Dielectric Resonators (DR) are low dielectric loss ceramic pucks that can act as frequency determining components in microwave filters and oscillators used in wireless communication industry. DRs should have high dielectric constant ($\varepsilon_r$) in the range 20 to 100 for better miniaturization, high Q factor (Q>2000) for better frequency selectivity and nearly zero temperature coefficient of resonant frequency ($\tau_f$) for frequency stability with temperature. Though several temperature-stable DRs are available at present, investigation is still going on to find new materials having better dielectric resonator properties and to improve the properties of the already available materials.

This thesis entitled “INVESTIGATIONS ON LOW LOSS DIELECTRIC CERAMIC MATERIALS FOR WIRELESS COMMUNICATION” which is divided into nine chapters, is the outcome of a detailed investigation carried out on the synthesis, characterization and microwave dielectric properties of three different groups of low loss ceramics (a) ordered complex perovskites Ba(Mg$_{1/3}$Ta$_{2/3}$)O$_3$ [BMT], (b) orthorhombic ceramics RETiA$_6$ [RE=Rare Earths, A=Ta, Nb] with aeschynite and euxenite mineral structure and (c) aluminate spinels based on MA$_2$O$_4$ [M=Mg, Zn].

Chapter 1 is a general introduction about the material, scientific and technological aspects of low loss materials. The different experimental techniques used to characterize the dielectric properties of low loss materials are also discussed. The practical applications of DRs such as filters, oscillators, antennas etc. are briefly discussed.

The chapter 2 presents details of preparation of dielectric resonators by conventional solid state ceramic and other routes. A brief description of the instrumentation used for studying the structural, microstructural and dielectric characteristics of low loss materials studied in the purview of this thesis is also presented.

The chapter 3 describes the preparation, characterization and properties of stoichiometric and non-stoichiometric Ba(Mg$_{1/3}$Ta$_{2/3}$)O$_3$ [BMT] ceramics. The effect of nonstoichiometry on the densification, structural ordering and microwave dielectric properties of BMT is discussed. It is found that a slight deficiency of Mg or Ba increase the density and order parameter which in turn improved the microwave dielectric properties. However excess of Mg or Ba deteriorate the properties considerably.
The fourth chapter describes the effect of different dopants on the properties of BMT. It is found that dopants such as Sb$_2$O$_5$, MnO, ZrO$_2$, WO$_3$ and ZnO improve the microwave dielectric properties of BMT. A correlation between the microwave dielectric properties of BMT and ionic radii of the dopant has been established.

The liquid phase sintering aspects of BMT with addition of low melting glass fluxes is discussed in the fifth chapter. The effect of these glass additives on the sintering temperature, suppression additional phases, densification, cation ordering and microwave dielectric properties of BMT is discussed. It is found that glasses such as B$_2$O$_3$, ZnO-B$_2$O$_3$, 5ZnO-2B$_2$O$_3$ and ZnO-B$_2$O$_3$-SiO$_2$ improve the Q factor $\tau_f$ and reduce the sintering temperature.

The sixth chapter deals with an investigation carried out on the effects of substitution on the chemistry and physics of BMT. In this study solid solution phases such as Ba[MG$_{1/3}$Ta$_{1-x}$]$_{2/3}$W$_{1/3}$O$_3$, Ba(MG$_{1/3}$Ta$_{2/3}$)$_{1/3}$Ti$_{1/3}$O$_3$ and Ba(MG$_{1-x}$Zn$_x$)$_{1/3}$Ta$_{2/3}$O$_3$ were investigated. The effect of solid solution formation on the phase transition from 1:2 ordered to disordered structure, and on the microwave dielectric properties is also discussed in this chapter.

The tailoring of the microwave dielectric properties by making solid solution phases between positive (aeschynites) and negative (euxenites) $\tau_f$ materials in an effort to design a possible zero $\tau_f$ material is discussed in seventh chapter. This has been successfully achieved in 5 different systems such as Pr$_{1-x}$Gd$_x$TiNbO$_6$, Nd$_{1-x}$Dy$_x$TiNbO$_6$, Sm$_{1-x}$Y$_x$TiNbO$_6$, GdTiNb$_{1-x}$Ta$_x$O$_6$, and Sm$_{1-x}$Y$_x$TiTaO$_6$ dielectric ceramics. The range of solid solution formation and the effect of morphotropic phase transition from aeschynite to euxenite on the density, phase evolution and microwave dielectric properties of the solid solution phases are also discussed in this chapter.

The eighth chapter probes the dielectric loss phenomena of ZnAl$_2$O$_4$ and MgAl$_2$O$_4$ spinels. The dielectric properties of these spinels were tailored by preparing isomolar mixtures with TiO$_2$ in an effort to tune their $\tau_f$ close to zero. The dielectric, thermal and mechanical properties of two new ideal microwave substrate material in the system MAI$_2$O$_4$-TiO$_2$ [M=Zn, Mg] which are even advantageous over alumina, have been developed.

The ninth chapter gives the conclusion of the thesis and scope for future work.