Chapter 1 introduction

1.1 Introduction to phase-change storage media

Until now, in the field of the multimedia applications, phase-change optical storage media have been developed for several years. Because the requirements for data storage density are quickly increasing, the main developing purposes are expected to greatly increase the storage density and stability of reversible cycles. The optical storage density is restricted by the diffraction limit of the laser beam. However, with the development of blue diode laser, the storage density can be greatly increased. In other words, the recorded signal spot size can be decreased by using short-wavelength laser.

Basic concepts of the mechanisms for the phase-change applications are the obviously different optical and electrical properties such as reflectivity and resistivity between amorphous and crystalline state. The phase-change alloys are asked for low melting point, small grain size, high crystallizing rate, high carrier to noise ratio, easily amorphizing, stable reversibility in phase transformation, et al.

The obvious different optical or electrical properties could be utilized as storage media application of digital signals. This application involves the formation of amorphous marks with a focused laser beam, these marks symbolizing recordable digital data. For the intention to erase a bit, amorphous region should be heated above the glass transition temperature for enough time to facilitate the happening of recrystallization. To write a bit, the crystalline regions should be heated and quenched into amorphous state. [Frendrich 01-239].

The stoichiometric composition, $Ge_2Sb_2Te_5$ is the phase-change material which was used in the experiment. It was extensively used as optical storage applications such as rewritable digital versatile disks (DVD). $Ge_2Sb_2Te_5$ belongs to one intermediate compound of the GeTe-Sb_2Te_3 psedobinary system, and it has many recording advantages as follows: it performs perfect reversibility between amorphous and crystalline phases ($>10^6$ cycles) as well as ultrahigh optical contrast. It also has attractive features of fast crystalline rate and good thermal stability at room temperature (could be preserved more than 30 years [Yamada 91-2849]). Therefore, it is a suitable phase-change material for optical storage media.

1.2 Introduction to carbon nanotubes (CNTs)

Carbon is a very interesting element on the earth. Some carbonaceous structures such as diamond, amorphous carbon film, and fullerene (C_{60}), Carbon nanotubes (CNTs), and et al. have been discovered. Since CNTs were first discovered by Dr. Ijima [Iijima 91-56], many research groups all over the world are attracted to investigate and study its growth mechanisms, structures, morphologies, and corresponding applications. The experimental results show that CNTs are fullerene-related structure and just like the shape of the elongated fullerene. Depends on the number of graphite layers, they are generally considered single-walled carbon nanotubes (SWNT) and multi-walled carbon nanotubes (MWNT).

The synthesizing methods of CNTs can be mainly divided into two groups, catalyst methods and non-catalyst methods. For the catalyst-assisted CNTs, the transition metals such as Fe, Co and Ni are the most popular catalysts for CNTs synthesizing, and the recent fabricating methods of catalyst-assisted CNTs contain arc-discharge, laser ablation, vapor-condensation method, pyrolitic method, chemical vapor deposition (CVD), et al. On the other hand, the non-catalyst methods such as arc-discharge, pyrolitic method, plasma torch-decomposition method are adopted to fabricate CNTs.

A lot of applications of CNTs have been proposed depend on their unique properties, e.g. electron field emitter, composite material, hydrogen storage, atomic force microscopy (AFM) tips, single electron transistor and biosensor, et al. It has been reported that the abilities of field emission performance and hydrogen storage can be enhanced by opening the CNTs tips. Some methods with respect to open-ended CNTs and their mechanisms will be discussed in later paragraphs.

1.3 Motivation

So far the phase-change alloys have been commercially used for optical storage applications in rewritable digital versatile disks (DVD). Users require high data storage density. However, its storage capacity is so limited (< 35 Gbyte/in^2). In order to increase the storage capacity, the alloy-ended carbon nanostructures were successfully developed to fabricate the nano-resolution phase-change type storage media by coating proper constituents of phase-change alloys on tips of open-ended CNTs. The cyclotron resonance chemical vapor deposition (ECR-CVD) system was adopted to fabricate carbon nanotubes, and the open-ended CNTs could be obtained via post-treatment. Some apparatus such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), Raman, field emission measurement and auger electron spectroscopy (AES) were used to examine the experimental results.