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Analysis the Optical Properties of Co, Tio_2 And Co/Tio_2 Multilayer Thin Films of Different Thickness Deposited By E-Beam Technique.

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Abstract: *This paper presents the fabrication of the Co doped TiO_2 film for studying the optical properties. In this case, at first Co/TiO_2 multilayer films were prepared by e-beam evaporation in a vacuum better than 10^{-5} Torr. The optical properties of the as deposited Co, TiO_2, Co/TiO_2 films had been studied. The surface morphology had been studied by Atomic Force Microscopy. In the multilayer, the thickness of Co and TiO_2 is kept same. Each layer thickness was varied from 5nm to 15 nm and repeated three times. In this research paper the deposition rate of the Co and TiO_2 thin films are about 1.33 nm/sec &.1.25 nm/sec respectively. The optical transmittance of the as deposited Co, TiO_2, Co/TiO_2 multilayer thin film, it is seen for all the cases that the transmittance is zero from wavelength 200 to 300nm and transmittance increases as the wavelength increases from 300 to 800nm. It is also seen that in the case of as deposited Co the variation of maximum transparency for different thicknesses is between 25 to 70 percent where in the case of as deposited TiO_2;it is between 85 to 90 percent which means that transparency of Co is less than that of TiO_2 thin films. In all the cases, the average transparency of Co/TiO_2 multilayer thin film is roughly about 55% and decreased with increasing film thickness. The value of absorption co-efficient for the as deposited Co, TiO_2, Co/ TiO_2 multilayer thin film is found to be the order of 10^7 m^{-1} and increased with increasing photon energy. In all the cases higher thickness has lower absorption co-efficient. The extinction co-efficient is found to be decreased with wavelength initially and after wavelength 350nm it shows the random nature.*
Keywords: *Co, TiO_2, e-beam, optical properties, thickness.*

I. Introduction

Co-doped TiO_2 has been a promising candidate for dilute magnetic semiconductor (DMS). Many researchers are investigating this system to study and further manipulate their, magnetic or semiconductor properties, The material cobalt doped titanium dioxide which has received widespread interest since it was discovered to be ferromagnetic at room temperature by Y. Matsumoto *et al* [3]. In addition to its magnetic properties Co:TiO_2 has a wide indirect band gap and is transparent in the optical and near infrared, making it desirable for optoelectronic applications. Newly discovered room-temperature ferromagnetic semiconductor cobalt-doped titanium dioxide (Co-doped TiO_2) is known as wide-band gap diluted magnetic semiconductors(DMSs), it has a higher Tc (above room temperature), which makes it an extremely attractive material [4,5].DMSs are semiconductor doped with magnetic atom. The magnetic material is doped in transparent oxide in a motivation that the magnetic properties can be controlled by controlling the optical interaction. The reason for choosing cobalt and titanium dioxide in this research is because cobalt is a well-known magnetic element while the titanium dioxide has been extensively studied for several decades since it has many technologically important properties. TiO_2 is soft solid and melts at 1800℃. The films formed are mainly in rutile structure. It absorbs ultraviolet light and has a high stability which is suitable to act as a matrix layer in semiconductor. Meanwhile, Co-doped TiO_2 naturally has high value of Curie temperature (Tc) [11], very much well above room temperature. With all these properties and a doping with cobalt magnetic ions, it would be able to control its optical, magnetic and semiconductor characters for suitable applications. Therefore, it is interesting to investigate the optical properties of Co /TiO_2 multilayer thin film

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II. Experimental Process

Optical spectra has been measured in wavelength ranges 200nm<λ<800nm using a SHIMADZU UV-visible spectrophotometer(UV-1650PC) for both the Co, TiO_2 and Co/TiO_2 multilayer A sample with substrate is placed in the spectrometer. Optical transmission [in percentage] of the film for normal incidence is obtained from a graph that is automatically plotted against wavelengths during the period of spectral transmission. The optical spectra have been measured for different thicknesses of Co, TiO_2 and Co/TiO_2 multilayer samples. The film whose thickness is to be measured is required to form a step on a glass substrate and over it another plane glass plate (Fizeau plate) is placed. When the interferometer is illuminated with a parallel monochromatic beam of light (sodium light) at normal incidence, a fringe system is produced and is viewed with a low power microscope. Dark fringes are also observed against a white background. The fringe spacing and fringe displacement across the step are measured to calculate the film thickness. If h is the step height and d is the fringe spacing the film thickness t is given by,

$$\mathbf{t} = \frac{\mathbf{h}}{\mathbf{d}} \times \frac{\boldsymbol{\lambda}}{\mathbf{2}} \qquad (2.1)$$

where, λ is the wave length of monochromatic light. The thickness of the film has been calculated by Equation 2.1.Optical absorptions co-efficient of these samples have been calculated from the transmission data at different wavelengths. Since the samples are transparent in the visible region of the spectra, the reflection coefficients for the normal incidence were taken negligible in consideration. The AFM works much the same way a phonograph works only on a much, much smaller scale: a very sharp tip is dragged across a sample surface and the change in the vertical position (denoted the "z" axis) reflects the topography of the surface. By collecting the height data for a succession of lines it is possible to form a three dimensional map of the surface features. The first detail we'll discuss is the AFM tip or the part that makes contact with the sample. This represents one of the most critical features of the AFM, and advances are always being made to create a better tip (we'll soon see what makes a really good tip).There are several requirements for the tip - it must be sharp and thin to get into all the nooks and crannies of the sample but it must be very durable to survive the forces and it shouldn't bend under normal loads.

III. Result And Discussion

Our main objective is to study the optical properties of Co/TiO_2 multilayer thin film. In the multilayer, the thickness of Co and TiO_2 was kept same. Each layer thickness was varied from 5nm to 15 nm and repeated three times. There are six alternative layer of Co and TiO_2 in each film and the upper layer is TiO_2. S_1 denotes that each layer is 5nm and S_2, S_3 denotes that each layer is 10nm and 15nm respectively. The optical spectra of transmittance, T(%) have been measured at wavelength ranges 200 ≤ λ ≤ 800nm using a "UV-Visible SHIMADZU spectrophotometer"(UV-1650PC).Fig-1,2 and 3 respectively shows the variation of transmittance, T(%) with wavelength for thickness variation as deposited Co,TiO_2 and Co/TiO_2 multilayer thin films.

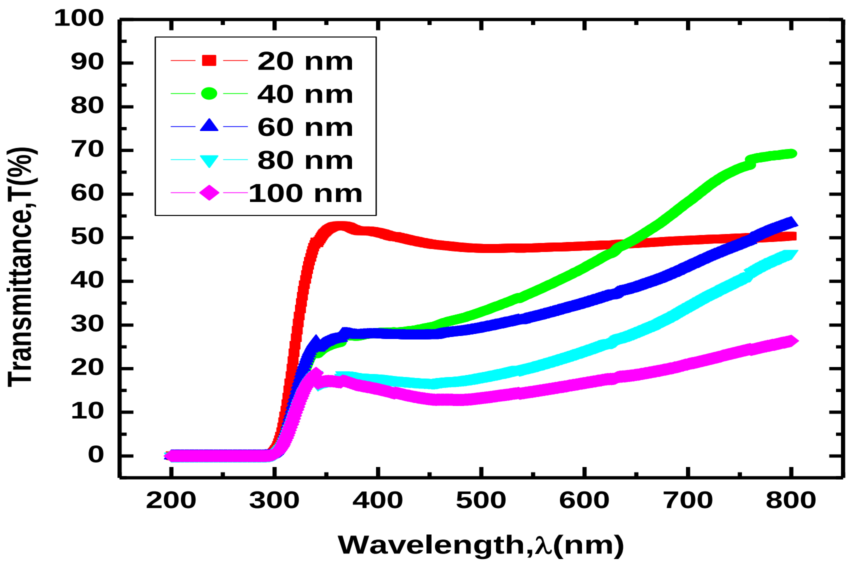

Fig-1: For the Co thin films of different thicknesses.

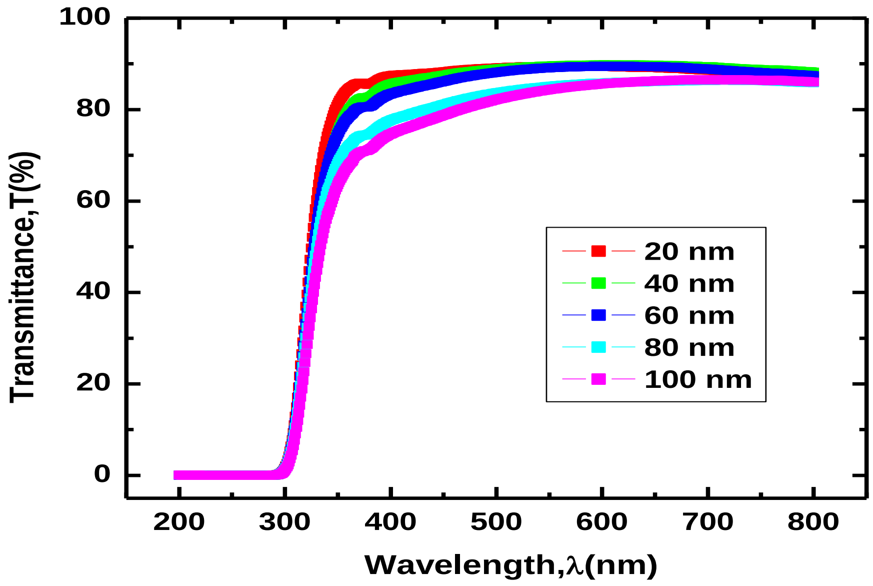

Fig-2: For the TiO_2 thin films of different thicknesses.

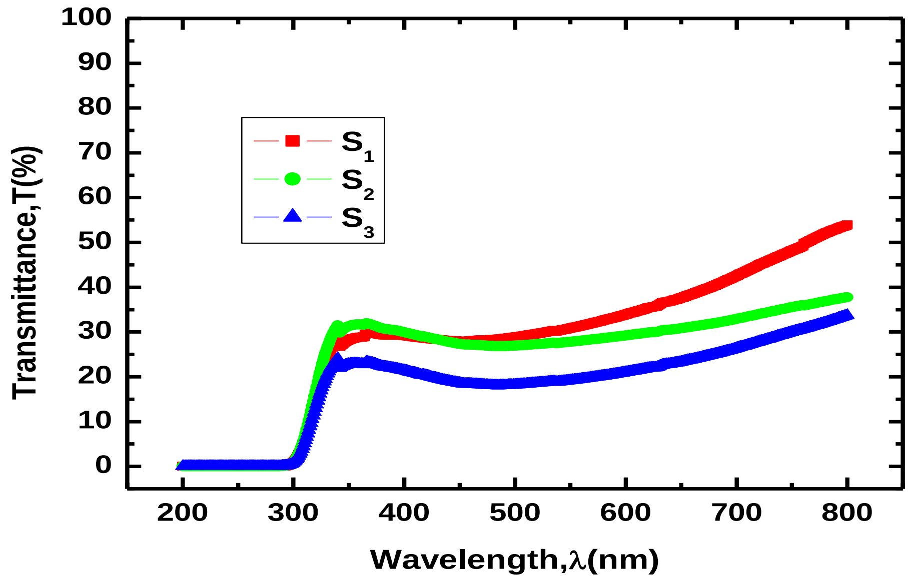

Fig-3: For deposited Co/TiO_2 multilayer thin films of different thicknesses.

Fig. 4, 5 and 6 shows the variation of absorption co-efficient with photon energy for thickness variation as deposited Co, TiO_2 and Co/TiO_2 multilayer thin film respectively.

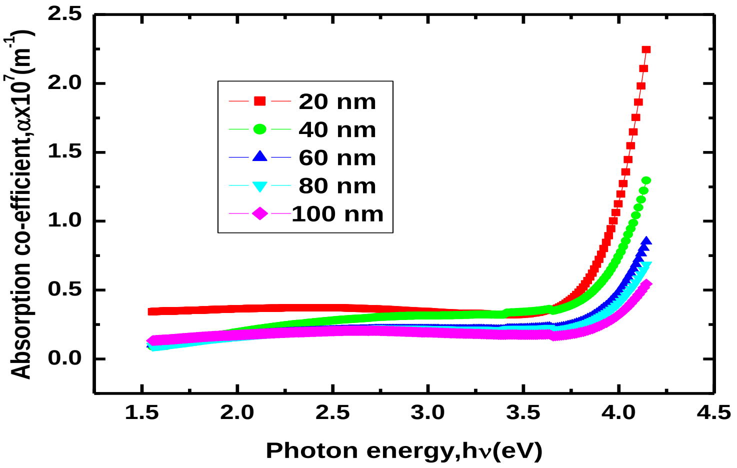

Fig-4: For deposited Co thin films of different thicknesses.

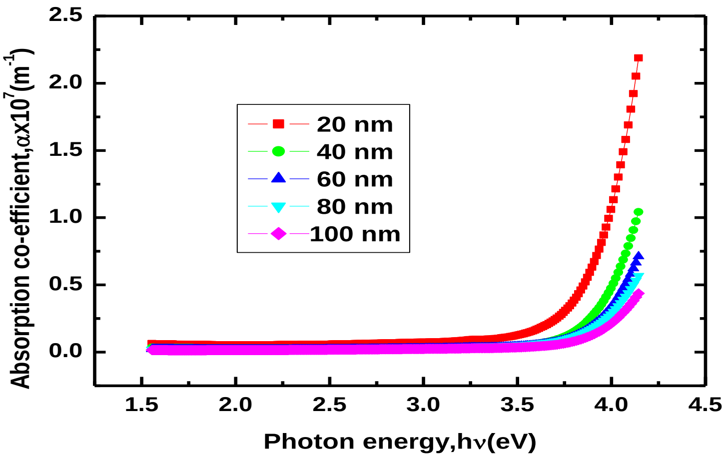

Fig-5: For deposited TiO_2 thin films of different thicknesses.

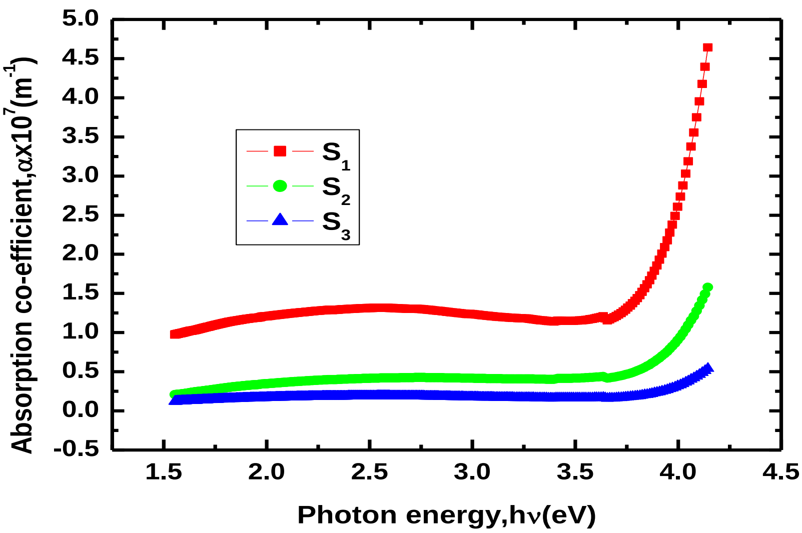

Fig-6: For deposited Co/TiO_2 multilayer thin films of different thicknesses.

Fig-7, 8 and 9 shows the variation of extinction co-efficient with wavelength for thickness variation as deposited Co, TiO_2 and Co/TiO_2 multilayer thin film respectively.

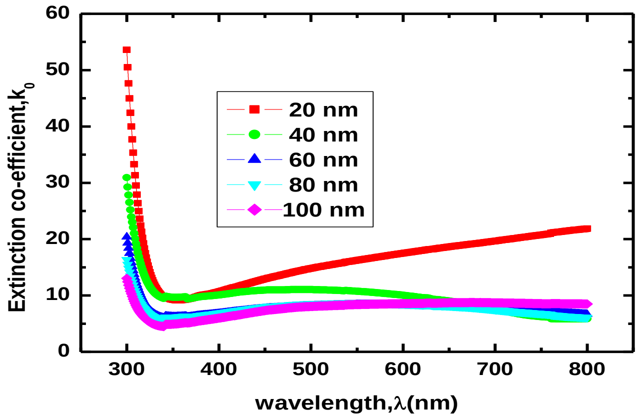

Fig-7: For deposited Co thin films of different thicknesses.

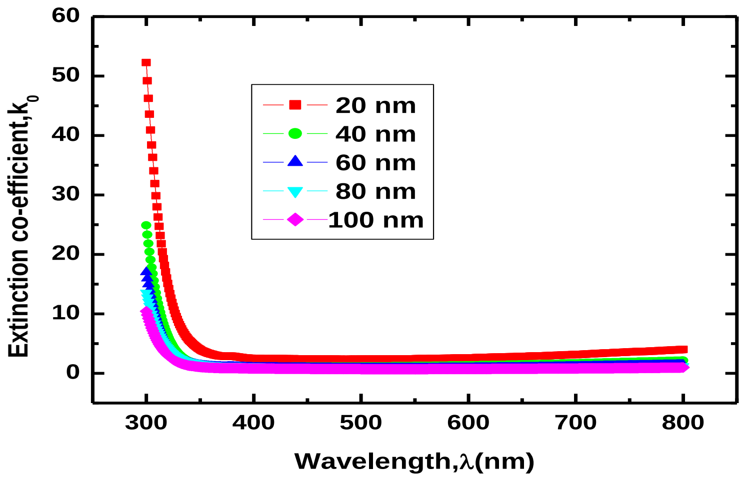

Fig-8: For deposited TiO_2 thin films of different thicknesses.

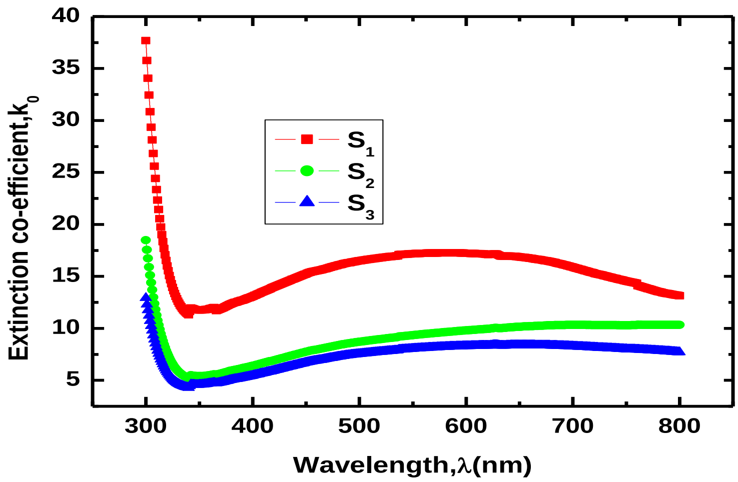

Fig-9: For deposited Co/TiO_2 multilayer thin films of different thicknesses.

IV. Conclusions

In the light of the experimental investigations and analysis on the optical studies of Co, TiO_2 and Co/TiO_2 multilayer thin films of different thicknesses deposited by e-beam technique. Co, TiO_2 and Co/TiO_2 multilayer thin films with variable thickness ranges from 20 to 100 nm have been prepared onto glass substrate by e-beam evaporation technique in vacuum at a pressure of ~4×10^{-5} Pa. The deposition rate is about 1.33nms^{-1} for Co and 1.25nms^{-1} for TiO_2. The various effects on optical properties of the films have been studied in details. The optical transmittance of the as deposited Co, TiO_2, Co/ TiO_2 multilayer thin film is carried out in the wavelength ranging from 200 to 800 nm at room temperature. It is found that for same thickness Co/TiO_2 multilayer thin film is more transparent than Co and less transparent than TiO_2 thin film. The average transparency of the Co/TiO_2 multilayer thin film is roughly about 55% and decreased with increasing film thickness. The value of absorption co-efficient for the as deposited Co, TiO_2, Co/ TiO_2 multilayer thin film is found to be the order of 10^7 m^{-1} and increased with increasing photon energy. In all the cases higher thickness has lower absorption co-efficient. The extinction co-efficient is found to be decreased with wavelength initially and after wavelength 350nm it shows the random nature. It has the opposite relation with film thickness.

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