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Structural, electrical, optical and gas sensing properties of $MgTiO_3$-B doped polyaniline thin films

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Abstract
The structural, electrical, optical, and gas detecting properties of porous $MgTiO_3$-B doped thin films have been diagnosed by a chemical spray pyrolysis process, thin films were formed by changing the mass fractions of $MgTiO_3$-B doped polyaniline (20%, 30%, 40% and 50%). The films were set aside at 250 °C and the precursor solution was made by dissolving magnesium chloride ($MgCl_2$) in ethanol and in addition with 5% boric acid also PANI (polyaniline) in equal amounts (1:1). UV-vis Spectrometry, SEM, XRD and voltage-current measurements were used to describe the deposited films. H_2S gas was utilized to investigate the behavior of gas sensors.

Keywords: Polyaniline, thin film, XRD, H_2S, gas sensor

Introduction
Conducting metal oxide materials have been received advanced and intensive applications in recent times owing towards the vital functions like heat reflectors, solar cells and sensors etc in the devices of optoelectronics. $MgTiO_3$ be a metal oxide having dielectric characteristics that is utilized in electronic equipments. Due to its inexpensive cost, it is broadly used in the growing field of gas sensors. These characteristics assist sensors, transistors of thin films, solar cell electrodes, light-emitting diodes, and thin-panel displays. $MgTiO_3$can also be utilized in the production of reflective infrared films using the similar doping technique related to other metal oxides. $MgTiO_3$is worn to create energy-saving materials by lowering the product of energy it takes to increase the temperature was observed by Standler (2012) [1].
In the new year, Magnesium chloride is a good conductor it's been a while working in the manufacture of skeletal films. It is favored for the reason of its outstanding thermal stability and the fact that it may be utilized as visible and near-infrared light-sensitive resistors. The structural, optical, and thin film electrical properties are discovered to be affected by the concentration of doping was recorded by H. Cachet (2001) [2]. Sensitivity has recently gained a large attention, moreover, there has been instances where a great number of initiatives to develop gas sensors' selectivity and sensitivity. We made thin films by the chemical spray pyrolysis method (CSP), due to its ease of usage and low cost it has shown to be a good chemical approach for creating thin films with larger areas. Various parameters, for example Physical, electrical, and thin films of optical properties are affected by the cooling rate after sublimation which is affected by air pressure, amount of deposition, concentration of dopants, and nozzle-to-substrate distance was observed by Xiao Zhi (2008) [3].
The semiconducting metal oxide act as a gas sensor, which constitute one of the most investigated groups of gas sensors. Due to their lowest price, flexibility in production, these sensors are simple to use and have a broad range of application, enhance the interest of many researchers in the area of gas sensing. Number of research scholars has demonstrated the gas's reversible interaction with the substance surface is a property of gas sensors conducting metal oxide. The surface area of sensor layer's and microstructure, surface additives and temperature, are all intrinsic characteristics of the underlying material can all have an impact on the interaction. Metallic oxide gas sensors have archived a wide attention, but there is still a plenty of work to be done (K. K. Purushothamma) [4]. Sensitivity has got gobs of interest lately, and numerous attempts has been impelled to progress the gas sensors sensitivity and selectivity.

The goal of this study was to evaluate the effect on structural, optical, electrical, and sensing capabilities of $MgTiO_3$-B doped PANI thin films for varied mass fractions using the spray pyrolysis method.

Materials & Methods

Materials

Prior to usage, aniline ($C_6H_5NH_2$, Merck) was double distilled and kept at 4^0C. Merck supplied magnesium titanate, ferric chloride ($FeCl_3$), and boric acid (H_3BO_3), including ammonia (NH_3) and hydrochloric acid (HCl). The solutions were produced with the water which has been de-ionized and all are of analytical grade ingredients.

Preparation of PANI

In aqueous acid media two aniline monomer and $FeCl_3$ solutions were mixed. The first solution includes 0.5 M aniline in a 250 ml of 0.1 M HCl aqueous solution. The second solution includes 0.03 mol $FeCl_3$ in 250 ml of 0.1 MHCl aqueous solution. The $FeCl_3$ solution was added to the aniline in a drop-by-drop manner solution while maintaining a constant temperature of 5 °C. The originally colorless fluid turns blue and then dark green during aniline polymerization. The dark green color suggested that emerald was being produced. To eliminate impurities and untreated monomer the residue was recovered and rinsed with 0.1 M solution of HCL before being dried in methanolD. Zaouk (2000) [5].

Fabrication of $MgTiO_3$-B PANI Thin Film polymers

The initial pioneer solution was created by dissolving 0.16M Magnesium chloride in 25ml ethanol, plus 5% boric acid and PANI (1:1).Throughout deposition, the flow velocity of the solvent was kept constant at 5ml/min, and 35cm away from the substrate, the needle was inserted. At 2500C temperatures, pyrolysis occurred when particles of aerosol drew near to substrates, resulting in highly adherent $MgTiO_3$-B: PANI coatings. The heater was switched off when the spray was done, and allowing the films to cool to room temperature was observed by L. Chinnapa (2011) [6]. On a Surgical tiny glass plate’s thin coating of the film are deposited.

Characterization of $MgTiO_3$-B: PANI Thin Films

Further characterization was passed out on the MgTiO3-B doped PANI films that had been produced. Using anCuK radiation (=1.5405) on 40 mA and 40 kV next to a scanning speed of 0.02 per sec in an X-ray diffractometer (Ultima IV Japan) these films' crystalline was investigated. The morphological parameters of the films was analysed by (SEM) scanning electron microscopy was observed by M. Adnane (2005) [7]. A UV-vis spectrometer be utilized to analyze the characteristics of optical films in the range of wavelength 200-1100 nm (Specord- 200 plus Germany). The film's (I-V) current-voltage character were investigated by a programmable Keithley basis metre(Keithley 2636A) C.H. Han (2007) [8].

Gas Sensing Measurements

Sensing measurements of gas were conducted out with the help of a sensor gas unit by E. Elangovan (2004) [9]. An automated multimeteris worn to determine resistance, and a digital thermometer with an alumel-chromell thermocouple measures the temperature of the micro heater. The gas H_2S is utilized as a probe. First, the oven is set to a specific temperature value by delivering 12.5 V towards the heater to sustain the temperature at a steady of 250 °C, after then, the sensor's worn resistance to air is determined. The bottle is opened and the sensor is uncovered to open air once the least amount of constant resistance value is obtained, the build up in resistance over time is nowbeing recorded. Under the same conditions, a related method was repeated numerous times for all samples (films) observed by Hee Tai Eun (2003) & B. Thangaraju (2002) [10-11].

Result & Discussion

Spray pyrolysis used to make a deposit MgTiO3-B: PANI thin films that were both transparent and electrically conductively.

X-Ray diffraction study

The figure of the regular crystallite is calculated by the formula of Debye Scherer based on the XRD pattern. Obtaining an XRD pattern at 45 °C had low noise and more powerful primary peaks than those obtained at lower temperatures. This supports the idea A.V. Moholkar (2007) [12] that crystalline nature improves with increasing Ts.

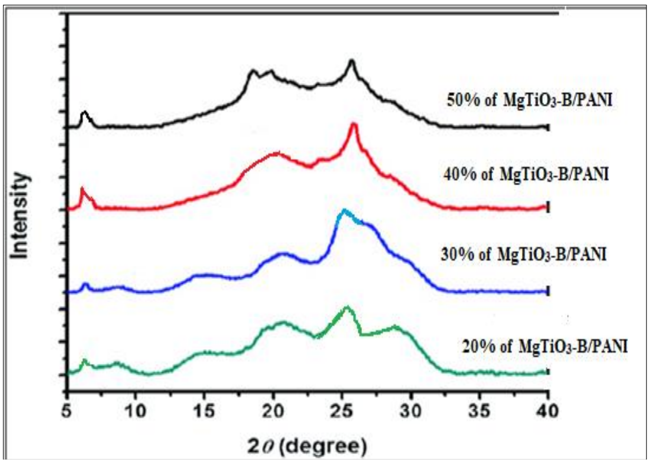

Fig 1: X-ray diffraction pattern of spray deposited $MgTiO_3$-B thin films with variation of dopant composition

As doping concentration increases, the crystallite density is also rises, and the peaks grow thinner and more refined, as evidenced by the drop in terms of crystallite size, which reduces charge carrier grain boundary scatteringJ. Liu (2015) [13]. The rise in vacancy concentration which enhances electron transfer, as the doping concentration rises the consistency of dislocations increases. The dimension of the pattern constants lowers as doping concentration rises, which correlates to shrinkage in crystal size was again recorded by J. Liu (2015) [14].

Morphological Analysis

The $MgTiO_3$-B: PANI thin films surface morphology was examined using (SEM) scanning electron microscopy pictures at various doping concentration, as shown in Figure (2).

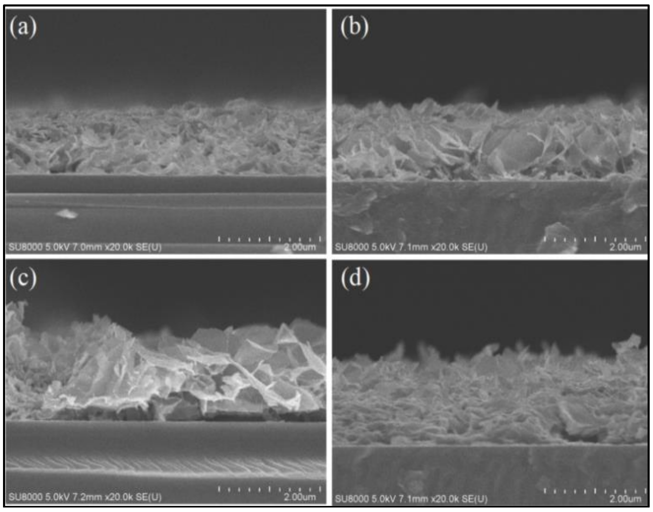

Fig 2: SEM image of $MgTiO_3$-B with different doping concentration

At 30% doping concentration of $MgTiO_3$-B, grain-shaped tiny grains with a slick surface and dense packing are observed by M. Afzal (2015) [15]. Other Ts have no discernible shape, despite the film's thick grain packing. By the cause of inadequate dissociation of the pioneer solution at concentration of 30% $MgTiO_3$-B giant shape grains can be detected. Thin film grain boundaries are visible at concentration of 30% $MgTiO_3$-B, and porosity has revealed the best susceptibility to H_2S.As the concentration dopant ($MgTiO_3$-B) increses, slightly sensitivity increases was observed by Q. Wang (2016) [16].

Optical properties

The absorbance peak of $MgTiO_3$-B film with varying concentration of dopant shifted towards the higher wavelength area, as doping concentration rises; in optical it indicates a downturn in band gap was recorded by K.K. Khun (2011) [17]. These films' band gap is predicted to be between 3.2 and 3.3eV. Figure (3) shows the absorbance curve of $MgTiO_3$-B: PANI thin films at various doping concentraion. The highest sensitivity to H_2S was seen at a thin film energy gap of 3.5 eV at 30% of $MgTiO_3$-B dopant with PANI. Sensitivity increases as concentration of dopant $MgTiO_3$-B with PANI increases.

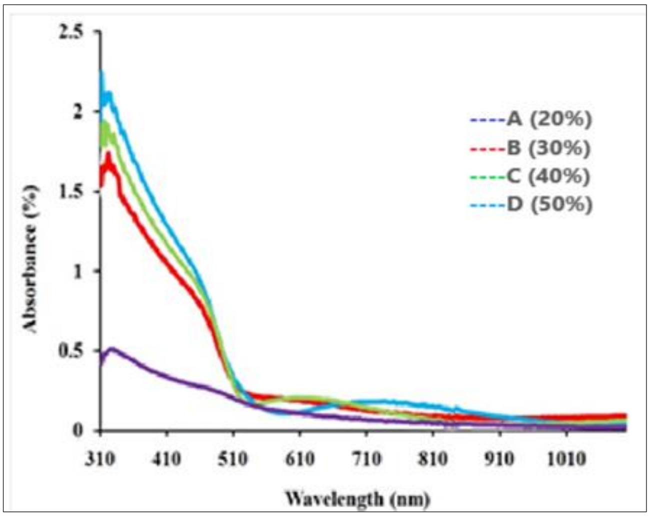

Fig 3: Optical Absorption of $MgTiO_3$-B:PANI Thin Films with different doping composition

Electrical properties

Keithley source metreswere utilized to calculate electrical resistivity at room temperature. The I-V characteristics Curve of $MgTiO_3$-B; PANI thin films at diverse doping concentration are depicted in Figure (4).

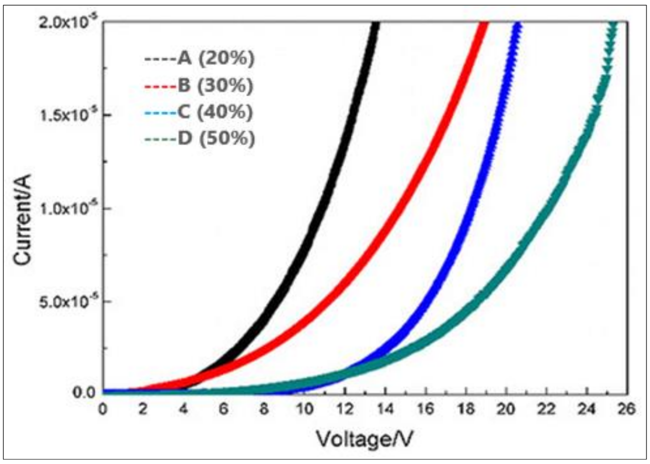

Fig 4: Current-Voltage (I-V) Characteristic Curves of $MgTiO_3$-B:PANI Thin Films with different doping composition

As the concentration of doping rises electric resistivity of the film lowers, this could be because the film's crystallinity has improved, allowing the particles to move more freely. The transfer of particles in polycrystalate thin films is heavily influenced by intergranular effects. The crystal size decreases as doping concentration rises, indicating grain shaped crystal development, and the number of crystallites/unit volume rises with reducing the potential of the grain boundary was recorded by L.A. Patil (2006) [18]. Thin film resistivity of 23.5 K has shown highest sensitivity to H_2S at 30%of doping concentration.

Gas Sensing Characteristics

In present study we have recorded the gas sensor response using Laboratory gas sensor setup to sense H_2S gas at 250 °C, as the doping concentration of $MgTiO_3$-B increases sensitivity of thin film also increases was observed by both S.R. Morrison (1987) & M. Morimitsu (2000) [19-20]. At 30% concentration of doping $MgTiO_3$-B thin film exhibited maximum sensitivity to H_2S gas.

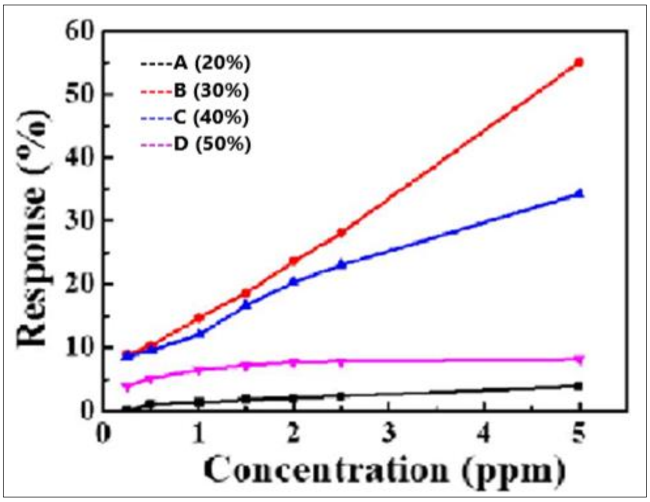

Fig 5: Sensitivity of $MgTiO_3$-B:PANI Thin Films for H_2S

Conclusion

In this paper the XRD peaks get sharper as concentration of dopant increases during the deposition of $MgTiO_3$-B: PANI thin film, showing a reduction in particle size and better crystalline. The geometry of the particles reduces in morphological examination. The absorbent edge changed aiming for a higher wave lengths in UV-vis spectrum study, indicating reduces in energy gap. Resistance reduces as concentration of dopant increases. From I-V characteristics it is found that gas sensitivity increases with concentration of the dopant. Fine porosity, high energy gap, lesser resistance and thin films displayed highest sensitivity to H_2S gas at the dopant concentration 30% of $MgTiO_3$-B: PANI.

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