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Original Research

Synthesis and characterization of cerium sulfide thin film

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Abstract

Cerium sulfide (CexSy) polycrystalline thin film is coated with chemical bath deposition on substrates (commercial glass). Transmittance, absorption, optical band gap and refractive index are examined by using UV/VIS. Spectrum. The hexagonal form is observed in the structural properties in XRD. The structural and optical properties of cerium sulfide thin films are analyzed at different pH. SEM and EDX analyses are made for surface analysis and elemental ratio in films. It is observed that some properties of films changed with different pH values. In this study, the focus is on the observed changes in the properties of films. The pH values were scanned at 6–10. The optical band gap changed with pH between 3.40 to 3.60 eV. In addition, the film thickness changed with pH at 411 nm to 880 nm.

Keywords: Cerium sulfide thin films; Chemical bath deposition; Thin film

1. Introduction

Cerium is the most abundant member of the element series known as lanthanides. Cerium made its first contribution to chemical technology in the 1890s. Since then cerium compounds, especially cerium oxides, has been used to produce technological equipment of automobiles, televisions, and other technological devices [1]. Cerium sulfide is an interesting material having specific properties. The sulfides of cerium which are rare earth elements are known as good heavy metal color pigments. Cerium sulfide can give different colors such as orange, red and burgundy [2,3]. Some cerium sulfides are known [3–6] as cerium(III) sulfide Ce_2S_3, cerium mono sulfide CeS and triceriumtetrasulfide Ce_3S_4. Cerium sulfides absorb the light in the ultraviolet area.

Especially cerium mono sulfide is more interesting than others. The color of CeS is metallic bronze; it adopts NaCl structure with ions Ce^{+3}, S^{-2}, and one electron in conduction band [4–6]. Cerium mono sulfide also has higher electrical conductivity, higher thermal conductivity, higher (c.a. 2715 K) melting point, and good thermal shock resistance when compared to the other cerium sulfides. Cerium salts can be transformed to cerium(III) oxysulfide (Ce_2O_2S) known as cerium oxide, which is also a better melting stable compound. Cerium(III) oxysulfideis a well-known material because of the afore mentioned thermodynamic properties [5,6].

Cerium(III) sulfide also exists in the forms as α-Ce_2S_3, β-Ce_2S_3 and γ-Ce_2S_3 with different structures [7,8]. The structure and colors of these sulfides are in black/brown or orange color in the structure of orthorhombic, burgundy color in the structure of tetragonal and dark red color in the structure of cubic, respectively. According to literatures, α-Ce_2S_3, β-Ce_2S_3 and γ-Ce_2S_3 occur at high temperatures lower than 900 °C, higher than 900 °C and higher than 1200 °C, respectively. Cerium mono sulfides also have different properties such as thermal and electrical properties. Cerium oxides, as a result of their properties, are used in various technologies [3,7–9].

In the relevant literature it is seen that cerium sulfide thin films have not been produced with chemical bath deposition for the solar cell substrates, sensor or detector until today. Therefore, there haven't been any records concerning the effects of pH of the bath on the cerium sulfide film structure and optical properties. In this paper, cerium sulfide thin films

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were produced with chemical bath deposition in higher pH values. In the experiment cerium sulfide thin films with different properties were produced and their structural and optical properties were investigated. The crystal structure and optical properties of cerium sulfide were controlled with pH of chemical bath.

2. Experimental

The components of bath were concentrate ammonia solution, 0.1 M $(NH_4)_2Ce(NO_3)_6$ and 0.2 M thioacedamide. First, 10 ml 0.1 M $(NH_4)_2Ce(NO_3)_6$ and 10 ml 0.2 M thioacedamide were put in baker and 20 ml deionized water was added to the

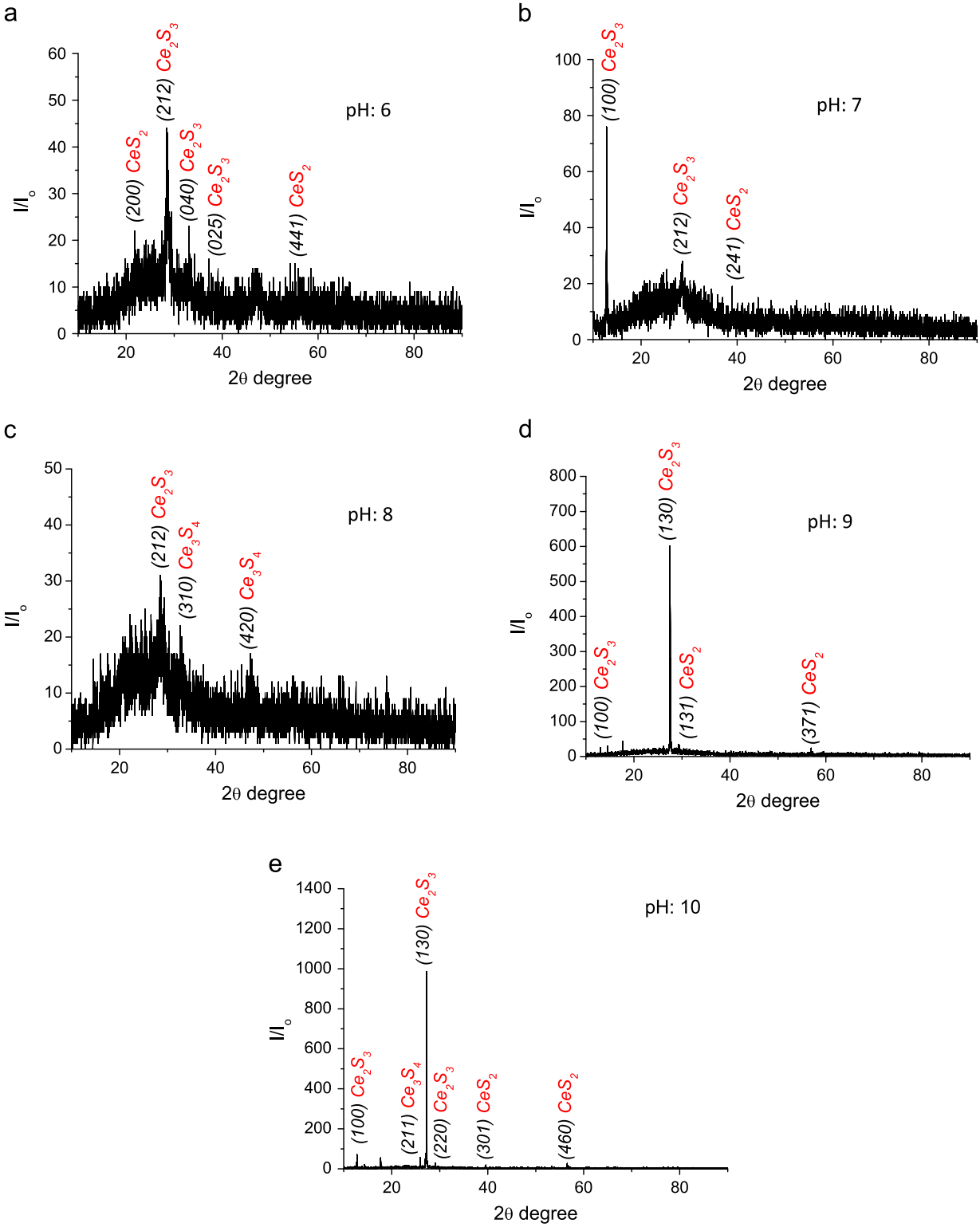

Fig. 1. XRD spectrum of cerium Sulfide thin films depending on different pH, (a) pH: 6, (b) pH: 7, (c) pH: 8, (d) pH: 9, (e) pH: 10.