Piezoelectric Effect

Experimental

Piezoelectricity is the ability of certain materials to produce a voltage when subjected to mechanical stress. Piezoelectric materials also show the opposite effect, called converse piezoelectricity, where application of an electrical field creates mechanical stress (size modification) in the crystal.

Figure 1 Piezoelectric effect

The effect known as piezoelectricity was discovered by brothers Pierre and Jacques Curie; they showed that crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt (sodium potassium tartrate tetra hydrate) generate electric charge from mechanical stress. Quartz and Rochelle salt exhibited the most piezoelectricity.

The class of piezoelectric materials was enlarged, when was observed that many other materials exhibit the effect, like berlinite (AlPO4) and gallium orthophosphate (GaPO4), ceramics with perovskite or tungsten-bronze structures (BaTiO3, KNbO3, LiNbO3, LiTaO3, BiFeO3, NaxWO3, Ba2NaNb5O5, Pb2KNb5O15). Later was observed that polymer materials like rubber, wool, hair, wood fiber, and silk exhibit piezoelectricity to some extent. The polymer polyvinilidene fluoride, (-CH2-CF2-)n, exhibits piezoelectricity several times larger than quartz.

Background and actual explanation

In a piezoelectric material, the positive and negative electrical charges are separated, but symmetrically distributed, so that the crystal overall is electrically neutral. When a stress is applied, this symmetry is destroyed, and the charge asymmetry generates a voltage.
In reverse effect, when an external voltage is applied, on such crystal, because the charges inside the crystal are separated, the applied voltage affects different points within the crystal differently, resulting in the distortion and size modifications.
The effect was studied by Curie brothers before 1900, using a quadrant electrometer and a piezoelectric crystal subjected to an external force.
It was considered a curiosity when was discovered, but in time, the effect gained a lot of applications.
Except of an ulterior classification of piezoelectric substances depending on the type or crystal symmetry, no significant advancements were registered in a quantum treatment of this subject. The quantum mechanic theoreticians are able to apply the quantum idea to a lot of cosmic phenomena, but none was able to apply it to piezoelectric effect. Books of physics or physical chemistry omit the topic completely. Maybe instead of cutting leaves to the dogs, some theoreticians will give a complete quantum treatment of this simple effect. The subsequent text will present some ideas important for actual theoreticians and for a future quantum theoretical treatment.

Why the actual explanation is absurd

In actual orthodox explanation, it is not clear what does it mean a charge separation in a crystal, and where this charge is generated.
In any material (piezoelectric or not), electrons are bound on nucleus with strong electric forces. In order to remove an electron from an atom, it is necessary to give at a specific atom an energy greater then ionization energy. Considering a quartz crystal, which is simply a variety of silicon dioxide, in order to produce a charge separation it is necessary to give a ionization energy greater then 13,6 eV for a oxygen atom or greater then 8,15 eV for a silicon atom.
An easy to follow math (entire demonstration in the book), will show that external pressure exerted on faces of quartz crystal does not produce the ionization of quartz material.
The actual physicists are not able to explain how is possible to furnish a smaller energy like ionization energy to a quartz crystal, and to obtain a charge separation. Maybe in the meantime, the ionization process is produced as result of quantum tunneling effect?
Let’s analyze in detail this possible charge apparition and its movement. Considering a cube made from a piezoelectric material, two equal forces act on the x dimension as in fig. 2
In the piezoelectric material a small number of compensated (positive and negative) charges are figured. As result of external force, actual orthodox physics suppose a charge separation, but...what kind of charge and where are they appear?

Are the charges appearing only at the surface of compressed material or they appear in entire volume?

Because the atoms are neutral before the mechanical stress, it must be supposed that under force action an equal number of positive charge and negative charges appears. In the same time, it is a common sense concept to admit the immobility of nucleus, and the mobility of electrons.

Let’s suppose for the first case, the charges are appearing only to the surface of piezoelectric material as in fig.3. In this case, on both side of material an equal number of negative charges are available for conduction. A voltmeter connected between these faces should register a null difference of potential. This is because there is no electric charge moving into external circuit. If a „charge” is produced at the surface of crystal, the potential of both surfaces modify simultaneously and no potential difference appear. The result is in contradiction with experiment.
Maybe actual theoreticians are able to demonstrate that positive nuclei are traveling around circuit?

A second possibility regards generation of charges in the entire volume of piezoelectric material as in fig. 4.

With such distribution, an electron generated somewhere inside piezoelectric material, with an energy greater than ionization energy, will leave its nucleus and...
be soon attracted by another nucleus. There is an equal probability for electrons to arrive on a face of crystal; again no potential differential should appear on crystal surface.

Of course, there is a possibility for generated electrons to groups and to travel to one of crystal surface, but in this case actual theoreticians should provide a mechanism able to produce an electron grouping in a region of piezoelectric material. For a common sense mind, it is completely absurd to believe that such charge distribution permit a grouping of positive charge into a spatial region and negative charge in another region. In proposed theory, there is no reason for a charge separation apparition on a crystal surface and in fact, in reality, there are no such phenomena as result of a mechanical force action.

The case is not a singularity in actual physics… When two materials are rubbed one another, actual physics suppose a charge generation. The problem is … rubbing does not produce enough energy to remove an electron from a nucleus. But who cares? For actual physics it is important to have an explanation and not a coherent one.

In the frame of actual physics, in the book, a simple exemplification of how a small force (mechanical) is able to break a more potent force (electrical) which keep electrons around nucleus. It seems that a new physics must be proposed by actual theoreticians, where the Newton laws are ruled out, in order to fit with piezoelectric effect results.

Another problem regards the charge acceleration and electromagnetic wave generation. As result of a mechanical force, in actual explanation some positive charges are supposed to be separated by negative charges. This separation means in fact charge acceleration (electrons or nuclei). In the same time a well known postulate of classical electrodynamics affirms that an accelerated charge emits electromagnetic waves. What kind of electromagnetic waves emit a piezoelectric material? In microwave? In radio? In infrared, VIS or UV?

Does the emitted photon is correlated with the applied force? With other words a smaller mechanical force produce a microwave photon and a greater force produce a VIS or UV photon?

I leave to actual theoreticians the pleasure to formulate an answer at this simple problem.

A further problem is related to: How the piezoelectric effect fits with quantum hypothesis?

Similar to another well known physic effect (photoelectric effect), if the quantum hypothesis is valid, the potential difference should appear only when the pressure acting on crystal overpasses a certain limit. Does this thing happen in reality? It is well known from the time of Curie’s experiments that generated potential is related to applied pressure, without a threshold pressure for generated potential. In the book, the experiments are repeated and described in details, and no threshold pressure for piezoelectric potential apparition was observed. Therefore, a „common mind” explanation of piezoelectric effect will ruled out either quantum hypothesis and an ionization process in quartz crystal. There is no electron removed from silicon or oxygen atom.
The pyroelectricity is closely related to piezoelectricity, and expresses the ability of certain materials to generate electrical charge when heated. The same discussion made for piezoelectric effect is valid for pyroelectricity. It is absurd to believe that a temperature of 200°C is able to produce ionization in a material. The entire discussion is presented in the book.