Chapter 1

Introduction

At present, electronic devices are widely used in diverse technological applications. These instruments are composed of many components, including metals, ceramics, polymers, and composite materials. For ceramics, there are various kinds which are employed in these electronic devices, such as a ferroelectric ceramic as it has excellent electrical properties. The ceramic materials are well-known in this area, for example, barium titanate ($BaTiO_3$), lead zirconate titanate (PZT), lead lanthanum zirconate titanate (PLZT), lead magnesium niobate (PMN), and etc. Properties of these materials have been modified by doping with additives, for example, Nb^{5+} is doped into PZT (Nb^{5+} replacing Zr^{4+}) in order to increase remanent polarization, dielectric constant, and mechanical compliance. However, dielectric loss also increases at the same time. The ferroelectric ceramics are also used in infrared detectors, high dielectric constant capacitors, photostrictors, ferroelectric memories, relaxor ferroelectrics, and so on.

Ferroelectric materials can also be used in various forms, such as bulk, thick films, and thin films. These forms are fabricated by different techniques, which depend on applications and cost. Of all these forms, thick films decrease a gap between thin films and bulk because of their moderate range of thickness. The thick films generally are between 1 and 100 microns. They are fabricated by a tape casting, spin coating, or screen printing. Tape casting technique can easily gets films with high thickness comparing to other techniques. However, this technique has the risk of delamination problems between ceramic and electrode layers during sintering. On the other hand, a spin coating method is somewhat difficult to get thick films because the films contained high organic volume ane trend to crack after drying and firing. A screen printing technique is suitable for thick film fabrication because of its precise, efficient technique, versatile, reproducible and low cost. In order to get good thick films by this technique, we shall consider many conditions, such as the particle size and particle size distribution of the starting materials, composition and viscosity of paste, screen type, snap-off distance, attack angle, and also firing conditions.

In this research, we studied Pb-based ferroelectric thick films by screen printing technique. There were 3 types of Pb-based ferroelectric ceramic materials that were chosen to be be the starting powders in this work. The organic vehicle was composed of terpineol as an organic solvent and ethyl cellulose as a binder. In addition, frit was used in the paste compositions as a sintering aid and phosphate ester as a dispersant. After batching, the ferroelectric paste was screen-printed onto commercial stainless steel substrates, then drying, firing, and characterizations were done respectively.

The objectives of this study are as follows:

1) To investigate the effect of paste compositions on electrical properties,
2) To optimize the firing conditions, i.e. temperature and time for Pb-based ferroelectric films on stainless steel substrates,
3) To characterize thick film properties, such as phase and crystal structures, microstructure, and electrical properties. The target values for dielectric constant shall be higher than previous works (~110) and dissipation factor less than previous study (~0.25).

Since there are few studies regarding ferroelecric thick films on typical substrates, such as stainless steels. Therefore, the significance of this study is to be able to fabricate thick films with good properties onto low-cost substrates, such as stainless steels at low sintering temperature and in short time. The ferroelectric thick films on stainless steel substrates can make very useful commercial devices, such as the acoustic instruments, loudspeaker, and piezoelectric bimorph if we are able to fabricate the thick films with good ferroelectricity and co-sintering with metal substrates, i.e. stainless steels as low as 700-800°C. While, the regular sintering temperature of these ferroelectric materials is at about 1350°C so it limits the substrates to be used with only ceramic materials. Therefore, it will be very useful if we can demonstrate the low-sintering thick films on metal substrates as they will make many potential devices and applications.