CHAPTER 1

INTRODUCTION

1.1 Overview

Glass-ceramics are polycrystalline materials produced by the controlled crystallization of glass which are characterized by fine-grained, randomly oriented crystals with some residual glass, no voids or porosity between crystals and generally high strength [1, 2]. These properties allow glass-ceramics to have mechanical properties better than a typical glass and bulk ceramic. This means glass-ceramic materials share many properties with both glasses and more traditional crystalline ceramics. These materials are formed as a glass and then made to crystallize partly by heat treatment. In the past decade, a number of materials scientists [3] have focused their attention on the improvement of optical and electrical properties of glass by surface crystallization of ferroelectric crystals, such as lithium niobate ($LiNbO_3$), sodium niobate ($NaNbO_3$), potassium niobate ($KNbO_3$), lead niobate ($PbNbO_3$), etc. [4, 5] which is generally known as ferroelectric glass-ceramics.

Ferroelectric materials are materials that exhibit, over some range of temperature, a spontaneous electric polarization that can be reversed or reoriented by an applied electric field, being a sufficient criterion for a ferroelectric phase [6]. Hence these ferroelectric materials are widely used in many applications of optoelectronic devices and communication devices such as modulators, the Q-switch, waveguide lasers, interconnects, optical filters and capacitors, etc. [7-9]. Most of the ferroelectric materials used for these applications, however are in the form of single

crystals. The production process is a slow, very difficult, complicated technique which gives rise to the very high cost of these devices [10]. Recently, transparent ferroelectric polycrystalline materials have been successfully produced if the growth crystals, having nano-size compositions in glass-ceramics [1, 3] are controlled by suitable processing parameters and chosen proper based glasses.

In this work, a simplify method has been developed for the preparation of glass-ceramics containing ferroelectric nano-crystals by the incorporation method. The effect of key processing parameters on the phase formation, microstructure, crystal sizes, physical properties, optical and electrical properties will be quantitatively evaluated and compared.

1.2 Research objectives

1.2.1 To study suitable chemical compositions and conditions for preparing ferroelectric materials, transparent glasses and glass-ceramics containing ferroelectric nano-crystals by incorporation method

1.2.2 To control and improve crystal size by heat treatment method

1.2.3 To investigate and characterize the properties of glasses and glass-ceramics containing ferroelectric nano-crystals with pre- and post- heat treatment

1.2.4 To study the effect of crystal size and basic chemical composition on various properties, i.e. physical properties, optical and electrical properties of glasses and glass-ceramics containing ferroelectric nano-crystals

1.3 Usefulness of the research (Theoretical and/or applied)

The main educational advantages of this work are:

1.3.1 To establish some basic criteria for the preparation method of glass-ceramics containing ferroelectric nano-crystals

1.3.2 To gain an understanding of crystal size and basic chemical composition effects on various properties of glass-ceramics containing ferroelectric nano-crystals

1.3.3 To find out the possibility of glass-ceramics containing ferroelectric nano-crystals for optical and electrical applications

1.4 Research plan, methodology and scope

1.4.1 Literature survey

1.4.2 Glass-ceramics containing ferroelectric nano-crystals will be prepared by incorporation method.

1.4.3 Crystallization on glass will be controlled and improved by heat treatment method.

1.4.4 Physical properties, phase transformation, crystal size, microstructure, optical and electrical properties of glass-ceramics containing ferroelectric nano-crystals will be investigated.

1.4.5 Effect of crystal size and basic chemical composition on glass-ceramics containing ferroelectric nano-crystals will be studied.

1.4.6 Discussion and conclusions