1. Introduction

Ferroelectric BaTiO₃ is the material of choice for multilayer ceramic capacitor (MLCC) manufacturing. To fabricate thinner dielectric layers for increasing volume efficiency, nano-sized BaTiO₃ powders are essentially required. As the BaTiO₃ particle size gets smaller, the uniform distribution of additives becomes more difficult. Chemical coating techniques are effective in enhancing the uniform distribution of additives along the grain boundaries. The advantages of coating methods include improvements in the dispersability of powders, the introduction of a uniform incorporation of additives and microstructure control [1-2]. Hence, various coating techniques have been developed [3-5]. SiO₂ coating is an important way to improve the sintering behavior of BaTiO₃ powders because SiO₂ is known to be an effective sintering aid [6]. The sol-gel method is widely used to form a silica layer coating on powders using silicon alkoxides. In this paper, the effects of silica coating on the powder characteristics and sintering behavior of nano sized Ba TiO₃ powders will be discussed.

2. Experimental and Results

Nano sized BaTiO₃ powders were prepared using the liquid mix method developed by Pechini [7]. The silica coating on barium titanate powders was achieved via sol-gel method and the amount of SiO₂ addition was 0.5 and 5.0 wt%.

The primary BaTiO₃ particles were heavily agglomerated with uniform particle sizes of about 30~50nm. The average size of BaTiO₃ particles was observed to be about 35nm. Figure 1 show TEM micrographs of bare BaTiO₃ powders and SiO₂ coated BaTiO₃. The thickness of the SiO₂ coating layer was about 5nm. The uniform coating of silica on BaTiO₃ was formed by hydrolysis and condensation reactions of TEOS.

Figure 2 shows zeta potential of BaTiO₃, SiO₂ and SiO₂ coated BaTiO₃ powders as a function of pH value. Above pH 3.0, the zeta potential of SiO₂ coated BaTiO₃ powders are more negative than that of the uncoated BaTiO₃. This confirms that the surface of BaTiO₃ particles was coated by SiO₂ layer, which caused the change of the surface characteristics of BaTiO₃ powders and improved the dispersion of BaTiO₃ primary particles. The disappearance of powder agglomeration with increasing SiO₂ content is thus believed to be due to the increase in electrostatic repulsions between the coated SiO₂ layers on the surface of the BaTiO₃ particles.

Figure 3 exhibits the shrinkage curves of BaTiO₃ as a function of temperature for various silica contents. The SiO₂ coated BaTiO₃ powders began to shrink at higher temperatures than the uncoated BaTiO₃. This confirms that the shrinkage of BaTiO₃ powders was retarded by the coating of SiO₂ layer on the surface of the BaTiO₃ particles.

Keywords: BaTiO₃, SiO₂, Nano, Coating, Zeta potential
3. Summary

BaTiO$_3$ powders were prepared by the Pechini process and coated with silica by the sol-gel process. The zeta potential of the SiO$_2$ coated BaTiO$_3$ is more negative than the uncoated BaTiO$_3$. The zeta potentials of 5.0 wt% SiO$_2$ coated BaTiO$_3$ approached that of pure SiO$_2$ particles. As the SiO$_2$ content was increased, powder dispersion improved due to the electrostatic repulsion between the coated silica layers on the surface of BaTiO$_3$ particles. The onset temperature of shrinkage curves is dependent on SiO$_2$ contents and shifts to higher temperatures with increasing SiO$_2$ because the SiO$_2$ coating layer prevents the direct contact between BaTiO$_3$ particles and retards the sintering rate at lower temperatures.

4. References