ABSTRACT

Since the discovery of high T_C oxide superconductors (1986), the potential application of these materials as in thin film form for microwave/ microelectronic devices and squid based devices, has motivated several researchers all over the world to work on high T_C superconducting thin film devices. Following this trend, in the current investigation, a humble effort is made to prepare and characterize high T_C BPSCCO thin films, thick films, and their substrate materials for microwave applications. **Chapter 1** gives a brief introduction to the relevant literature survey along with the outline of the present thesis work.

The details of sputter deposition of Bi(Pb)-Sr-Ca-Cu-O (BPSCCO) thin films, their annealing schedule, XRD studies and superconducting characterization are discussed in **chapter 2.** This includes a brief description of the deposition set-up (d.c. sputtering) and preparation of conducting target, and the cryostatic arrangement for R-T measurement. The results indicated that the sputtering pressure plays an important role in stabilizing high T_C phase (110 K). Further, the annealing schedule was optimized for d.c sputtered thin films to get zero resistance temperature [$T_C(0)$], as high as 101 K. The temperature variation of the critical current density (J_C) in these films was interpreted in the light of granular superconductivity with inherent Josephson coupling between the grains.

In **chapter 3,** surface analysis (surface composition and surface chemistry) of these films using X-ray Photo electron Spectroscopy (XPS) was discussed. The results on as deposited (electrically insulating) and annealed (superconducting) films revealed dramatic changes in both surface composition and surface chemistry. The changes in surface composition were attributed to the reduction in surface free energy due to the segregation of Bismuth from bulk to the surface. Further, the changes in binding energies of the constituent elements before and after annealing were discussed in relation with the

superconducting phase formation of the films after annealing.

Photolithographic process has been extensively used to pattern microbridges on high T_C BPSCCO thin films with different dimensions (of the order of 10 microns). A simple and low cost photolithographic set-up is developed in the laboratory to transfer the microbridge pattern (feature size 10-40μm) onto high T_C thin films. The process parameters such as spinning time, exposure time, etching time, etchant concentration and developing time were optimized to maximize the sharpness of the pattern as monitored by an optical microscope. These details along with the superconducting properties of patterned microbridges are covered in **chapter 4.**

Chapter 5 discusses the microwave response studies on these superconducting microbridges. The critical current of these microbridges decreased sharply when exposed to microwave radiation. The observed strong interaction of microwaves with high T_C granular films was exploited to realise useful microwave detectors. Microwave detection experiments on BPSCCO thin film microbridges were carried out in superconducting state at 60 K using square wave modulation/demodulation technique. The detection signal measured synchronously, showed a peak at an optimum d.c.bias current, which was found to be independent of microwave power. Further the observed linear variation of detection signal with microwave power made it attractive to realize a linear and sensitive microwave sensor at low power. The details of the microwave cryostat and the associated instrumentation for the detection studies were also explained in this chapter. The results on microwave response were discussed in the light of Josephson type weak links present inherently in these granular thin films.

A cryostatic set-up was developed to measure microwave absorption in high T_C materials based on cavity perturbation technique in reflection mode down to 60 K. These details were discussed in **chapter 6** along with the results on BPSCCO thick films. This chapter also describes the making of high T_C

BPSCCOthick films by screen printing process and optimization of their annealing schedule to maximize $T_C(0)$.

It is well established that the substrates in high T_C thin film devices play an important role, when they are applied for microwave applications. These substrates should have optimum dielectric constant (ε') and low loss ($\tan\delta$) at microwave frequencies and in the operating range of temperatures. **Chapter 7** describes the details of construction of microwave cryostat using a transmission cavity to measure ε' and $\tan\delta$ atmicrowave frequencies down to 100K temperature. Using this set-up, the in-house developed $LaAlO_3$ substrate from nano-size powders was characterized. The compatibility of these substrates for high T_C films was tested with BPSCCO thick films.

Finally a summary of the investigations reported in this thesis and the important conclusions drawn, are presented in **chapter 8**. Further, the scope for future work in this direction was also incorporated.