CONCLUSIONS AND FUTURE SCOPE

CHAPTER 7

7.1 CONCLUSIONS

Materials synthesis, characterizations and processing of high dielectric constant ceramics for capacitor applications are challenging for realization of the passive technology. This work focuses on the study of the synthesis, characterization and dielectric properties of undoped and doped $Y_{2/3}Cu_3Ti_4O_{12}$ ceramic materials using a novel semi-wet route were characterized by TG/DTA, XRD, SEM, EDX, AFM and TEM techniques. To study the effect of dopants, the dielectric behavior of these materials was studied systematically as a function of temperature and frequency within the range 300- 500 K and $10^2 – 10^6$ Hz frequency.

- Undoped $Y_{2/3}Cu_3Ti_4O_{12}$ (YCTO) ceramic and doped ceramic with different concentration of lanthanum, zinc and iron on yttrium site, copper site and titanium site were prepared by the semi-wet route using constituent metal nitrates and solid TiO_2.
- Thermal studies (DTA/TGA) were carried out for both undoped YCTO and doped YCTO ceramic for all the compositions and found that, there is no weight loss and no DTA peak observed beyond of 950-1000 $^{\circ}$C. This shows that final product forms around 950 $^{\circ}$C. In case of iron doped YCTO ceramic, final product forms at 980 $^{\circ}$C
- All the synthesized samples were calcined at 800 $^{\circ}$C and sintered at 950 $^{\circ}$C. Crystal structure remains cubic in all the compositions in various systems.
- Average grain size in all the samples was found to be in the range of 0.5-4 µm. No distinct grain boundaries were present in these samples. The absence of grain boundary may be due to lower sintering temperature.

- Energy dispersive X-ray spectroscopy (EDX) studies confirmed the purity of different synthesized samples under study.
- Atomic force Microscopic studies showed that the surface of thin film deposition of some samples were smooth, compact and crack-free surface fully covered by grains. Average and root mean square roughness of these samples were in the range of 0.3-2.5 nm and 0.4-3.2 nm, respectively.
- Transmission electron microscopy (TEM) shows that the particles are well dispersed with high extent of agglomeration. The grans were faceted and almost spherical in shape and corresponding selected area electron diffraction pattern shows single phase crystalline samples.
- The origin of polarization and lossy capacitor behavior of ceramic were confirmed by polarization-electric (P-E) Loop tracer technique.
- The value of dielectric constant of YCTO ceramic was found to be 8434 at 308 K and 100 Hz, which is much higher than the value reported earlier.
- In lanthanum doped YCTO sample, the value of dielectric constant got decreased by the doping. The dielectric constant got reduced due to decrease in concentration of oxygen vacancies, which give rise to orientation polarization. However, the dielectric loss for YLCTO was also less than the undoped YCTO ceramic.
- In zinc doped samples, dielectric constant got increased by the increase in zinc concentration due to interfacial polarization while dielectric loss got decreased with increase in zinc concentration. It leads to decrease in the conductivity of grains.
- High values of permittivity are due to space charge polarization at grain-grain boundaries interface due to difference in their compositions and also due to chemical micro heterogeneities present within the grains due to slow thermochemical diffusion controlled process.
- Dielectric constant and loss tangent (tan δ) are temperature independent in higher frequency region but temperature dependent in low-frequency region.
- The impedance studies of YCZTO ceramic showed two major contributions

associated with the grain boundaries and electrode effect. The resistance of grain-boundaries appears as a major contribution at higher temperature and electrode resistance appear at low temperature due to electrode polarization. The asymmetric broadening of peaks in YCZTO ceramic also suggests the presence of electrical phenomena with a wide spread of relaxation time.

- The impedance of different YCTO ceramic shows two significant contributions associated with the grain boundaries and electrode effect. The grain-boundary resistance appears as a significant contribution at a higher temperature. The electrode resistance appears at a lower temperature due to electrode polarization.
- Impedance and Modulus analysis of different doped and undoped YCTO ceramic confirmed the presence of temperature dependent Maxwell-Wagner type of relaxation.

7.2 FUTURE SCOPE

- In order to study the mechanism of formation of final product, DTA/TGA results are to be coupled with X-ray diffraction studies at respective temperatures.
- It is essential to study the influence and to find the proper processing parameters to obtain the CCTO ceramics with optimized desirable properties. With a view to understand and improve the dielectric properties of these electro-ceramics the effect of different parameters such as sintering temperature, sintering time, ceramic compositions and different processing methods for preparation etc. will be studied.
- To optimize different processing parameters it is essential to study the thermal decomposition behavior of the precursor powder, surface morphology, particle size and phase purity of the ceramics.
- For the optimization of sintering duration to achieve enhanced densification of the sintered YCTO and isomorphs of YCTO, study of the densification and grain growth behavior during intermediate and final stage of sintering are of potential importance.

- It may be useful to study dielectric properties with different electrodes, as a function thickness of samples and samples prepared under different processing parameters such as sintering atmosphere such as annealing atmosphere in the presence of different gases like nitrogen (N_2), Argon (Ar) etc. during annealing of the samples and cooling rate after annealing etc. to understand higher value of dielectric constant. This will also throw light on the presence and role of oxygen vacancies.
- Iron and lanthanum doped YCTO ceramic may display excellent magnetic properties. The magnetic characterizations must be employed for theses samples.