CHAPTER 10

CONCLUSIONS

Since this work was focused on the physical and electrical properties development of modified $CaCu_3Ti_4O_{12}$ (CCTO) ceramics. The experimental procedures were divided in to six parts;

(1). Effects of processing conditions on the dielectric properties of $CaCu_3Ti_4O_{12}$ ceramics.

(2). Influences of the partial Mn -for Ti substitution on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

(3). Influences of doping In_2O_3 on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

(4). Influences of doping GeO_2 on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

(5). Influences of doping cesium on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

(6). Influences of doping CeO_2 on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

10.1. Effects of processing conditions on the dielectric properties of $CaCu_3Ti_4O_{12}$ ceramics.

The effect of processing, it was observed that the different preparing techniques and sintering temperatures (950, 1000, 1050, 1100 and1150^{o}C). The dielectric constant (ε_r) of CCTO ceramic samples, which prepared by vibro-milling and sintered at 1100^{o}C for 4h gave a higher dielectric constant than that of CCTO ceramics which prepared by ball-milling technique. These vibro-milled CCTO ceramics also possess excellent dielectric constant even at higher frequency (10 – 500 kHz) while their dielectric loss still under 0.1 at temperature not over 100^{o}C.

10.2. Influences of the partial Mn -for Ti substitution on the dielectric response of $CaCu_3Ti_4O_{12}$ceramics.

The partial Mn -for Ti substitution, the dielectric loss was suppressed remarkably while the dielectric constant (ε_r) still remains high. The sample $CaCu_3Ti_{3.76}Mn_{0.24}O_{12}$ exhibits a high ε_r over 1200 and a low dielectric loss below 0.06 at room temperature. Furthermore, the ε_r value of this sample shows rather independent with temperature. SEM micrographs show that no impurity was observed in the Mn doped CCTO ceramics which exhibit the dense microstructures without abnormal grains.

10.3. Influences of doping In_2O_3 on the dielectric response of $CaCu_3Ti_4O_{12}$ceramics.

Influences of In_2O_3 doped CCTO were produced a reduction in dielectric constants in CCTO but the dielectric constants of In doped CCTO were still high (ε_r ~

24,250 for 2.0mol% In_2O_3 doped) and showed a temperature stability at high frequency. Furthermore, the loss tangent was found to improve after doping. Low loss tangent of 0.02 at 1kH and at 60 ^oC were recorded for the 2.0 mol% sample. The loss tangent properties could be interpreted by the internal barrier layer capacitor model and the impedance measurement data.

10.4. Influences of doping GeO_2 on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

The GeO_2 doped CCTO were produced a slightly smaller grain size. A reduction in dielectric constant was observed, but it still high. The 2.0 mol% GeO_2 doped sample exhibited a high dielectric constant > 26,000 at room temperature, at frequency 1 kHz. The dielectric measurements showed that the modified samples exhibited a stronger dielectric independent of temperature and frequency. In addition, the loss tangent reduced after doping. The reduction in the dielectric constant and loss tangent is proposed to relate with the microstructure of the samples.

10.5. Influences of doping cesium on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

The effects of dopants including caesium on the properties of $CaCu_3Ti_4O_{12}$ (CCTO) were studied. Caesium doping enhanced the grain growth. The caesium doping showed an improvement in loss tangent performance. High dielectric constant > 15,000 with dielectric loss lower than 0.06 were observed for caesium 2.0 mol% doped CCTO at high frequency. The results were related to the change in microstructure and the properties of grain boundary after doping.

10.6. Influences of doping CeO_2 on the dielectric response of $CaCu_3Ti_4O_{12}$ ceramics.

Influences of CeO_2 doping on the dielectric properties of $CaCu_3Ti_4O_{12}$ ceramics were investigated. The ceramics were prepared by a solid-state reaction method. Although the doping produced a reduction in dielectric constants, while cerium doping produced grain growth inhibition. The dielectric constants after doping were still high ($\varepsilon_r \sim 23{,}000$) and dielectric loss lower than 0.06 were observed for cerium 2.0 mol% doped CCTO at high frequency. The results were related to the change in microstructure and the properties of grain boundary after doping.