Exercises N8 08.04.2025 ThermoElectroMechanics

In all the exercises, the material used is $BaTiO_3$ in its tetragonal phase $4mm$. The 4-fold axis is always directed along the x_3 axis. You may use the table of values for $BaTiO_3$ given below if needed.

s_{11}	$8.05 \times 10^{-12}\ \mathrm{m^2/N}$	d_{15}	$392 \times 10^{-12}\ \mathrm{C/N}$
s_{12}	$-2.35 \times 10^{-12}\ \mathrm{m^2/N}$	d_{31}	$-35 \times 10^{-12}\ \mathrm{C/N}$
s_{13}	$-5.24 \times 10^{-12}\ \mathrm{m^2/N}$	d_{33}	$86 \times 10^{-12}\ \mathrm{C/N}$
s_{33}	$15.7 \times 10^{-12}\ \mathrm{m^2/N}$	K_{33}	150
C	$2.42 \times 10^6\ J/(m^3 \cdot K)$	p_3	$-5 \times 10^{-4}\ C/(m^2 \cdot K)$
α_3	$3.5 \times 10^{-5}\ 1/K$		

8.1. The effect of mechanical conditions on the pyroelectric response is measured. To do it, the (001) surfaces of the parallelepiped $BaTiO_3$ sample are covered with electrodes, and the change of the surface charge, driven by the temperature change, is measured (**Fig.1**).

In measurement **(a)**, the sample is kept mechanically free.

In measurement **(b)**, the sample is kept mechanically free in the x_1 and x_2 directions, while the motion in the x_3 direction is blocked.

Find the difference between the pyroelectric coefficients $p_{(a)}$ and $p_{(b)}$ measured these two ways (provide the answer in the analytical form)

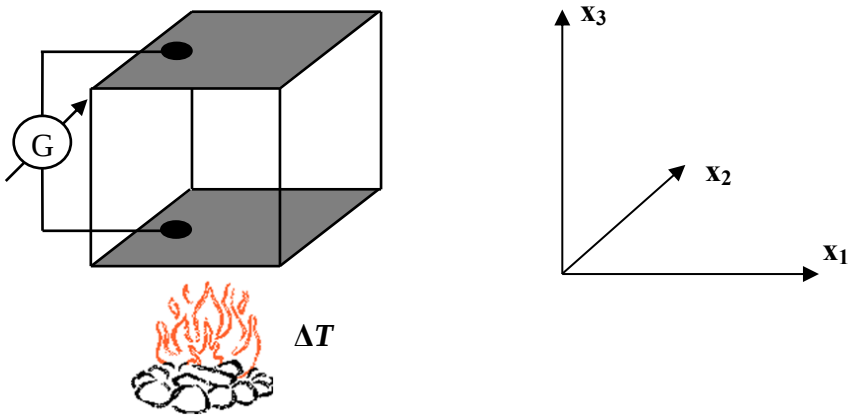

Fig.1. BaTiO3 sample for pyroelectric measurements.

8.2 The material used is $BaTiO_3$ under isothermal conditions.

The effect of mechanical conditions on the capacitance is investigated. To do it, the (001) surfaces of the parallelepiped $BaTiO_3$ sample (distance between the (001) faces is L , the area of each (001) face is S) are covered with electrodes (**fig.2**), and the capacitance of the sample is measured.

In measurement **(a)**, the sample is kept mechanically free.
In measurement **(b)**, the sample is kept mechanically free in the x_1 and x_2 directions (i.e., in plane of capacitor), while the distance between electrodes L is forced to not change.

Show that the two measured capacitances $C_{(a)}$ and $C_{(b)}$ have different values. Calculate the relative difference between them $\frac{C_{(a)}-C_{(b)}}{C_{(a)}}$. All measurements are done at constant temperature.

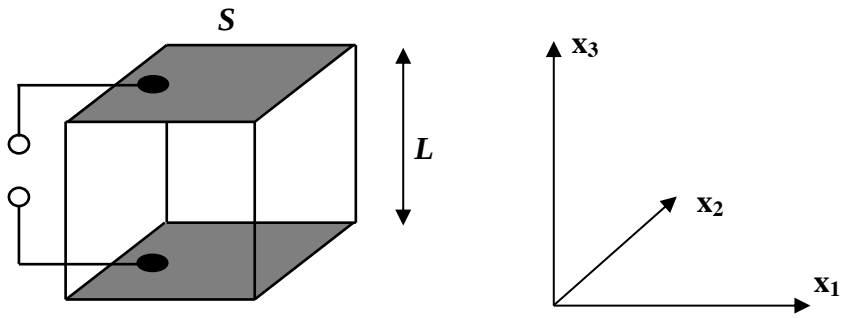

Fig. 2. $BaTiO_3$ sample for capacitance measurements.