Physics Department

Preparation, Characterization and Study Some Physical Properties of ($Ge_4Sb_4Te_X$) Thin Films

Thesis

Submitted to Women's College, Ain Shams University
for PhD Degree of science in Physics (Solid State Physics).

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Abstract

The advantages of chalcogenide phase change materials include the high data storage density, high operational speed, excellent scalability to nanoscale cell size and lower consumption as phase random access memory (PRAM) cell.

The compound with chemical composition of $Ge_4Sb_4Te_X$ (where X=6, 8, and 10 at. %) was prepared from high purity constituent of element by melt quench technique. The vacuum thermal evaporation technique is used to deposit thin films of these materials onto glass substrate. The structures of thin films for three compositions are investigated by x-ray diffraction patterns for as deposited and annealed films from 200^{o}C to 350^{o}C. As deposited films for three compositions are amorphous phase, after the annealing which indicates the existence of two crystalline phases face centered cubic (FCC) and hexagonal (hex) phase.

The optical (UV-visible) transmission and reflection spectra for as deposited and annealed films were measured in the range (500-2500 nm). The optical transmission and reflectance were measured to calculate the direct and indirect energy gap. The direct and indirect energy gaps were affected by the concentration of tellurium and the annealing temperature of GST system.

High resolution transmission electron microscope (HRTEM) confirms the crystallization through electron diffraction pattern. The electron diffraction patterns confirm the existence of the crystalline phases of GST. The lattice pattern indicates the shape of crystals and the lattice plane of the phase formed due to annealing from 200^{o}C to 350^{o}C.

The electrical resistivity and conductivity is measured in temperature range from room temperature to 250^{o}C for as deposited and annealed films. The temperature dependence of sheet resistance of GST show drop at 150^{o}C due to

the formation of first phase. Further increase to 200^{o}C show another drop due to the other crystalline phase (hexagonal one). After that calculate the activation energy for as deposited and annealed films from Arrhenius relation, we found that the activation energy decrease with increasing annealed films.

The morphology of as deposited and annealed films was studied by field emission scanning electron microscope (FESEM). The surface morphogical features for as deposited show amorphous phase, while the morphogical surface for annealed films indicated that two crystalline phases, the transformation from face centered cubic (FCC) to hexagonal (hex) phase.

The results obtained through the thesis indicated that (Ge-Sb-Te) is a very good for application in the field of optical memory devices.

Chapter (I)

Introduction

1. General Introduction:

Phase change materials are frequently semimetallic alloys or semiconducting containing periodic table elements of VI group, eliminating oxygen (i.e., S, Se, and Te). During last decade (1968) electronic switching phenomena was first observed in amorphous chalcogenide and becomes voluble for electronic storage applications. Subsequent research of GeTe fast crystallization dynamics stimulate the discovery of ternary alloys (Ge–Sb–Te GST) and stoichiometric compounds along the GeTe–Sb2Te3 pseudo-binary ensemble the fast nucleation driven crystallization**[1,2]**.

The active material characterized by a critical arouse device performance, therefore additional options were actively investigated in order to improve retention cycling endurance, increase speed and lowering power consumption. A device performance perchance was tuned by changing the alloy stoichiometric composition via proper doping or stops non-chalcogenide phase change compositions. Ge2Sb2Te5 (GST) is still considered as a stander dereferences material for phase change electronic storage **[3-5]**.

GST has a metastable rock-salt structure in their crystalline phase, considering that Te atomic planes were intersect with Ge/Sb planes through 20 % vacancies. These vacancies are crucial for preservation for energy stability of the octahedral structure and leads to p-type conduction "by removing electrons from the valence band". Amorphous phase can be obtained from crystalline phase by heat-induced melting combined with fast quenching which result of loss in the long-range ordering and development of a covalently bonded