PREFACE

The discovery of superconductivity in ceramic oxides has generated an enormous amount of research activities in materials with perovskite type crystal structure. It was realized that the immediate applications of the high temperature ceramic superconductors are in the form of thick and thin films. Thick films of high temperature superconductors have wide applications in microwave integrated circuits, transmission lines, and other high frequency electronic devices. Among the different copper oxide superconductors discovered, \( \text{YBa}_2\text{Cu}_3\text{O}_7 \) (YBCO) and \( \text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{x} \) [Bi (2223)] and \( \text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_x \) [Bi (2212)] (BSCCO) superconductors have gained considerable attention and a great deal of effort has been made for the production of high quality superconducting films of these compounds for suitable electronic applications. In the growth of superconducting thin films with high critical current density, the choice of a substrate is a key factor. The chemical non-reactivity between the substrate and the superconductor at the processing temperature is the most crucial factor for obtaining a superconducting film. The high chemical reactivity of these high \( T_c \) superconductors (HTS) at the processing temperature with most of the known substrate materials imposes severe restrictions on the material available as substrate for HTS films. Therefore the search for new substrate materials which satisfy the substrate requirement is undertaken on a global level.

A study on the development and characterization of a new group of complex perovskite ceramic oxides with general formula \( \text{Ba}_2\text{REZrO}_{5.5} \) for their use as substrates for high \( T_c \) superconductors and the preparation and characterization of superconducting films on the newly developed substrates are described in this thesis. These materials have an ordered cubic perovskite crystal structure and have favorable dielectric properties for substrate application at microwave frequencies. These materials do not show any phase transition up to 1350°C and are highly stable under atmospheric conditions. They melt congruently making it possible to grow them as single crystals from melt. \( \text{Ba}_2\text{REZrO}_{5.5} \) materials do not show any chemical reaction between YBCO, and Bi (2212) superconductors at extreme
processing conditions. Two materials in this group are non-reacting with Bi (2223) superconductor also. The suitability of these materials as substrate for high Tc superconductors was confirmed by dip-coating superconducting thick films on Ba$_2$REZrO$_{5.5}$ substrates. The superconducting YBCO thick films developed on polycrystalline materials by dip-coating and melt texturing technique gave a T$_c$(0) of 92 K and J$_c$ of $\sim 3 \times 10^4$ A / cm$^2$ at 77 K in zero applied magnetic field. Bi (2212) and Bi (2223) films developed on Ba$_2$REZrO$_{5.5}$ gave a T$_c$ (0) of 85 K and 110 K respectively. The current density of the films are $\sim 10^3$ A / cm$^2$ at 77 K.

In the course of this work, we have developed a modified combustion process for the synthesis of Ba$_2$REZrO$_{5.5}$ materials as nanoparticles in a single step to achieve better phase purity, homogeneity and sinterability. The powders obtained through the modified combustion process were nanoparticles and no calcination at high temperature for prolonged duration was needed to obtain Ba$_2$REZrO$_{5.5}$ materials as phase pure powders. The high-resolution lattice image taken on the as-prepared samples of Ba$_2$REZrO$_{5.5}$ revealed that the intercrystalline boundary was sharp and free from impurities. The nanoparticles of Ba$_2$REZrO$_{5.5}$ synthesized through the present method could be sintered to high density (>98%) at lower temperatures as compared to their coarse grained counterparts obtained through the solid state route.