

Identification of a new function model for the AC-impedance of thermally evaporated undoped selenium films using the Eigen-coordinates method

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Abstract

The experimental AC-impedance data of undoped amorphous and polycrystalline selenium films were taken at $T = 300\text{K}$ in the frequency range 100 Hz–10 kHz in the dark and under band-gap illumination. The data were analyzed using the Eigen-coordinates method in conjunction with a ‘separation’ procedure without prior use of equivalent circuits. A unified circuit model with generalized impedances was recognized to parameterize well the observed AC-impedance behavior. The features of this electrical model were linked to the fractality of the heterogeneous structural regions in these selenium specimens via one or two *recap* elements, each represented by a complex impedance of fractional power-law frequency behavior. These *recap* elements reflect the electric properties of scale-invariant circuits of self-affine normal (ideal) resistor–capacitor (RC) cells of the Cauer/Forster type. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Due to the potential use of selenium films in many technological applications and in the fabrication of solid-state devices, many studies have been conducted to understand their structural, optical, and electrical properties as a function of alloying, doping, heat treatment, and illumination [1–15]. It is well known that heat treatment can produce some pronounced changes in the properties of thin films, and sometimes this treatment is required for the improvement of these properties. Selenium films that are deposited at substrate temperatures below the glass-transition temperature of selenium ($T_g \sim 55\text{--}60^\circ\text{C}$) are amorphous and

possess a polycrystalline structure when they were then properly annealed at temperatures above T_g [6–10]. A dramatic change in the conduction mechanisms in undoped amorphous selenium films and a large decrease in their DC resistivity should accompany this structural phase transition. This change was found to be more pronounced on illuminating such films with visible light [7–12]. Although a number of studies were conducted on the DC/AC properties of amorphous/polycrystalline selenium films under dark and light environments [1,2,6–15], the issue is still a subject of controversy. In a recent attempt to contribute to a better understanding of the electrical phenomena in selenium films, we have investigated the effect of annealing and visible-light illumination on the DC conduction in these films as a function of temperature down to 100 K [10]. However, the effect of heat treatment/illumination on the AC behavior of selenium films needs further investigation.

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