RESEARCH ARTICLE

CRYSTAL Research & Technology
www.crt-journal.org

Investigations on The Effect of Cd Dopant on The Properties of 2D Nanostructured Vanadium Oxide Thin Films

Niju Rajan and D. V. Manjunatha*

The structural, morphologic, and photosensitive characteristics of pure and Cd-doped V_2O_5 thin films grown by spray pyrolysis are investigated in this work. To stabilize the precursor, glycine is added during preparation. The choice of Cadmium (Cd) as a dopant is made with Vanadium's ionic radius compatibility in consideration. X-ray Diffraction (XRD) measurements show that the orthorhombic structure does not alter with the addition of Cd dopant. The morphological studies reveal that the surface roughness of synthesized V_2O_5 increases with dopant concentration. Investigation of field emission scanning electron microscope (FESEM) images indicate that as the dopant concentration increases, the produced film's particle size reduces and hence It is suitable for gas sensing applications. UV–vis spectroscopy is employed to investigate the influence of doping on the absorbance, transmittance, and optical energy gap of the deposited thin film. The material can be taken into account for photovoltaic applications, as the investigations demonstrate an improved transmittance rate, lower absorption rate, and an increase in the optical bandgap in the visible spectra.

1. Introduction

Among other metal oxides, the growth of Vanadium Oxide thin films at lower temperatures has proven to be challenging.[1,2] V_2O_5 thin films were grown using a variety of growth techniques, including spray pyrolysis, spin coating, thermal evaporation, sputtering, sol-gel, and Chemical Vapor Deposition (CVD).[3-7] One of the main sets of techniques used to create a variety of metal oxides is the CVD method. When dealing with melting precipitations or powders as precursor materials, the term "Spray Pyrolysis" (SP) is employed. Spray Pyrolysis is an efficient method for replacing components in the precise concentration in the precursor mix. Numerous compounds, including vanadium monoxide (VO), vanadium sesquioxide (V_2O_3), vanadium dioxide (VO_2), vanadium pentoxide (V_2O_5), and others, are produced by vanadium when combined with oxygen. Among the potential Vanadium Oxide compounds, the stable stage V_2O_5 has a wide optical bandgap, good chemical and thermal stability, and exceptional thermoelectric properties, making it a likely candidate for use in a variety of sensors and photovoltaic applications.[8-11] The growth and development of both pure and Cd-doped V_2O_5 are investigated in this work employing the spray pyrolysis process on glass as the substrate. Based on ionic radius compliance, Cadmium with an ionic radius of 1.44 A° has been considered a viable equivalent for Vanadium with an ionic radius of 1.34 A°. To the greatest extent of the author's comprehension, little study on the characteristics of Cd-doped V_2O_5 generated using the spray pyrolysis process has been published to date. It has been established that the sensitivity and selectivity of a gas sensor are enhanced by an increase in surface roughness and a reduction in particle size of the produced thin films, which can be enhanced by introducing a suitable dopant. It has been observed that with the introduction of Cd as a dopant, there is an increase in surface roughness, a reduction in particle size, and an improved transmittance rate, a lower absorption rate, and an increase in the optical bandgap in the visible spectra. Thus, the incorporation of Cd dopant enhances the possibility of using these films in photovoltaic and gas sensing applications. Therefore, studies have been conducted to determine how different concentrations of impurities affect physical, morphological, and photosensitive properties.

N. Rajan, D. V. Manjunatha
Department of ECE
Alvas' Institute of Engineering and Technology
Visvesveraya Technological University
Karnataka, Belagavi 590018, India
E-mail: nijurajan@nitte.edu.in

N. Rajan
Department of ECE
NMAM Institute of Technology
Affilaited to Nitte Deemed to be University
Karnataka, Nitte 574110, India

The ORCID identification number(s) for the author(s) of this article can be found under https://doi.org/10.1002/crat.202300207

DOI: 10.1002/crat.202300207

2. Experimental Section

2.1. Thin Film Development

The spray pyrolysis process was exploited to create thin layers of pure V_2O_5 and V_2O_5 with Cd doping in various amounts in equal volumes on a glass substrate. Holmarc Spray Pyrolysis Equipment was utilized for the development of thin films. Cd was chosen as the dopant because its ionic radius was close to that of vanadium. The 0.05 M precursor solution was made by mixing 0.5849 g of Ammonium Metavanadate and 0.3753 g of Glycine