Structural and optical properties of annealed CdO thin films prepared by spray pyrolysis

O. Vigil\textsuperscript{a,1}, F. Cruz\textsuperscript{a}, A. Morales-Acevedo\textsuperscript{b,*}, G. Contreras-Puente\textsuperscript{a}, L. Vaillant\textsuperscript{c}, G. Santana\textsuperscript{b,2}

\textsuperscript{a} Escuela Superior de Física y Matemáticas — Instituto Politécnico Nacional (IPN), Edif. 9, U.P. ALM, Lindavista, Mexico, D.F., C.P. 07738, Mexico
\textsuperscript{b} Sección de Electrónica del Estado Sólido, Departamento de Ingeniería Eléctrica, CINVESTAV-IPN, 07360 Mexico, D.F., Mexico
\textsuperscript{c} Facultad de Física — IMRE, Universidad de La Habana, 43100 Havana, Cuba

Received 21 February 2000; accepted 19 June 2000

Abstract

CdO films were prepared on glass substrates by the spray pyrolysis technique. Results on structural, optical and electrical properties of the layers as a function of the thermal annealing are reported. XRD data indicates that samples show microstructural perfection improvement as a function of annealing time. The optical band-gap shows a dependence with the inverse of the squared crystallite size, suggesting that electron confinement is an important effect. The lattice parameter and band-gap energy of the samples annealed at 450°C for 120 min correspond to the reported values of bulk CdO crystals. In addition, the electrical resistivity measurement shows a slight decrease when annealing time is increased up to 40 min but it saturates for larger times. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Optical properties; CdO thin films; Spray pyrolysis; XRD analysis

1. Introduction

The use of transparent conducting oxides (TCO) in optoelectronic and photovoltaic devices has stimulated research on this field in recent years. In particular, cadmium oxide is a promising material for solar cell application [1–3], but also for photodiodes [4] and gas sensors [5]. A variety of techniques have been reported to make CdO thin films [1,6–8], but published work on the preparation and characterization of CdO thin films grown by spray pyrolysis is still very limited. For example, recently we have reported some results on the structural, electrical and optical properties of CdO:F thin films deposited by spray pyrolysis, as a function of the concentration of [NH\textsubscript{4}F] in the initial solution and the substrate temperature [9]. In this work we report the variation of the structural properties and the optical band-gap of CdO thin films obtained by spray pyrolysis, as a function of the annealing time in an air ambient.

1.1. Corresponding author.

E-mail address: amorales@gasparin.solar.cinvestav.mx (A. Morales-Acevedo).

1 Permanent address: Facultad de Física-IMRE, Universidad de La Habana, 43100 La Habana, Cuba.

2 Permanent address: Facultad de Física-IMRE, Universidad de La Habana, 43100 La Habana, Cuba.

2. Experimental

CdO thin films approximately 300 nm thick were prepared by spray pyrolysis. The experimental set-up used is similar to that described in Ref. [10]. CdO was obtained from a solution containing cadmium acetate (0.1 M) dissolved in a mixture of methanol and deionized water (1:1), and sprayed onto soda-lime glass substrates at 250°C. The solution and carrier gas flows were kept constant at 5 ml min\textsuperscript{−1} and 6 l min\textsuperscript{−1}, respectively. The nozzle-to-substrate distance was approximately 25 cm, and the spraying time was around 20 min. Post-deposition thermal treatments of the samples were performed in an air atmosphere at a fixed temperature of 450°C for periods in the 15–120 min range. For these thermal treatments we proceeded as follows: the samples were divided into two parts, each with the same size. One of them was annealed during 15 min (called first annealing); a second annealing in the same sample was made during 30 min (called second annealing). For the second part, a third and fourth annealing were made during 60 and 120 min, respectively. After each annealing the structural, optical and electrical properties were measured.

The layer thickness was measured before and after the annealing by using a step profiler (Sloan Dektak II). No change of the sample thickness was observed within the resolution of the equipment. Optical transmission data were obtained...