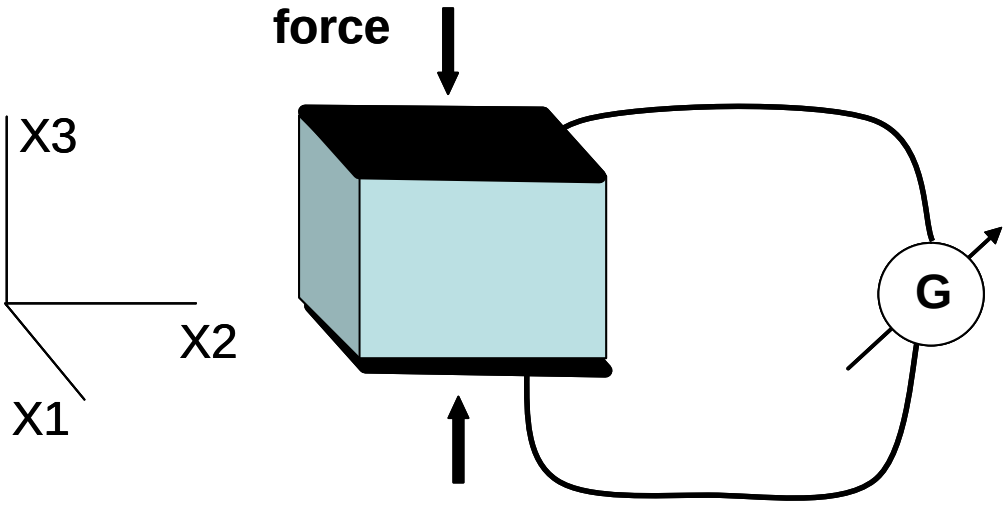
Exercises N6 25.03.2025 Piezoelectricity

6.1 A plate of GaAs (material of point symmetry $\bar{4}3m$) is tested for the piezoelectric effect in a set up where the plates of the capacitor are parallel to (001) plane of the crystal. The sample can freely expand in X1 and X2 directions as shown in the figure. Will the material show the piezoelectric response in such setup? Prove your answer.



6.2 Show that, in the group 432, the piezoelectricity is forbidden by symmetry

6.3 Is the piezoelectricity allowed by the $\infty\infty$ symmetry of a material?
(for your analysis you can use the results from previous exercises)

6.4

At room temperature $BaTiO_3$ is a piezoelectric. For this reason, the application of an electric field to a sample of $BaTiO_3$ leads to its deformation and to a change of its volume. Will the crystal increase or decrease its volume, if the field is directed:

(a) along the $[111]$ direction?

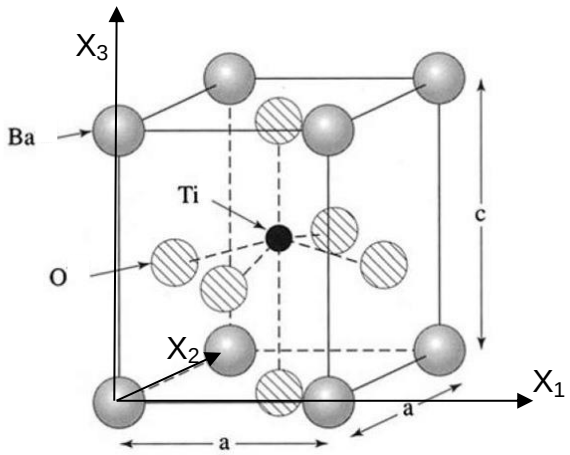
(b) along the $[11\bar{1}]$ direction?

The sample is mechanically free and its temperature is always kept constant. x_3 axis is directed along 4-fold axis (see **Fig.1**). For this reference frame, the piezoelectric tensor of $BaTiO_3$ (point symmetry 4*mm*) has 3 independent components at room temperature: d_{33}= 86 pC/N; d_{31}= - 35 pC/N; d_{15}= 392 pC/N

***Additional information*:** the relative change of volume of a sample deformed with the strain ε_{ij} is equal to its trace ε_{ii}

$\varepsilon_n = d_{in}E_i$ – converse piezoelectric effect.

Recommendation : to calculate the component ***E3*** use the cubic approximation i.e. assume that vector ***E*** is parallel to the diagonal of the cubic cell



6.5 Read the paper "Induced giant piezoelectricity in centrosymmetric oxides". Explain the mechanism of piezoelectric response that has been reported in a centrosymmetric material (where it is normally forbidden)