CHAPTER I

INTRODUCTION

1.1 Motivation

The innovative development at present has been used to improve and change properties of materials which are suitable to any desired applications. The effects of the inclusion of different transition metals on the structural, optical, electrical and magnetic properties of perovskite (ABO_3) thin films have been investigated. Various types of dopants and cations of different sizes can be accommodated in the ABO_3 sites [1, 2, 3, 4, 5, 6]. Barium titanate ($BaTiO_3$) is a well known perovskite material due to its high dielectric constant and its electric field tuning property. In addition, doping Fe ions into the $BaTiO_3$ lattice leads to the acquisition of both ferromagnetic and ferroelectric properties [7]. The ferromagnetism of Fe-doped $BaTiO_3$ ceramics was reported to be dependent upon the annealing atmosphere and Fe doping concentration, with the substitution by Fe^{3+} occurring in Ti sites being confirmed by Mössbauer measurements [8, 9]. Herner et al. showed that doping barium strontium titanate ($BaSrTiO_3$) with Fe could reduce the loss tangent [10], by means of improving the dielectric properties compared to pure $BaSrTiO_3$. Another way to change the fundamental properties of these materials is by exposure to high energy electromagnetic radiation or high energy particles, such as X-rays, gamma rays, electron or neutron bombardment. The retained polarization, dielectric constant and coercive field of lead titanate films decreased upon increasing gamma irradiation doses, but the material was less sensitive to neutron irradiation [11]. From the literature review, fundamental properties of various materials could be changed by gamma ray irradiation. Arshak et al. observed that the energy gap of a bismuth germanate film decreased from 1.95 eV to 1.76 eV after exposure to gamma irradiation with a 0.228 mGy [12]. Arshak et al. also reported that the capacitance for ZnO thick film exhibited from 21.58 pF at a dose of 1 mGy to 28.33 pF at 2.3 mGy dose and thick films of SnO_2 also showed an increase in the capacitance from 5.05 pF before irradiation to 8.69 pF at a dose 0.46 mGy [13]. Ta et al. have found that the capacitance-voltage (C-V) of Al/Y_2O_3/n-Si/Al capacitors before and after irradiation with cumulative dose of 2.4, 4.8, and 8.4 kGy moved towards the positive voltage when the irradiation dose increases [14]. Fasasi et al. have reported the use of high dose gamma irradiation to study the thermoluminescence glow curve characteristic of $BaTiO_3$ ceramics and the dose dependence on the glow curve [15]. These radiation imparted changes in $BaTiO_3$ are extremely useful for the effective design of modern radiation dosimeters for their low-cost and simplicity.

Many dosimeters such as thermoluminescent dosimeters (TLDs), optically-stimulated- luminescence (OSL) dosimeters and polymethylmethacrylate (PMMA) sheets are normally used for radiation safety [16]. The TLD material, which is commonly used to make badges, absorbs and stores energy when exposed to radiation and after heating the TLD releases the light. PMMA sheets could be used to stick with the products which are exposed to radiation. The change in the optical properties of PMMA is the indirect way of measuring the level and duration of radiation exposure. However, PMMA has a low melting temperature at 160 °C and most of the time can be used only once due to the case of scratching. Nowadays researchers have investigated the potential of several metal oxides including both single- (e.g., ZnO, SnO_2,WO_3,TiO_2 and Fe_2O_3) and multi-component oxides ($BiFeO_3$, $MgAl_2O_4$, $SrTiO_3$ and $Sr_{1-y}Ca_yFeO_{3-x}$) to be usable as dosimeters. Also, it is important to be able to enhance the performance of dosimeters through the material processing.

1.2 Objective

The objective of this thesis is to study the effects of gamma ray irradiation on fundamental properties of four perovskite materials. These thin films were deposited by a sol-gel spin coating technique on quartz substrates and Al_2O_3 in order to investigate the optical and electrical, respectively. The first of choices in this study are $BaTiO_3$ and Fe-doped $BaTiO_3$ thin films. We focus mostly on the optical properties (%transmission, optical energy gap and complex refractive index) of these two materials before and after gamma ray irradiation with difference doses. The further investigation is on the effects of gamma ray irradiation on the optical properties of a new discovered material, Fe-doped calcium copper titanate thin film. Finally, the calcium copper titanate thin films deposited on $Al2O_3$ substrate was fabricated as coplanar capacitor. The electrical properties of calcium copper titanate thin films was measured in the form of capacitance before and after gamma ray irradiation. X-ray diffraction and atomic force microscope techniques were used to study crystal structure and surface morphology of the films. The composition of elements in the films was calculated by wavelength dispersive X-ray data. This thesis work is basically for further development of dosimeter based on changing optical and electrical properties of the films after exposure with different doses of gamma ray.

1.3 Thesis outline

This thesis is divided into six chapters. In Chapter I, we introduce the motivation, the objective, barium titanate, Fe-doped barium titanate, calcium copper titanate and Fe-doped calcium copper titanate. The theory of a sol-gel process, gamma ray, interactions between gamma ray and barium titanate, Fe-doped barium titanate, calcium copper titanate and Fe-doped calcium copper titanate films and determination of film thickness from transmission data will be presented in Chapter II. Fundamental of X-ray diffraction, wavelength dispersive

X-ray, energy dispersive X-ray spectroscopy, atomic force microscope and optical transmission will be explained in Chapter III. Chapter IV focuses on the films preparation, gamma ray irradiation experiment and UV-VIS-NIR spectroscopy set up. Chapter V presents the results of the experiments (X-ray diffraction, atomic force microscope, optical properties, electric properties). The final chapter, Chapter VI, is the conclusion of the thesis.