A STUDY ON MICRO STRUCTRES AND BONDING ABILITY OF PIEZO ELECTRIC MATERIALS WITH QUARTZ

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ABSTRACT
Piezoelectric materials have been widely used in applications such as transducers, acoustic components, as well as motion and pressure sensors. Because of the material's biocompatibility and flexibility, its applications in biomedical and biological systems have been of great scientific and engineering interest. In order to develop piezoelectric sensors that are small and functional, understanding of the material behavior is crucial. The major objective of this research is to develop a test system to evaluate the performance of a sensor made from qurtz mixed polymers fluoride and its uses for studying insect locomotion and behaviours. A linear stage laboratory setup was designed and built to study the piezoelectric properties of a sensor during buckling deformation. As a part of it the sample materials tested for SEM analysis for the bonding of electrons placement in samples.

Key words: Piezoelectric materials, Qurtz, SEM.

Introduction

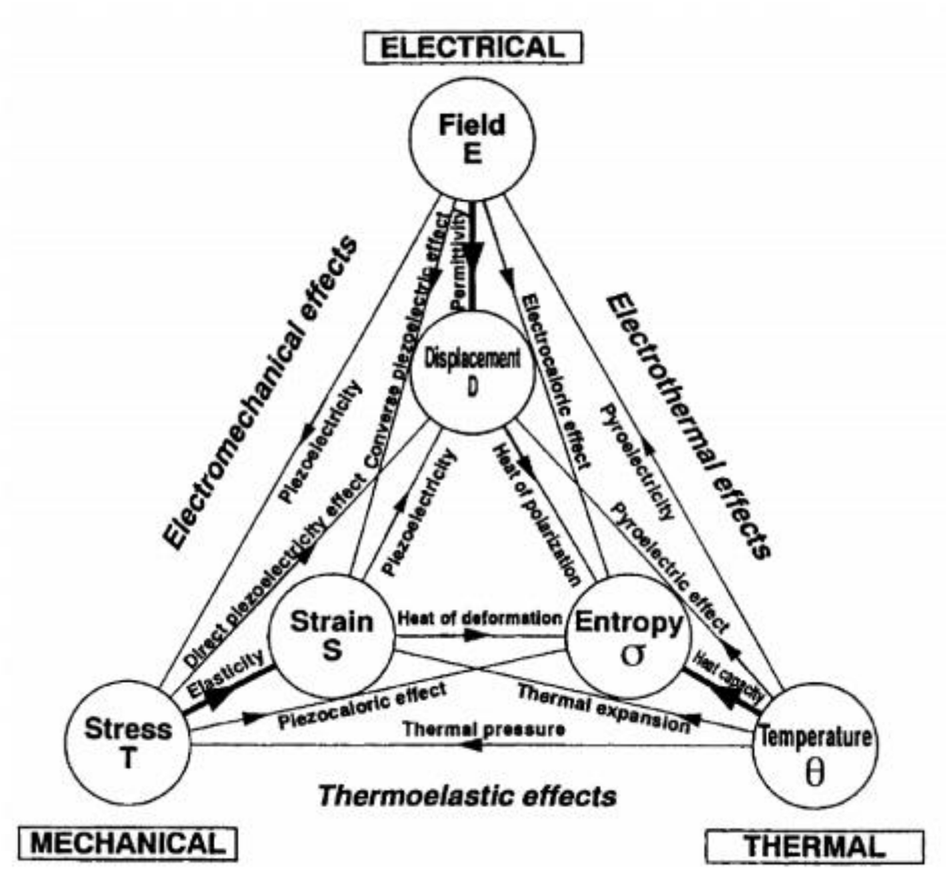
Piezoelectric materials are materials that produce a voltage when stress is applied. Since, this effect also applies in the reverse manner; a voltage across the sample will produce stress within the sample. It was subsequently demonstrated that the converse effect is also true; when an electric field is applied to a piezoelectric material it changes its shape and size. This effect was found to be due to the electrical dipoles of the material spontaneously aligning in the electrical field. Due to the internal stiffness of the material, piezoelectric elements were also found to generate relatively large forces when their natural expansion was constrained. This observation ultimately has led to their use as actuators in many applications. Likewise if electrodes were attached to the material then the charge generated by straining the material could be collected and measured. Thus piezoelectric materials can also be used as sensors to measure structural motion by directly attaching them to the structure.

Most contemporary applications of piezoelectricity use polycrystalline ceramics instead of naturally occurring piezoelectric crystals. The ceramic materials afford a number of advantages; they are hard, dense and can be manufactured to almost any shape or size. Piezoelectric transducers have become increasingly popular in vibration control applications. They are used as sensors and as actuators in structural vibration control systems. They provide excellent actuation and sensing capabilities.

Concept of relation in piezoelectric materials

This enables them to produce comparatively large forces or displacements from relatively small applied voltages, or vice versa. Consequently, they are the most widely utilized material in manufacturing of piezoelectric transducers. The high modulus of elasticity of many piezoelectric materials is comparable to that of many metals and goes up to 105 N/mm^2. Even though piezoelectric sensors are electromechanical systems that react on compression, the sensing elements show almost zero deflection.

This is the reason why piezoelectric sensors are so rugged, have an extremely high natural frequency and an excellent linearity over a wide amplitude range. Additionally, piezoelectric technology is insensitive to electromagnetic fields and radiation, enabling measurements under harsh conditions. Some materials used (especially gallium phosphate or tourmaline) have an extreme stability over temperature enabling sensors to have a working range of 1000°C. The single disadvantage of piezoelectric sensors is that they cannot be used for true static measurements. A static force will result in a fixed amount of charges on the piezoelectric material.



Relationships among material properties

Need of SEM study

One of the most suitable methods for obtaining the energy from surrounding system is achieved by using piezoelectric crystals. Piezoelectric crystal is one small scale energy source. When piezoelectric crystals are subjected to vibrations, they generate a very small voltage, commonly known as piezoelectricity. It has crystalline structure that converts an applied vibration into an electrical energy .the piezoelectric effect exists in two properties. The first is the direct piezoelectric effect that describes the material's ability to transform mechanical strain into electrical charge. The second form is the converse effect, which is the ability to convert an applied electrical potential into mechanical strain energy. These properties allow the material to function as a power harvesting medium.

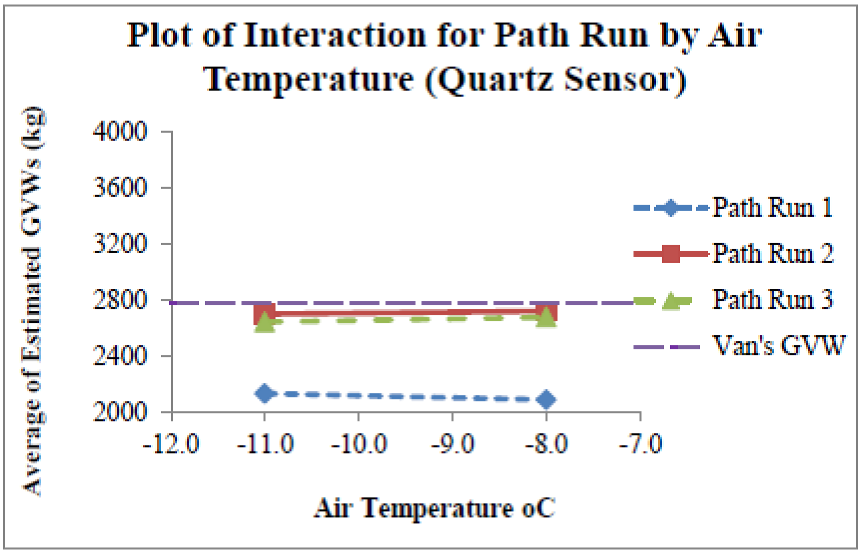
Some of the typical piezoelectric materials include quartz, barium titanante, lead titanate, cadmium sulphide, lead zirconate titanate (PZT), lead lanthanum zirconate titanate, lead magnesium niobate, piezoelectric polymer polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF).

Piezoelectric Properties of Representative Piezoelectric Material

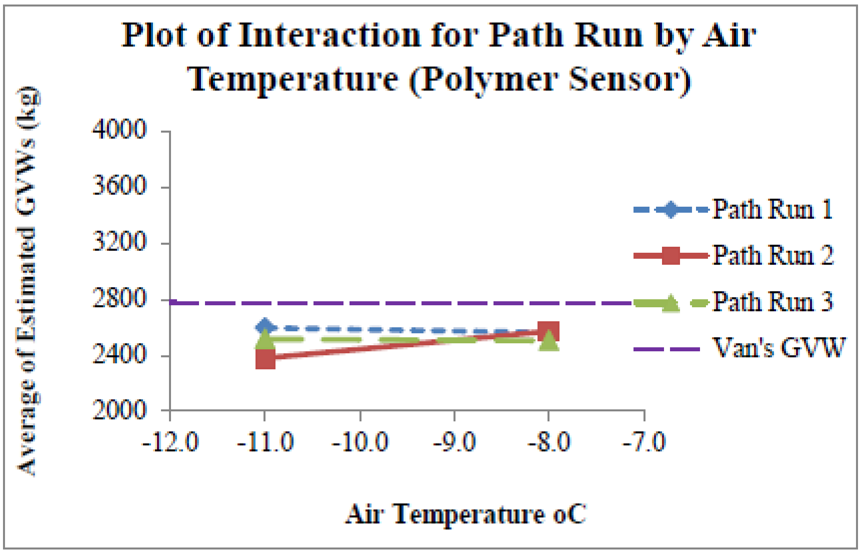
Parameter	Quartz	$BaTiO_3$	PZT 4	PZT 5H	(Pb,Sm) TiO_3	PVDFTrFE
d_{33} (pC/N)	2.3	190	289	593	65	33
g_{33} (10^{-3} Vm/N)	57.8	12.6	26.1	19.7	42	380
k_t	0.09	0.38	0.51	0.50	0.50	0.30
k_p		0.33	0.58	0.65	0.03	
$\varepsilon 3$ X/$\varepsilon 0$	5	1700	1300	3400	175	6
Q_M	$>10^5$		500	65	900	3–10
T_C (°C)		120	328	193	355	

Results and discussions

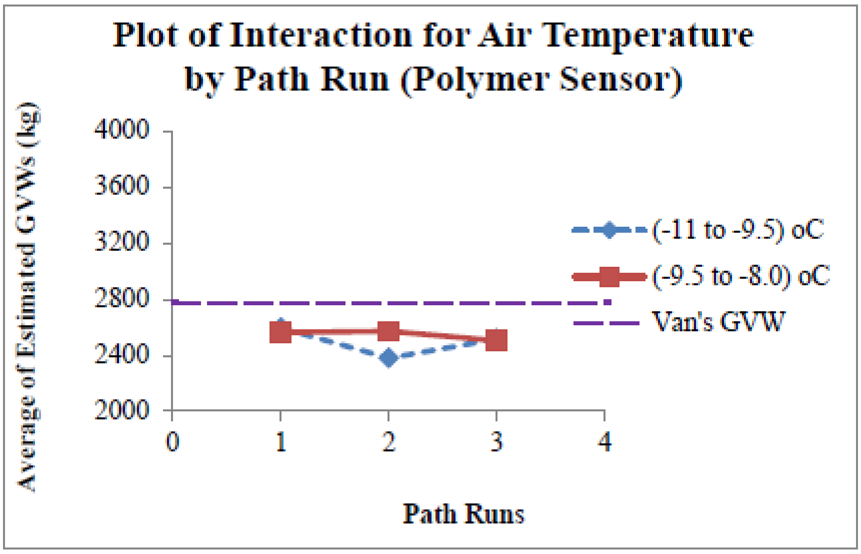
The possible reason for this is that the tire loads were not fully on the sensors in path run 1. Figure below illustrates no-interaction since the lines are nearly parallel; however, the line for speed 30 km/hr show a significant different estimation. A normal probability plot of the residuals and standardized residual computations demonstrated that all residuals are in the range of a normal distribution including no outlier.



Graph 7.14The interaction effect for path runs by air temperature (quartz)

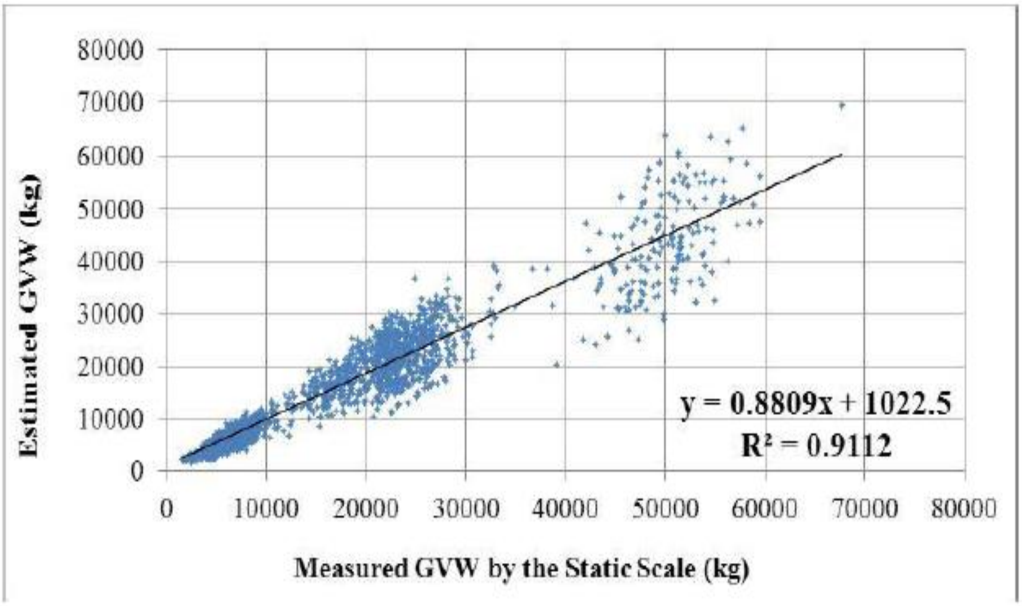


Graph 7.15 The interaction effect for path runs by air temperature (polymer)

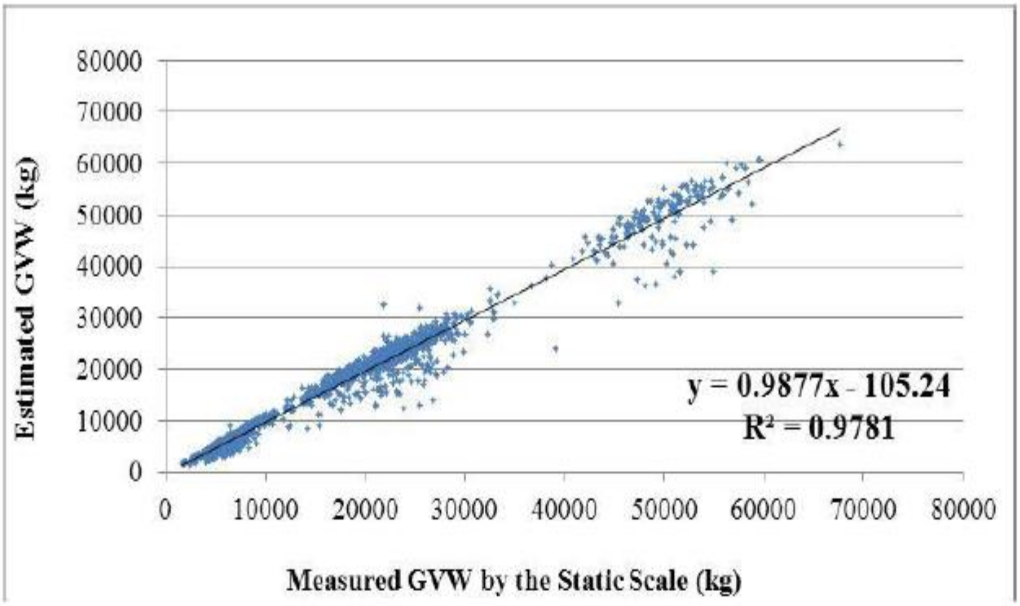


Graph 7.16 **The interaction effect for air temperature by path run**

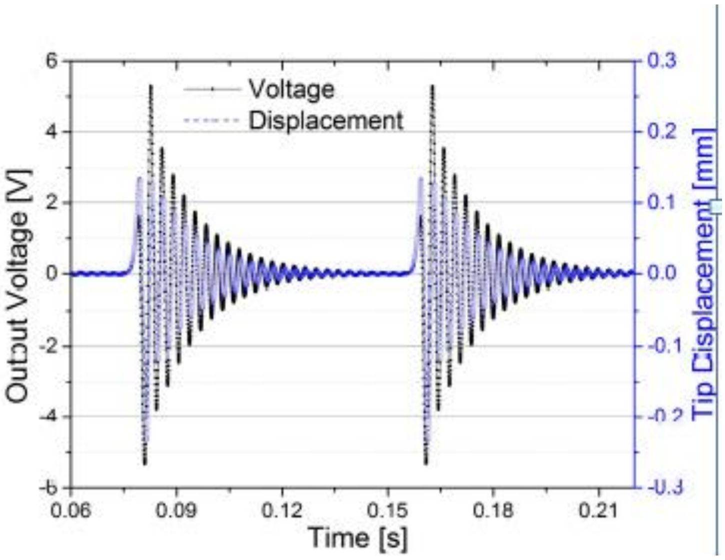
The polymer piezoelectric sensors data in November 2010 and according to the conditions mentioned above were selected and averages of axles in each tandem axle were calculated. Regression between steering axle and average of axles at drive tandem and also between steering axle and average of axles in the semitrailers tandem (rear tandem) were constructed.



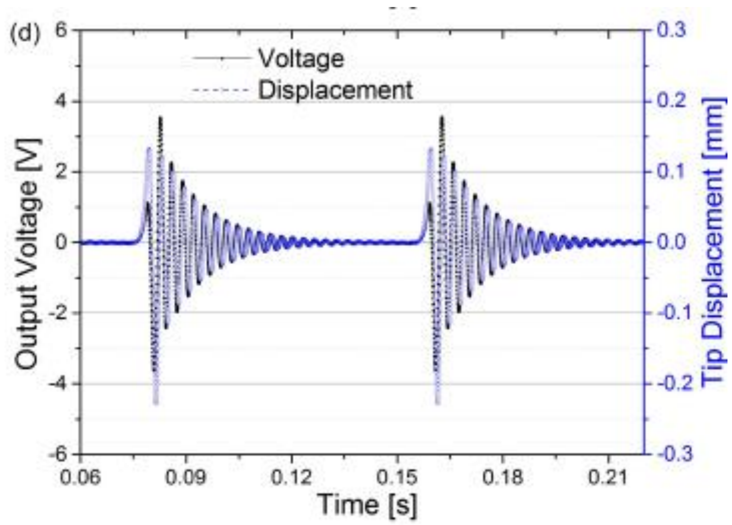
Graph 7.17 Static GVW versus polymer piezoelectric GVW estimation



Graph 7.18Static GVW versus quartz piezoelectric GVW estimation



Graph 7.19 The variation of beam tip displacement and output voltage for different electrode coverage ratios with their optimal resistive loads connected 32.1% (235 kW)



Graph 7.20The variation of beam tip displacement and output voltage for different electrode coverage ratios with their optimal resistive loads connected 100% (95 kW)

7.1 Density and microstructure:

Ba(ZrxTi1-x)O3 (BZT, x=0.1, and 0.2) ceramics are prepared by SPS and conventional sintering. By application of SPS, the Ba(Zr,Ti)O3 ceramics with more than 96% relative densities could be obtained by the sintering at 1100˚C for 5 minutes in air atmosphere. The grain growth is suppressed in the ceramics prepared by SPS, the average grain sizes were less than 1micron. Carbon contents of SPS prepared BZT ceramics and the conventionally sintered BZT are 0.15% and 0.024%, respectively.(Maiwa, 2008b) It should be noted that the SPS prepared BZT ceramics examined carbon content contained organic binder intentionally for comparison. Since the organic binder is not added to SPS prepared ceramics usually, carbon contents of the SPS prepared ceramics would be less than 0.15%.

In conventional sintering, the relative density was found to increase and the grains grew with increases in the sintering temperature. The relative densities of the ceramics sintered at 1300, 1350, 1400, and 1450°C were 4.67, 5.03, 5.68, and 5.77 g/cm3, respectively. These values were lower than those of the SPS-BZT20 ceramics. It should be noted that the normally sintered ceramics contained pores, as show in Fig. 2. The average grain sizes were approximately 1 μm for the samples annealed at 1300-1400°C, with the size increasing slightly with temperature. Grain growth occurred over the range from 1400-1450°C.

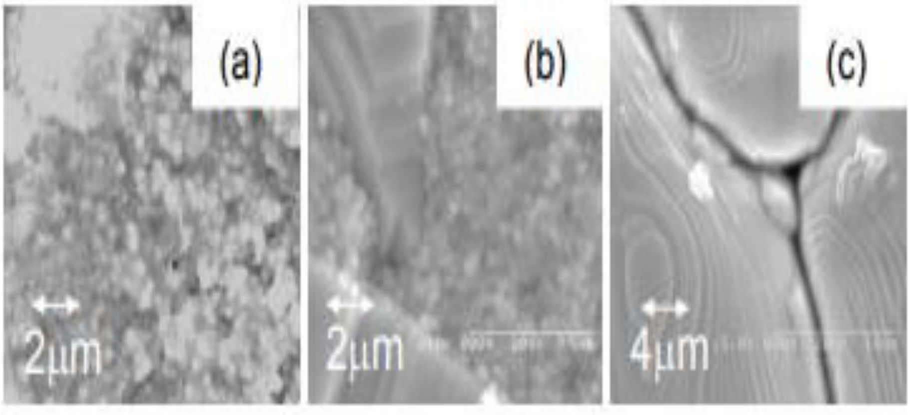
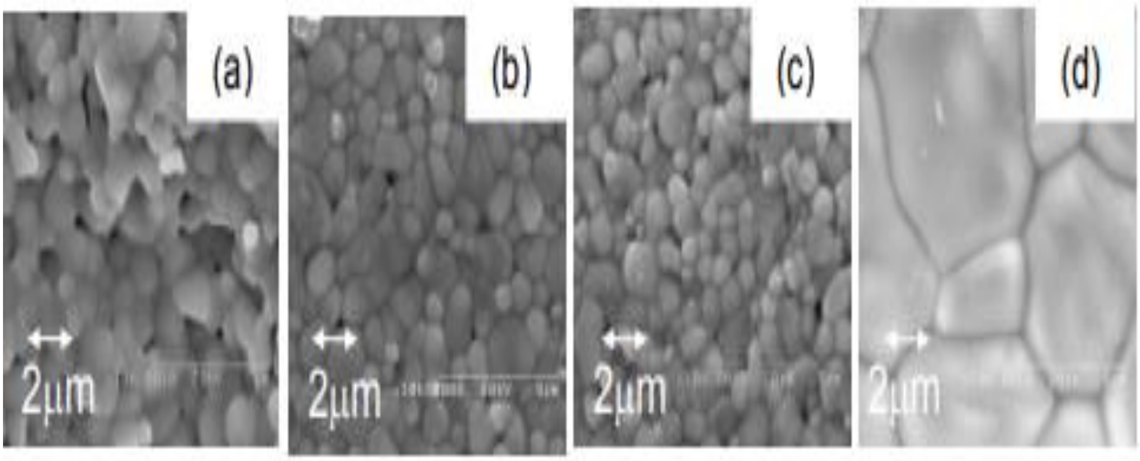


Figure 7.9 SEM images of the Ba(Zr0.2Ti0.8)O3 ceramics SPS-prepared at 1000°C and annealed at (a) 1200, (b)1300°C, and (d)1400 °C



7.10 SEM images of the Ba(Zr0.2Ti0.8)O3 ceramics normally sintered at (a) 1300, (b) 1350, (c) 1400, and (d)1450

The lattice elongation is caused by deoxidization. The X-ray diffraction patterns of the ceramics conventionally sintered at 1100 °C and the ceramics prepared by SPS at 900 °C and then annealed at 900-1100 °C were different in terms of the normal splitting peaks, with 1:2 intensity ratio of tetragonal (002) and (200) observed in the ceramics conventionally sintered at 1200 and 1300 °C. This is due to the structural change derived from the stress in the small grain below 1 µm

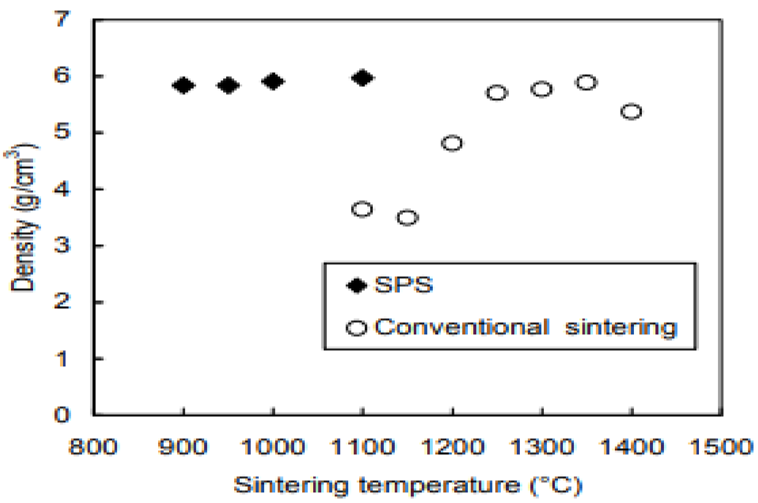


Figure 7.11 Relative densities of BaTiO3 samples

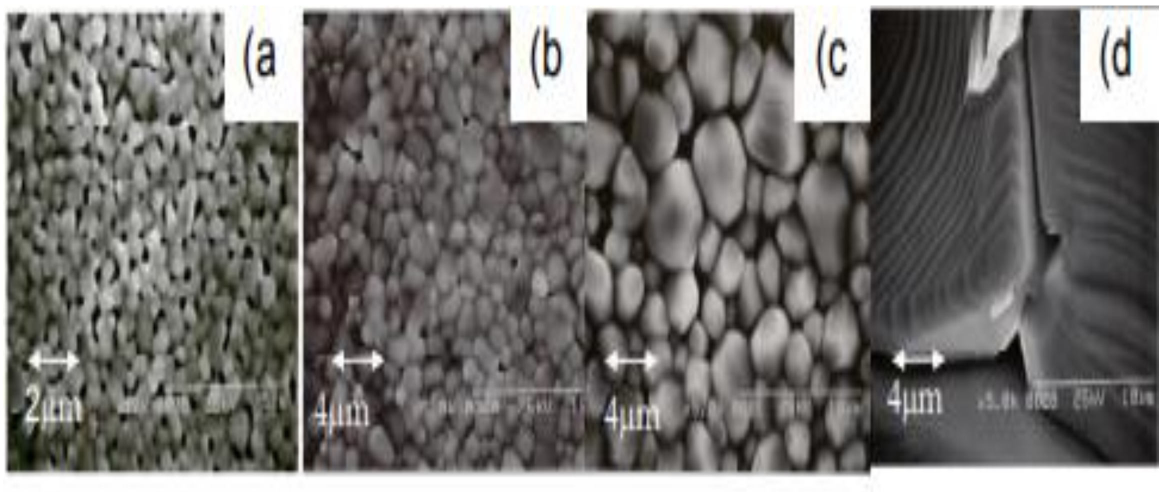


Figure: 7.12 SEM images of the BaTiO3 ceramics normally sintered at (a) 1100, (b) 1200, (c) 1300, and (d) 1400 °C

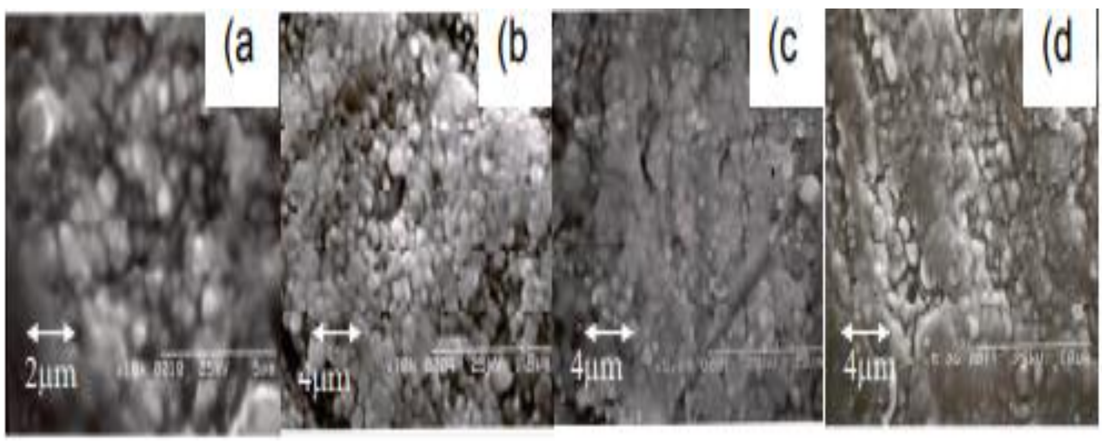
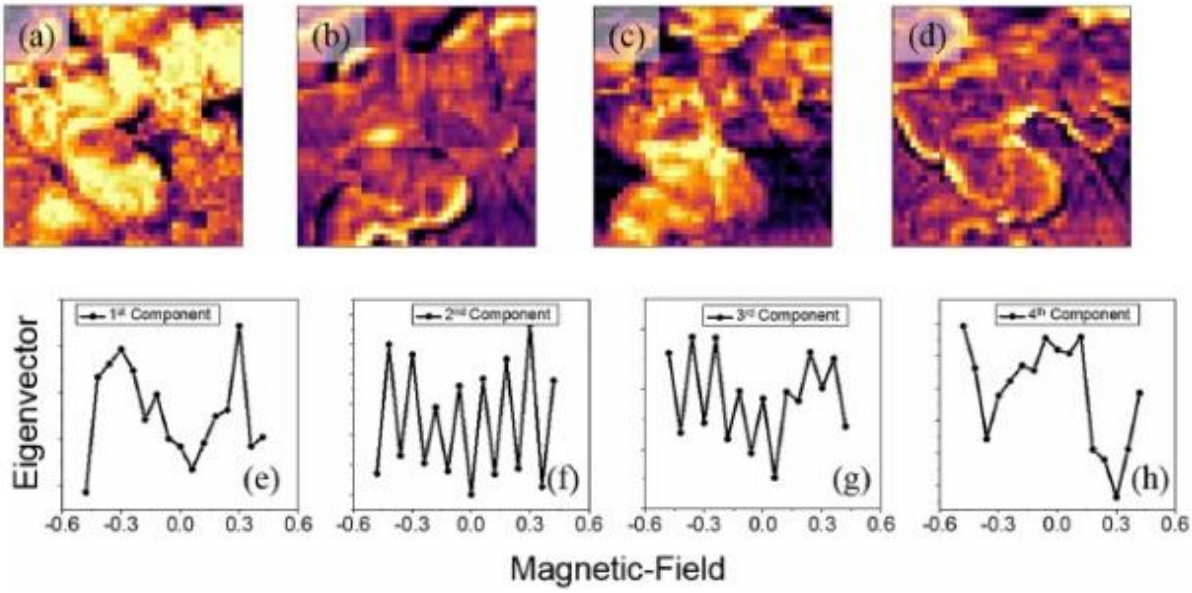


Figure: 7.13 SEM images of the BaTiO3 ceramics SPS-prepared at 900 °C and then sintered at (a) 900, (b)1000, (c) 1100, and (d)1200 °C



Conclusions

The study of wave propagation inside piezoelectric materials attracted much attention for the application of delay line. The time delay effect was achieved when a piezoelectric element is used to transform the electrical signal into the elastic wave propagating through it] studied acoustic wave propagating around a piezoelectric cylinder with thin metallic overlay and showed that the wave propagation characteristics changed with different metallic layers. Their investigation manifested the importance of evaluating the electro-mechanical effect in a layered structure. Also performed experiments and achieved results in agreement with those from theoretical predictions.

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