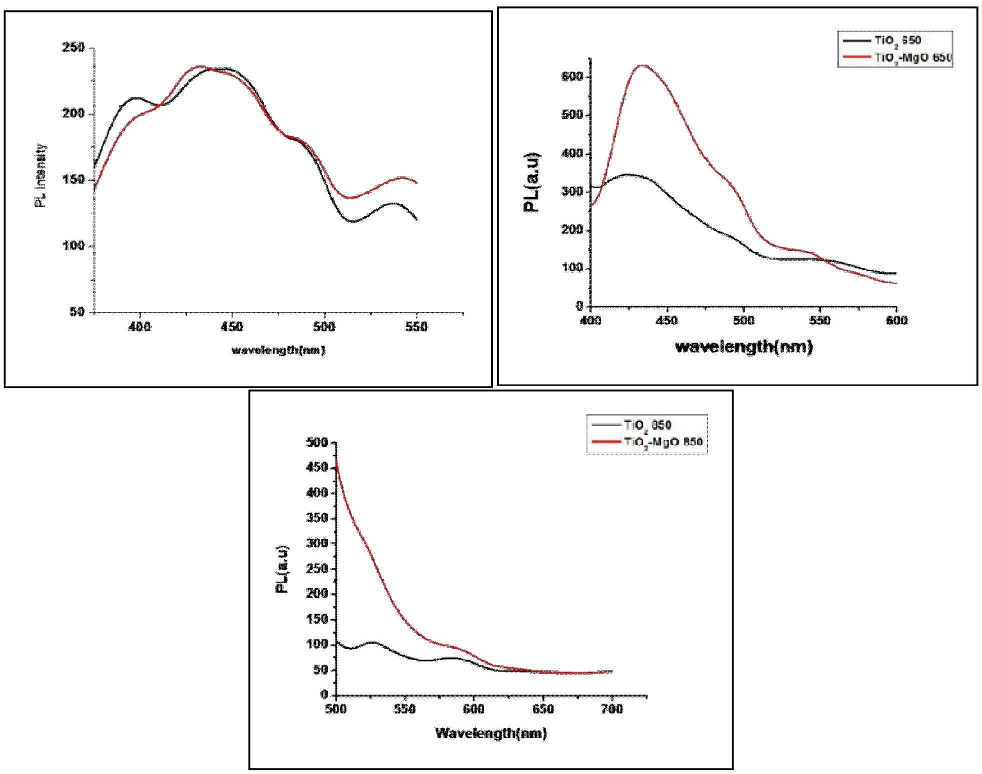

Figure 4: Photoluminescence spectra

The black curve shows the PL spectra of TiO_2 nanoparticles (left fig) while the red one shows the PL spectra of TiO_2/MgO nanostructure. Here we can see that the intensity of the peak present in TiO_2 due to band edge emission is lowered in the core-shell structure than the core .The lowering of the TiO_2 related UV peak should be due to relatively thick and dense MgO layer,thus the excitation source has low penetration intensity to excite the inner TiO_2 nanoparticles. The peak around 433 nm in fig (left) is attributed to self trapped exciton emission while the peak at the same position (centre image) is due to recombination of free electrons [6-7]. That peak is absent in Fig 4(right) only the oxygen vacancy related peaks are visible in the rutile structure. The absence of band edge emission peak makes them more favorable in fabrication of photovoltaic devices.

Conclusion

Thus, we have successfully fabricated core-shell TiO_2/MgO nanostructures with core annealed at different temperatures. With increasing annealing temperatures, it is observed that a phase transition from anatase to rutile occurred in the sample which is confirmed by XRD spectra and it directly affects the emission spectra. Also from absorption spectra, it is found that the core-shell nanostructure satisfies all the essential criteria to be used in photovoltaic devices.

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