DIELECTRIC PROPERTIES AND AGING OF FAST-FIRED BARIUM TITANATE

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Abstract — The dielectric properties and their aging rate of three chemically prepared BaTiO₃ compositions, from Ba-rich to Ti-rich fast fired to 1450°C, were measured from 470 K down to 225 K. Ba-rich samples, in spite of their similar sintering behavior when compared to stoichiometric samples, exhibited the highest dielectric constant values of all compositions. The 1 kHz dissipation factor values in Ba-rich and stoichiometric samples were not observed to decrease with increasing fired density of the samples. High density samples of all three stoichiometries exhibited fairly small losses just above the Curie temperature, while Ba-rich and stoichiometric samples exhibited a marked decrease in the dissipation factor below 260 K.

Keywords — Fast-firing, sintering, barium titanate, dielectric, aging.

I. INTRODUCTION

Some work has been done in the past studying the effect of microstructure on the dielectric properties of polycrystalline BaTiO₃. A strong dependence of the permittivity of the ferroelectric phases with average grain size in this material has been reported for fine-grained samples. Room-temperature dielectric constant values ranging from 3500 up to 5500 have been reported for dense polycrystalline ceramics with average grain sizes at around 1 μm (Kniekamp and Heywang, 1954; Kimishita and Yamaji, 1976).

Prior studies have tried to optimize densification and control grain growth phenomena in order to produce samples with high permittivity and small dielectric losses by using sintering aids or particular sintering conditions (Mostaghaci and Brook, 1981; Yoo et al., 1987).

Fast firing has received some attention since this technique allows for an increase in densification while minimizing grain growth by establishing temperature conditions in which the mass-transport mechanisms available for densification during sintering are favored over those leading to grain growth. This method involves, basically, heating rapidly through the low temperature region, with heating rates as high as 500°C/min, to relatively high sintering temperatures where the ceramic is held for a short period of time. Fast firing has been successfully applied to a variety of materials (Harmer et al., 1978; Morell and Hermosin, 1980).

Besides the microstructure benefits, fast firing can be favored over other techniques, such as grain growth inhibitors– Ta₂O₅, Nb₂O₅, ZrO₂ (Jonker and Noorlander, 1962; Harkulich et al., 1966)- or hot pressing (Mostaghachi and Brook, 1983; Sharma and McCartney, 1974), because of its simple set-up as well as the potential of decreased production times due to the relatively short firing cycles employed. Fast firing applied successfully to BaTiO₃ requires a highly homogeneous starting powder, since the existence of localized stoichiometry differences may result in discontinuous grain growth (Yoo et al., 1987) even with Ba-rich chemically prepared powders (see Fig. 1) that render uniform microstructures when conventionally sintered (Alles et al., 1989).

![Figure 1. SEM (SE) 2000X micrograph of the fired surface of a chemically prepared barium titanate sample with a Ba/Ti ratio of 1.01 fired at 500°C/minute to 1450°C and held for 5 minutes.](image-url)