Piezoelectric Coefficient of Rice Husk Silica Ceramics with $BaTiO_3$ Addition

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Abstract: *Piezoelectric coefficient (d_{33}) will show the potential of a material to have piezoelectric properties. Once the piezoelectric properties of a material have been known, the application of that material will be easily determined. In this paper, study on piezoelectric coefficient for silica ceramic samples derived from Rice Husk Ash sintered at 1000ºC, 1100ºC and 1200ºC temperatures was done. $BaTiO_3$ was added to enhance the piezoelectric d_{33} values in the Rice Husk. Characterization of piezoelectric coefficient (d_{33}) of pure Rice Husk Ash, Rice Husk samples with 5wt% and 10wt% $BaTiO_3$ addition were discussed. The value of d_{33} increases with increasing percentage of $BaTiO_3$ addition.*
Keywords: *rice husk ash silica, sintering temperature, cristobalite, piezoelectric coefficient, Barium Titanate*

INTRODUCTION

Rice Husk (RH) is an abundant agriculture waste material in rice producing countries. However previous studies show that it contains over 20%wt silica [1] which can be changed into cristobalite with proper thermal treatment. Cristobalite is a crystalline form of silica and should have a chemistry formula SiO_2 like quartz crystal which is a piezoelectric material. Meanwhile, Barium Titanate is an inorganic compound which appears in white powder form with chemical formula $BaTiO_3$[2]. It falls into ferroelectric ceramic materials which possess piezoelectric properties. Piezoelectric materials can be used as a means of transforming ambient vibrations into electrical that can be stored and used to power other devices [3]. They are used in many different applications as sensors or mechanical actuators. Piezoelectric coefficient d_{33}, quantifies the volume change when a piezoelectric material is subject to an electric field [4]. In this study RH samples were tested to determine whether they possess piezoelectric properties by checking the value of d_{33}.

MATERIALS AND METHODS

Rice husk was calcinated at 900ºC to get white rice husk ash (WRHA) and then grounded to produce powder form. Barium titanate was then prepared by heating barium carbonate and titanium dioxide. $BaTiO_3$ powder was added in the ratio of 5wt% and 10wt% to the WRHA powder to enhance the piezoelectric properties. All samples were pelletized into disc form. The samples were then sintered at 1000ºC, 1100ºC and 1200ºC respectively. The samples were polarized by using high voltage power supply to align the dipoles. Characterization of piezoelectric properties (d_{33}) of all samples has been carried out by using a Piezo d_{33} Test System 90-2030 from APC International at 50Hz frequency. This instrument is capable of directly measures the piezoelectric constant d_{33} values of piezoelectric ceramics and single crystals.

RESULTS AND DISCUSSION

Each samples of RH discs was tested by clamping it to the holder of the piezo meter. A frequency of 50Hz was then applied and the values of the d_{33} shown on the screen display were tabulated in Table 1. The first sample was a pure RH, the second and third samples were RH with the addition of 5% and 10% of $BaTiO_3$ respectively and the fourth sample was pure $BaTiO_3$ as control sample.

Table 1. d_{33} values for RH and $BaTiO_3$ addition

Sintering Temp. (°C)	d_{33} values (pC/N)		
	Pure RH (RH1)	RH with 5% $BaTiO_3$ (RH5)	RH with 10% $BaTiO_3$ (RH10)
1000	4	5	13
1100	4	4	5
00	4	4	5

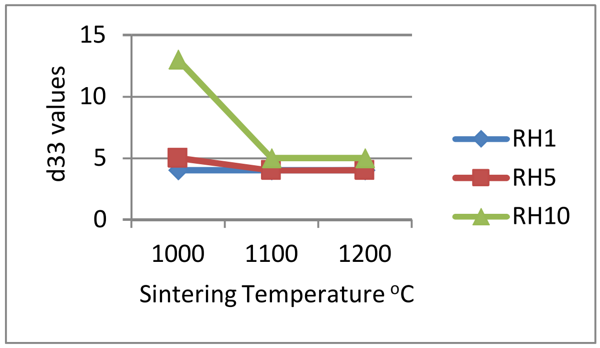

Fig. 1 Piezo d_{33} values at different sintering temperatures and $BaTiO_3$ ratio

From Table 1, it can be noticed that the piezoelectric constant in the samples was increased from 4 pC/N (for pure RH) to 13 pC/N (for RH with 10%$BaTiO_3$ addition) at 1000ºC sintering temperature. Figure 1 illustrates the result in graphical form. As mentioned before, the pure $BaTiO_3$ sample was also tested which acts as control sample and gave the value of 166 pC/N. Increase in piezoelectric properties with sintering temperature can be attributed to increase in density and grain size with sintering temperature. At higher sintering temperature, with increased grain size, a fewer number of grain boundaries would be present and diminished grain boundary caused the existence of very mobile domain walls thus increasing the piezoelectric value of the RH samples. During grain growth, pores become fewer which act as barrier to domain wall motion due to pinning of the wall. Piezoelectricity originated from the distortion of the unit tetrahedron gives rise to an electric polarization along the electric axis in the unit, which induces the piezoelectric effect in the quartz crystal [5]. The same phenomenon was expected to occur in RH cristobalite samples. Thus, when the pressure is applied to the samples, a very low value of piezoelectric polarization is produced. So, the piezoelectric polarization is considered as the sum of unit polarization since the balance of the polarizations is destroyed in a lattice structure when it is deformed by stress.

CONCLUSIONS

Piezoelectric properties have been inclusively investigated for a group of RH and RH with the addition of Barium Titanate ceramics which were fabricated by conventional solid-state method. Particular attention was given to the influence of sintering temperature and piezoelectric properties. The piezoelectric tests showed that, the pure RH sample possessed d_{33} constant at 4 pC/N which is relatively small amount compared to pure BaTiO3. However, the value increased with increasing percentage of $BaTiO_3$ addition (5% and 10%) at lower temperature which makes it possible to be used for sensor and actuator application.

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