ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2015; 1(10): 348-350
www.allresearchjournal.com
Received: 20-07-2015
Accepted: 21-08-2015

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Quarter wave optical thin film deposition and optical characterization of film

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Abstract
Thin film technology is very high usable in day to day life and small scientific application to very high technology. According to use of thin films; films are made of different materials like metallic thin film and dielectric material thin films. In semiconductor technology, solar cells; films of some compound semiconductor are formed. Dielectric thin films are used in various types of application from simple mirror to laser mirror and laser windows. Very interesting application of dielectric mirror in making head up display. Thin films formation has primary condition that it required very high vacuum. At particular vacuum level it works and desirable features of the thin film are achieved, otherwise impurity and other defects are occurring in the film. X-ray diffraction, Uv-Visible spectroscopy and FTIR is taken for characterization of film. From these amorphous, high reflective and antireflective and absorptive films are formed.

Keywords: Metallic film, dielectric film, solar cell, vacuum, x-ray diffraction

Introduction
The atmospheric air around us is said to contain nearly 2.5×10^{19} molecules for every cubic cm space. Any given spaces having molecular density less than this is said to be under "vacuum" conditions. A vessel with necessary pumping and the technology dealing with the production of such reduces pressure an environment using different scientific concepts is known as "vacuum technology". Vacuum technology is fundamental to a range of scientific explorations & technological processes; extending from analyzing atomically clean surfaces at extremely low pressure of the order of 10^{-11} Torr (1 torr = 1 mm hg) to freeze drying of foodstuffs at relatively high pressure in the range of 10^{-1} Torr. Vacuum conditions between these extremes are required TV tube production, vacuum furnance, vacuum coating, semi-conductor processing, particle accelerators, space stimulation, etc [1].
It is interesting to know that we human beings continuously create vacuum during respiration and suction. Another natural phenomenon is the decrease in atmospheric pressure with an increase in altitude (by a factor of 10 for every 15 km), from 760 Torr at sea level to a pressure of 10^{-3} Torr at an altitude of 90 km. Above 100 km atmospheric pressure decrease relatively slowly (by a factor of 10 for every 100 to 200 km) resulting in ultra high vacuum (UHV) of the order of 10^{-19} Torr at 1000 km. It is to be noted here that such clean UHV conditions ($< 10^{-10}$ Torr) [2, 3] obtained in limited space on earth by complicated expensive technologies are naturally available in an infinite large vacuum of deep space beyond 1000 km altitude. This natural facility is presently being explored for useful explorations by mankind.
Because of natural inherent limitations, no single vacuum pump exists which can cover the pressure range from 760 to 10^{-10} torr. Hence, depending on the ultimate pressure needed in the vacuum systems, combinations of different types of vacuum pumps have to be used for different applications [4]. There are two basic approaches to reduce the pressure in a vacuum vessel as

1. The removal of the gas molecules from the vessel and exhausting them from the system
2. The removal of gas molecules from the gas phase and retained them into the system.

Experimental

Rotary Vane Pumps

The rotating vane pump, known also as rotary pump is a simple and most popular +vi displacement pump. figure shows the cross section and exploded view of a typical rotating vane pump. It has a cylindrical steel rotor located eccentrically in acylinder stator housing, almost touching the stator surface at the top. The rotor is slotted at its diameter to take two spring loaded vanes which bear tightly against the inner surfaces of the stator.

The stator is a steel cylinder the ends of which are closed by suitable plates, which holds the shaft of the rotor. The stator is pierced by the inlet & exhaust ports which are positioned respectively a few degrees on either side of the vertical. The inlet port with a dust filter is connected to a vacuum system & the exhaust port is provided with a valve, which may be a metal plate moving vertically between arrester plates, or a sheet of neoprene, which is constrained to hinge between the stator and a metal backing plate.

The line of contact known as the top seal between rotor and stator must have clearing of 2-3 microns. All of the containing surfaces are ground to a high pressure and the whole stator rotor assembly is submerged in suitable oil, which serves a sealant, coolant & lubricant. A film of oil is used on all moving parts. The rotary sealed pumps normally operate at speed of several hundred revolutions per minute.

Diffusion Pump

The most common type of pump for use in high vacuum application is the diffusion pump. The vacuum diffusion pumps are one of the oldest and most reliable ways of creating a vacuum down to 10^{-10} torr or even lower at 25℃. A vacuum diffusion pump is basically a stainless steel chamber containing vertically stacked cone shaped jet assemblies. Typically there are three jet assemblies of diminishing type of oil having a low vapor pressure. The oil is heated to boiling by an electric heater beneath the floor of the chamber. The vaporized oil moves upward and is expelled through the jets in various assemblies. Water circulated through coils on the outside of the chamber cool the chamber to

The original diffusion pump fluid used was mercury, which could withstand elevated temperature but had a disadvantage of being toxic. Pump and jet designed have evolved over the years and synthetic fluids have advanced, enabling higher level of vacuum to achieve. There are several types of oil based variously on silicones, hydrocarbons, esters, perflourates and poly phenyl esters can be used. Although they have been replaced in some applications by more advanced designs such as cryo-pumps or ion pumps, vacuum diffusion pumps are still plentiful.

By achieving required vacuum of the chamber, the process of deposition is started. In this study thin film is deposited by e-beam deposition method gun is started and evaporation is occur till the required thickness is achieved which is monitored by the quartz crystal monitor. Structure characterization is done by X-ray diffraction method and optical properties are studied by Uv-Visible and FTIR.

Results and Discussion

X-Ray Diffraction

X-ray diffraction is explained on basic principle of Brag's law [5-7]. The samples were measured by XRD with 2θ angle in the range of 10º to 80º using filtered Cu –Kα radiation in steps of 4º. The inter-planar distance d was calculated by the equation of $2d \sin \theta = n\lambda$ where θ is the Bragg diffraction angle, λ is 0.154 nm of the Cu- Kα radiation [8, 9]. X-ray diffraction pattern has been used to investigate the phase of the prepared TiO_2 thin films. The X-ray diffraction pattern displays the existence of amorphous TiO_2 regions by showing the presence of the broad hump in the low 2θ region. In case of SiO_2 also the absence of any peak confirms the amorphous nature of film.

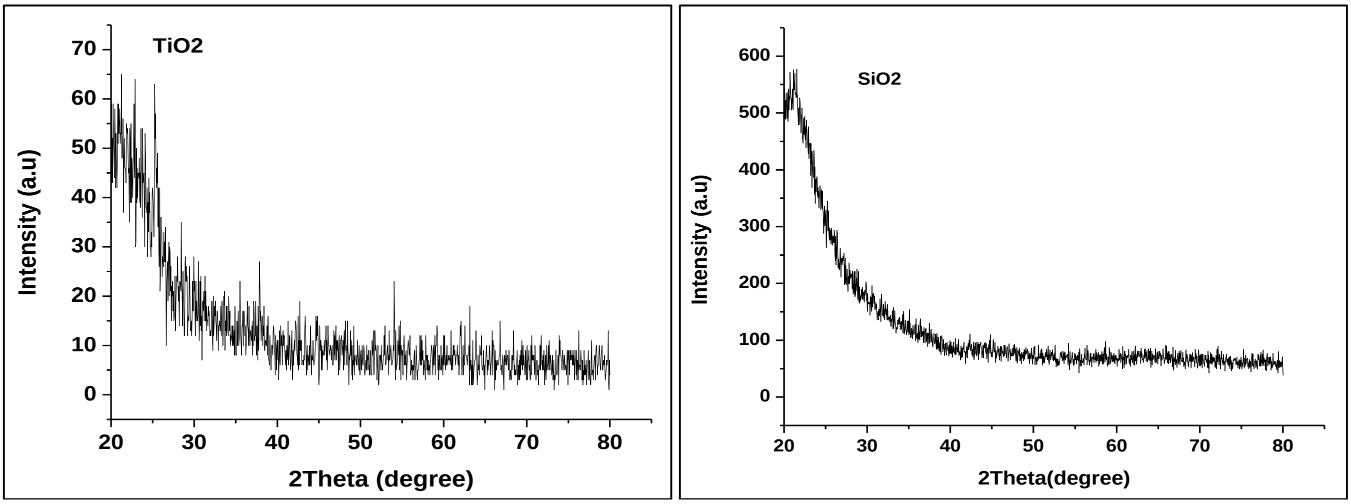

Fig 1: XRD pattern of TiO_2 and SiO_2 thin films

The amorphous phase of SiO_2 depicts the absence of grain in the grown film. The presence of grain boundaries usually provides a path for the transport of charge carriers which is not seen here. This demonstrating short range order and amorphicity [10]. XRD pattern of TiO_2 and SiO_2 both shows the amorphous behavior as shown in the figure 1.

Optical Properties

Reflection and transmission of TiO_2 and SiO_2 thin film is measured by simadzu spectrophotometer in wavelength range 380 nm to 780 nm in visible region. From single layer TiO_2 thin film reflectivity of 34% at 550 nm is achieved and for SiO_2 thin film it is very low reflective 2.69% is obtained. This shows that TiO_2 is high reflective and SiO_2 is antireflective as shown in the figure.

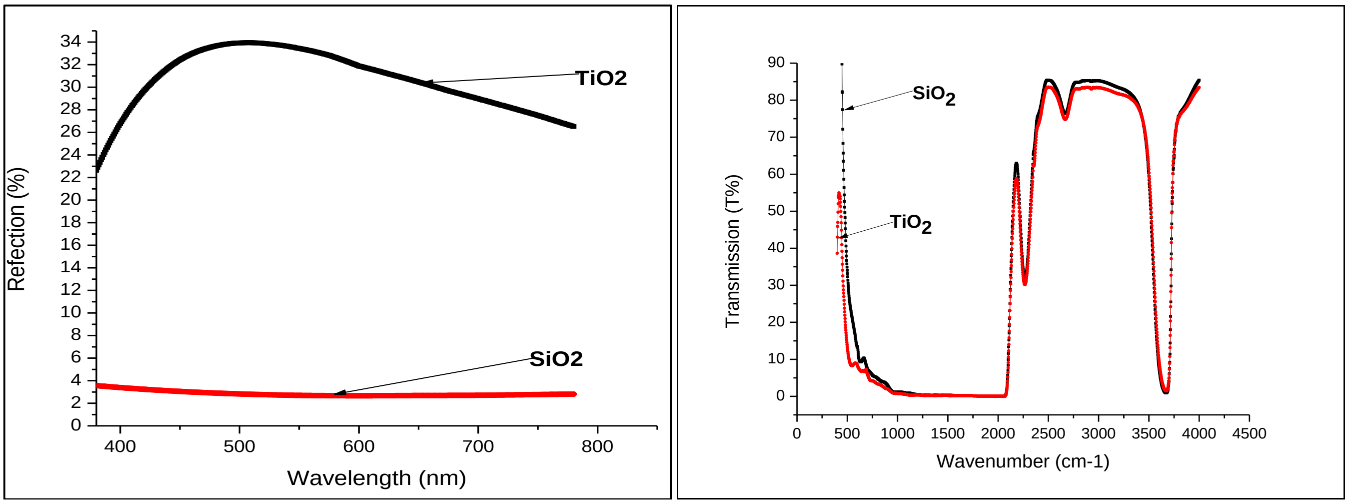

Fig 2: Reflection of TiO_2 and SiO_2 thin film and FTIR spectra of TiO_2 and SiO_2 thin film

FTIR spectrum of TiO_2 and SiO_2 thin film in the range 400–4000 cm^{-1} is taken. FTIR study confirmed the formation of TiO_2 with characteristic vibrational mode of Ti–O at 585 cm^{-1} and Si-O at 625 cm^{-1} [11-13]. FTIR spectra of TiO_2 and SiO_2 thin film is shown in the figure 2. Sharp peak at 500 cm^{-1} is found for both SiO_2 and TiO_2 thin film, then a peak arrive at 2250 cm^{-1} and a broad peak at 2600cm^{-1} occur [14]. Sharp valley at 3400 cm^{-1} also notified as shown in the figure 2.

Conclusions

Thin films of TiO_2 and SiO_2 is deposited by e-beam deposition method and a particular vacuum level of order 10^{-5} mbar for deposition is achieved by rotary and diffusion pumps. X-ray diffraction shows that the deposited films are amorphous in nature. Uv-Visible spectrometer shows that TiO_2 is high reflective and SiO_2 is Antireflective or high transmission.

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