CHAPTER II
LITERATURE REVIEW

2.1 Barium Strontium Titanate($Ba_{1-x}Sr_xTiO_3$,BST)

Zhou, L. *et al.*, (1999) studied the structural and dielectric properties of $Ba_{1-x}Sr_xTiO_3$ ceramic solid solutions on raw material processing. They found that fraction of strontium was 0 and 0.2, the structure was tetragonal while it was cubic for strontium =0.4, 0.6, 0.8, 0.9, 0.95 and 1. (Figure 2.1)

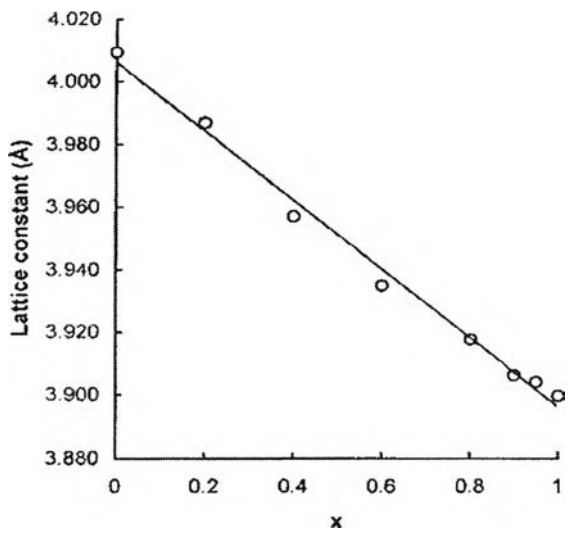

Figure 2.1 The lattice constant decreases linearly with increasing x value.

The dielectric permittivity at Tc increases with increasing Sr^{2+} content, reaching the high value at 0.6 of Sr^{2+} and then decreases confirmed by Tahan, D. *et al.*, (1995). However the dielectric constant was not seen to vary significantly with frequency (1 kHz -100 kHz) for fixed composition (if frequency increase, dielectric will slightly increase) but it was important with temperature which from at Tc ,dielectric constant exhibited a maximum, which it was same results with Hornebecq.V.*et* al.,(2004) and Helmi Abdelkefi *et* al.,(2005)

Giridharan, N.V., *et al.*, (2000) studied fabrication and characterisation of (Ba,Sr)TiO3 thin films by sol–gel technique through organic precursor route. They

found that thin films of barium strontium titanate with crystalline structure were successfully fabricated by sol–gel technique. It was confirmed that pre-fired films were amorphous and well-crystallized films were obtained by annealing at 700°C for 2 h.

Wua, D., *et al.*, (2000) studied preparation of $Ba_{0.5}Sr_{0.5}TiO_3$ thin films by sol–gel method with rapid thermal annealing. The results were well-crystallized BST films with uniform and dense surface was obtained by RTA (rapid thermal annealing) at 700°C for 5 min. The interface is better than films prepared by conventional annealing process (700°C for 60min). BST thin films with the same concentration of Ba and Sr, namely $Ba_{0.5}Sr_{0.5}TiO_3$ (BST) are most studied due to its paraelectric properties in the operating temperature range.

Garcia, D., *et al.*, (2000) studied growth and properties of of $Ba_{0.9}$ $Sr_{0.1}TiO_3$ single crystal fibers. They found that temperature dependence of dielectric properties between 160°C and 180°C, showed three structure rhombohedral–orthorhombic, orthorhombic–tetragonal and tetragonal–cubic structural transformations of general $BaTiO_3$ compounds. Transition temperature is very sensitive to the Sr^{2+}amount variation. The phase transition temperatures T_{R-O} = 93°C, T_{O-T} = 9°C and T_{T-C} = 100°C are in accordance to that expected for 10 mol% of strontium.

Ioachim, A., *et al.*, (2006) studied ferroelectric ceramic Ba_{1-x} Sr_xTiO_3 with x = 0.25, 0.5, 0.75 and 0.9.They found that the increasing concentration of Sr has the following effects: (1) decreases the unit cell volume; (2) decreases considerably the ferroelectric transition temperature; (3) decreases substantially the permittivity and losses, for both high and low frequency ranges.

Increasing of annealing temperature with increasing of grain size is expected because of the sintering wherein the small grains coalesce to form larger grains. From increase these parameter which this results gave a same result of Virginie Hornebecq *et al.*, (2004). But lattice parameter of the thin films annealed remained almost constant (Table. 2.1) Increasing of annealing temperature increased the dielectric constant due to the increase in grain size, film crystallinity and also the film density. Similar to dielectric constant, loss tangent also increased with increase in film thickness (Figure 2.2).

Table 2.1 Lattice parameter after annealing the thin film at different temperatures calculated using (1 1 0) reflection and Pt (1 1 1) peak as the standard

Lattice parameter after annealing the thin film at different temperatures calculated using (1 1 0) reflection and Pt (1 1 1) peak as the standard

Annealing temperature (°C)	Lattice parameter (Å)
500	3.9421
600	3.9399
700	3.9389
800	3.9217

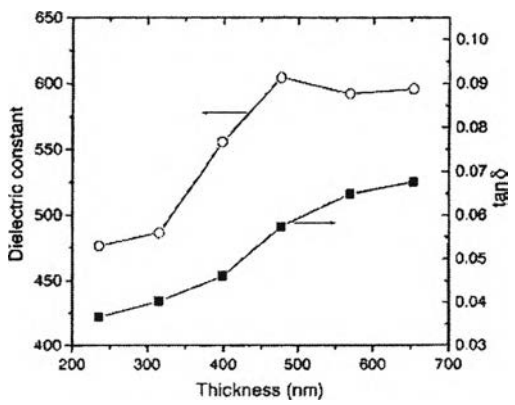

Figure 2.2 Variation of 100 kHz dielectric constant and loss tangent of the BST thin film prepared from 0.28M solution as a function of thickness.

Lu, Q., *et al.*, (2003) studied preparation and characterization of $Ba_{1-x}Sr_xTiO_3$ (x=0.1, 0.2) fibers by sol–gel process using catechol-complexed titanium isopropoxide. They found the grain size and the grain-size distribution increase with increasing of the strontium concentration. Moreover, with the addition of strontium, the dense surface of the BST ceramic fibers forms.

2.2 Poly vinylidene Fluoride (PVDF)

Salimi, A. and Yousefi, A .A . (2004) studied the conformational changes and phase transformation mechanisms in PVDF solution-cast Films.The crystalline-state chain conformations of isothermally solution-crystallized PVDF in N, *N*-dimethylacetamide (DMAc), and cyclohexanone are studied through the specific FTIR absorption bands of α and β phase crystals. There are no changes in the FTIR spectra of cyclohexanone solution-crystallized film in the temperature range of 50-120°c. In the case of DMAc solution-crystallized films, low temperature crystallization mainly results in formation of trans states (β phases), whereas at higher temperatures gauche states become more populated (α phase). This is due to the variations in solvent polarity and ability to induce a specific conformation in PVDF chains, through the changes in chain coil dimensions. This indicates that the intermolecular interactions between PVDF and DMAc are temperature-sensitive and more important in stabilizing conformations of PVDF in crystalline phase. Besides, uniaxial stretching greatly enhances piezoelectric properties of the film. This result is similar to Naarayan, S.S., *et al.,* (2005) studied the Electromechanical Behavior of Form I Uniaxially and Biaxially Stretched PVDF. They found that the piezoelectric constants increased in the longitudinal direction with increasing superimposed strains and decreased in the transverse direction for uniaxially stretched PVDF (Figure 2.3 and 2.4).

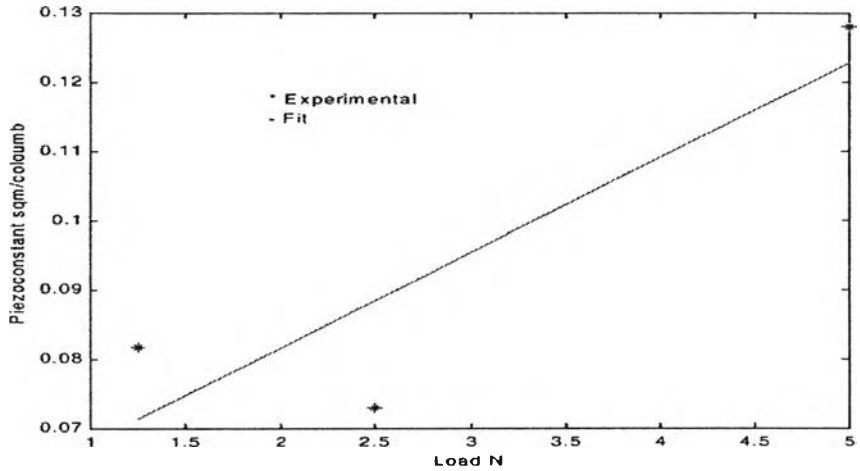

Figure 2.3 Piezoelectric constant of Uniaxially stretched sample in the longitudinal direction at various superimposed loads for frequency of 12 Hz.

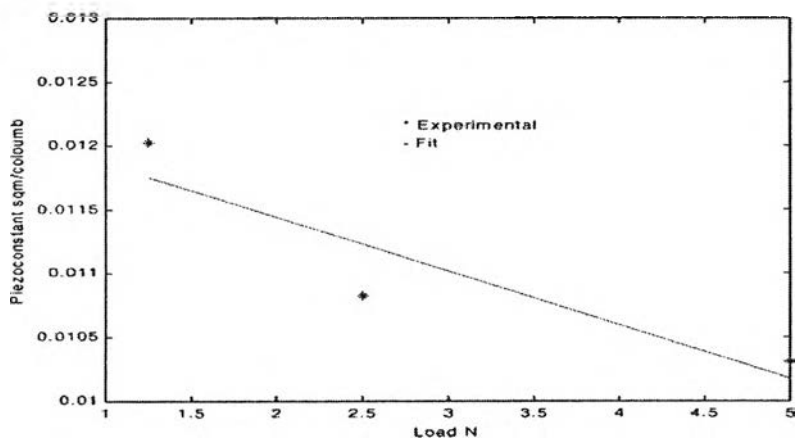

Figure 2.4 Piezoelectric constant of uniaxially stretched sample in the transverse direction for different superimposedload at 12 Hz frequency.

Judovits, L. (2006) studied thermal analysis of poly(vinylidene fluoride) film. This result found that from most part analysis of his research showed the unconstrained film leads to the melting properties of a relaxed material. The relaxation that takes place upon heating seems to mask any reorganizational response.

Mohammadi, B., *et al.*, (2007) studied effect of tensile strain rate and elongation on crystalline structure and piezoelectric properties of PVDF thin films.

They found that the highest piezoelectricity at certain poling conditions was obtained for stretched films due to β phase crystal orientation, which provided uniform lattice dipole moments of crystals.

2.3 Piezoelectric Composite

Olszowy, M., (1997) studied Polymer/ceramic films composites with 0-3 connectivity pattern have been produced by introducing fine grain $BaTiO_3$ powder in the matrix of PVDF. The results of measurements of the piezoelectric parameters and the dielectric properties of the PVDF/$BaTiO_3$ mixture depended on the volume fraction for $BaTiO_3$. When the volume fraction of $BaTiO_3$ increased, piezoelectric parameters and the dielectric properties also increased. Adikarya, S.U. *et al.*, 2002; Hilczer, B. *et al.*, (2005) also confirmed piezoelectric parameters and the dielectric properties of the composite mixture depended on the volume fraction for ceramic.

Dang, Z.M. *et al.* (2003) studied dielectric behavior of CF (carbon fiber)/(PVDF + $BaTiO_3$) composite. The dielectric properties of composites containing CF in (PVDF + $BaTiO_3$) matrix as a function of the frequency and the volume fraction of CF were studied. They found that dielectric constant had a weak dependence on the frequency below 1 MHz and increased rapidly when the CF content was very close to the percolation threshold. The temperature had little effect on the variation of the dielectric constant .In the next year Dang, Z.M. *et al.* (2004) studied dielectric behavior of MWNTs(multi wall nanotubes)/(PVDF + $BaTiO_3$) composites. The results were the same as last report that the dielectric measurement results show that the effective dielectric constant of the composite is slightly dependence on the frequency below 1 MHz but increases rapidly with the MWNTs concentration when the concentration was very close to the percolation threshold. However dielectric constant of PVDF + BaTiO3 composite which filled MWNTs had high dielectric than CF. Gimenes, R. *et al.*, (2004) studied PVDF-TrFE/BT composite used as bioactive membranes. They confirmed results of Olszowy, M., 1997 that increasing of the volume fraction for $BaTiO_3$ increased dielectric constant, however the thickness and flexibility of these composites with the larger ceramic fraction was significantly affected. The thickness increased with ceramic fraction whereas the flexibility decreased. The result of treating commercial barium titanate powder at

creased. The result of treating commercial barium titanate powder at1200 °C presented adequate morphology and particle size distribution for composites manufacture. The solvent casting method and hot pressing method can be a good alternative to produce the composite 0-3 connectivity type, due to easiness of manufacture, homogeneity, smooth surfaces and complete removal of solvent. From these literature reviews, variety of BT composites has already been done by many research groups. Whereas BST which offers superior properties than those of BT still shows less work in composite field. Therefore, it would be a new challenge to investigate the BST/PVDF composite.