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Master's thesis

Elaboration And Characterization Of Semiconductor Thin Films Based On Zinc Oxide (ZnO)

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GENERAL INTRODUCTION

The most common light source encountered is, of course, sunlight. Solar energy is one of the most promising sources to meet global energy needs. Solar energy has the advantage of being clean and renewable. Its development and use could reduce the use of conventional fossil fuels (oil, natural gas, coal) [1]. Energy production is a major challenge for the coming years as the energy needs of industrialized countries continue to increase. Developing countries will also need more and more energy to carry out their development.

Algeria is classified as one of the countries with the most solar energy, but it is also a country whose energy base consists mainly of hydrocarbons. Unfortunately, renewable energy accounts for only a small percentage of the national energy balance [2]. Algeria is committed to the path of renewable energies in order to provide global and sustainable solutions to the environmental challenges and problems of preserving fossil-based energy resources through the launch of an ambitious program for the development of renewable energies. Because of its geographical location, Algeria has one of the largest solar fields in the world. The duration of insolation over almost the entire national territory exceeds 2000 hours annually and reaches 3900 hours (high plateaus and Sahara) [3].

The exploitation of solar energy by means of collectors comes under two distinct technologies: one product of calories is solar thermal energy, and the other produces electricity by the photovoltaic effect [4]. Traditional solar cells convert light into electricity by exploiting the photovoltaic effect that appears at the junction of semiconductors. It consists of using photons to release electrons and create a potential difference between the cell terminals that generates a direct electric current. These are devices similar to transistors or integrated circuits. The semiconductor simultaneously performs the functions of light absorption and separation of the resulting electrical loads. For these two processes to be efficient, the cells must be made of high-purity materials [5, 6].

Transparent and conductive oxides (TCO) are remarkable materials in many fields. Their dual property of electrical conductivity and transparency in the visible range makes them ideal candidates for applications in photovoltaics and optoelectronics [7]. Zinc oxide (ZnO) is a semiconductor material belonging to this family of TCO. It has interesting electronic, electrical, and optical properties for optoelectronic applications, especially in the photovoltaic field. The forbidden band is of a direct nature, and the value of its width varies from 3.3 eV to 3.4 eV, with an excitonic binding energy of 60 meV [8].

In this context, we have chosen zinc oxide as the base material. Indeed, it is a relatively easy material to deposit and is among the most interesting materials in terms of properties compared to others [9, 10]. The purpose of our work is as follows:

- Development of thin films of zinc oxide deposited by the sol-gel (dip-coating) technique on glass substrates.
- Optimization of the quality of ZnO thin films by studying the influence of operating conditions on the physical properties of the layers (molarity).
- Improving the quality of these layers by studying the influence of dopants on structural, optical, and electrical properties to obtain transparent and conductive layers.

To study these parameters, different characterizations were performed. The physical properties of these films were studied according to experimental conditions. To do this, we characterized our films by X-ray diffraction (XRD) to deduce the evolution of their microstructure, along with morphological characterizations such as scanning electron microscopy (SEM) and atomic force microscopy (AFM). The optical properties were studied using UV-Visible transmission (UV).

The thesis is structured with an introduction, three chapters, and a general conclusion.

- The first chapter contains general information on thin films and their various applications. It also provides an overview of zinc oxide and its properties (structural, optical, and electrical), ZnO in thin films, as well as its nucleation and growth mechanisms.
- The second chapter is devoted to the method used for the production of thin films. It describes the sol-gel (dip-coating) method used for the production of our samples and provides a reminder of the various characterization techniques used, including X-ray diffraction (XRD), scanning electron microscopy (SEM), atomic force microscopy (AFM), and UV-Vis-IR spectrophotometry.
- The last chapter includes the preparation of the solutions, procedures, and methods for the elaboration of the different films. It also presents the results of the study on the different characterization techniques used during our research.

The thesis concludes with a general conclusion summarizing the main results obtained.

Abstract

In this work we developed thin layers of ZnO by the Sol-Gel method (Dip-Coating) achieved during this study. The structural characterization of the thin films was performed by X-ray diffraction (XRD), Morphological characterization was performed by scanning electronic microscopy (SEM) and atomic Force Microscope (AFM). Optical characterization was performed by visible UV radiation. XRD made it possible to confirm the crystal state of our thin films as well as the composition of the ZnO. Show both characterization by SEM and AFM detailed filming surface condition. Finally, UV-Vis-NIR spectrophotometry allowed us to measure the transmission of thin films based on ZnO.

Keys Words: ZnO, Sol-Gel, thin film, Dip-Coating.

Résumé

Dans ce travail, nous avons développé des couches minces de ZnO par la méthode Sol-Gel (Dip-Coating) réalisée au cours de cette étude. La caractérisation structurale des couches minces a été effectuée par diffraction des rayons X (XRD), la caractérisation morphologique a été effectuée par microscopie électronique à balayage (MEB) et microscope à force atomique (AFM). La caractérisation optique a été effectuée par rayonnement UV visible. XRD a permis de confirmer l’état cristallin de nos couches minces ainsi que la composition du ZnO. Montrer la caractérisation par SEM et AFM l’état détaillé de la surface de reprographie. Enfin, la spectrophotométrie UV-Vis-NIR nous a permis de mesurer la transmission de films minces à partir de ZnO.

Mots clés : ZnO, Sol-Gel, couche mince, Dip-Coating.

ملخص

في هذا العمل، طورنا طبقات ZnO رقيقة باستخدام طريقة Sol-Gel (طلاء غمس) التي تم تطويرها خلال هذه الدراسة. تم إجراء التوصيف الهيكلي للطبقات الرقيقة عن طريق حيود الأشعة السينية (XRD)، وتم إجراء التوصيف المورفولوجي عن طريق مسح المجهر الإلكتروني (SEM) ومجهر القوة الذرية (AFM). تم إجراء التوصيف البصري عن طريق الأشعة فوق البنفسجية المرئية. أكدت XRD الحالة البلورية لطبقاتنا الرقيقة وتكوين ZnO. أظهر توصيف SEM و AFM الحالة التفصيلية لسطح الفيلم. أخيرًا، سمح لنا قياس الطيف الطيفي UV-Vis-NIR بقياس انتقال الأغشية الرقيقة من ZnO.

الكلمات المفتاحية: ZnO ، Sol-Gel، طبقة رقيقة، طلاء غمس.