SC-221

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0.1 Question 1:

Piezoelectric material is kept under an external electric field E by applying a voltage across a piezoelectric material which leads to "electrical pressure" inside the atoms. They have to be re-balance themselves and that is what causes piezoelectric material to slightly change their shape. The following stresses are produced:

- piezoelectric stress
- elastic stress
- viscous stress (The stress due to internal friction is usually considered proportional to the gradient of the particle displacement velocity, as in the case of a viscous phenomenon)
- mechanical stress

0.2 Question 2:

Let the material be lying in an external electric field E. The application of an electric field on a piezoelectric material causes a deformation in the material's structure given by

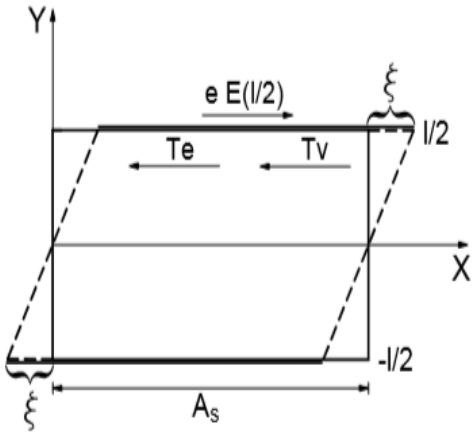
$$S_p = d * E$$

the electric field E exerts a force on the material's internal structure generating a stress given by

$$T_p = e * E$$

This stress is, definitely, the one that produces the strain and is of opposite sign to the elastic stress which tends to recover the original structure.
The elastic stress produced is

$$T_e = c * S_p$$



The strain S is defined as the gradient of the particles displacement in the direction considered. Thus, if the displacement that the particles experience along a distance y is ζ(y), the strain produced along this section will be:

$$S = \frac{\zeta}{y}$$

The stress due to internal friction is usually considered proportional to the gradient of the particle displacement velocity, as in the case of a viscous phenomenon

$$T_v = \eta \frac{dv}{dy} = \eta \frac{dS}{dt}$$

The resultant stress is:

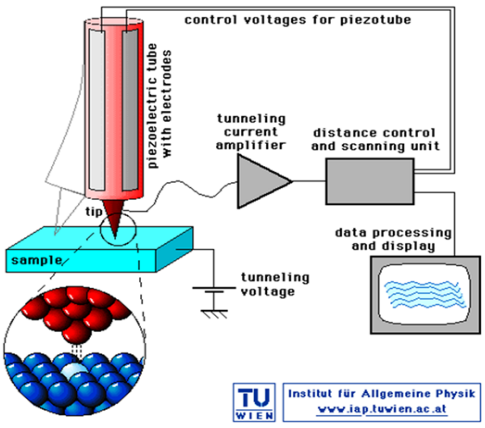
$$T_p - T_e - T_v = eE - cS - \eta \frac{dS}{dt}$$

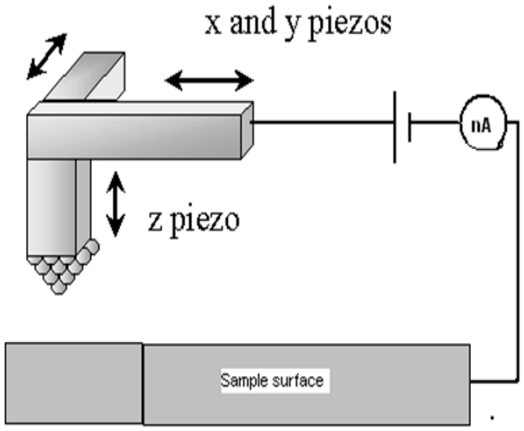
0.3 Question 3:

A STM consists of a piezo drive, which consists of three mutually perpendicular piezoelectric transducers: x piezo, y piezo, and z piezo. Upon applying a voltage, a piezoelectric transducer expands or contracts. One controls x-y piezo to scan in xy plane and uses coarse positioner and z piezo to bring the tip and the sample within a few angstroms.

STM use inverse piezoelectric effect, i.e., by applying voltage on the material and the material deforms. The piezoelectric materials used in STM are various kinds of lead zirconate (PbZrO3) or lead titanate ceramics (PbTiO3) or PZT(lead zirconium titanate) since these would have a larger piezoelectric coefficient. The applied voltage makes the element longer or shorter. The combination of three piezo elements makes it possible to move the STM tip in the X-, Y-, and Z-directions.

The STM uses a tip that ends in a single atom and a voltage is passed though the tip and the sample. The current that results depends upon the distance between probe tip and sample surface. The tip is attached to a piezoelectric tube and voltage applied to the piezo rod is altered to maintain a constant distance for the tip from the surface. Changes in this voltage allows a three dimensional picture of the material surface to be built up as the tip is scanned back and forth across the sample. It is possible to accurately control the relative positions of tip and surface by using sensitive piezoelectric positioning device.




x and y piezos
nA
z piezo
Sample surface