HIDDEN POWER

PIEZOELECTRICITY

How does changing a material's shape make electricity?

Question & Answer Fact Sheet

What is piezoelectricity?

Piezoelectricity is an electric charge that accumulates in certain materials when their shape is distorted by an applied force. The types of materials that support this effect are called piezoelectrics. When a force is applied, the atoms in that material redistribute, causing a redistribution of electric charge. This charge redistribution causes polarization (the net separation of positive and negative charges – an electric potential). The accumulated charge can then be used to provide an electrical current.

Piezoelectricity is a form of energy transfer in which mechanical energy is converted into electrical energy, and visa versa. Because the process is reversible, an applied current (electrical energy) can also cause a piezoelectric material to become strained and change shape (mechanical energy).

What kinds of common devices or applications utilize piezoelectricity?

Piezoelectrics are currently used in everyday devices, as well as devices used for testing other things. They act primarily to convert a mechanical signal, such as a sound wave or the impact of a hammer, into an electrical signal that can be analyzed by the user of the technology. Some examples are: microphones, time keeping devices, electric guitar pick-ups, electric lighters (such as the one in a barbeque grill), touch screens, medical ultrasound imaging, fuel injectors, and airbag deployment sensors.

In the future, piezoelectrics may be used for energy harvesting. For example, charge collected from a vibrating piezoelectric dance floor could be used to power the lights or sound system, or the act of typing on a piezoelectric computer keyboard could be used to partially power the computer itself.

What are some examples of how piezoelectricity has made a major impact on our society?

Piezoelectricity has allowed the development of many current technological advances. One example is ultrasound imaging, in which piezoelectrics both generate and sense an ultrasonic wave (a type of mechanical sound wave with a frequency above the human range of hearing).

Ultrasound technology is used to produce an image of a baby while still in its mother's womb.

The piezoelectric first converts an electrical input signal into an ultrasonic wave, which enters the patient's body. The waves strike the tissues and organs of the body, reflecting back differently from each one. When the ultrasonic wave returns back to the device, the piezoelectric then converts the vibration back to an electrical signal. This signal is processed and the result is an image of the body's tissues. The best piezoelectric materials today, such as lead zirconate titanate, contain the element lead. Researchers are now searching for non-lead based piezoelectrics that can match the performance of lead based piezoelectrics.

Another technology made possible by piezoelectrics is sonar detection that is used to map the ocean floor. Tiny micromotors and drill bits powered by piezoelectrics can precisely and safely perform delicate surgical operations such as replacing opaque cornea of the eye, making these procedures less error prone than when they were reliant on the skills of a surgeon. Finally, piezoelectric actuators and sensors are used to control the tips of atomic force microscopes, which are so sensitive that they can image individual atoms.

What's happening on the cutting edge of research in this area right now?

Engineers are working on increasing the maximum frequency at which a piezoelectric can vibrate. This will allow sensors and resonators that are used in applications such as microphones and medical imaging devices to be operated at a higher frequency, thereby producing sharper images.

The greater the shape change you can get out of a piezoelectric from an applied electric field, the more potential applications there will be for that material. Scientists are trying to create new materials that maximize shape change with a minimum applied electric field. Similarly, scientists are also finding ways to maximize the electrical output for a minimum amount of applied load.

In addition to searching for new piezoelectric materials that do not contain lead, researchers are exploring if other phenomena such as flexoelectricity can give the same performance as the current piezoelectrics. Flexoelectric materials can generate charge when bent or flexed.   Unlike piezoelectricity, which exists only in certain material structures, this phenomenon exists in all materials.

Piezoelectrics in the news:

Ammu Kannampilly, "How to save the world one dance at a time," ABC News: July 11, 2008, http://abcnews.go.com/International/story?id=5358214&page=1

Pawel Piejko, "New discovery might lead to laptops powered through typing," gizmag: June 23, 2011, http://www.gizmag.com/self-powered-battery-piezoelectrics-rmit-research/19007/