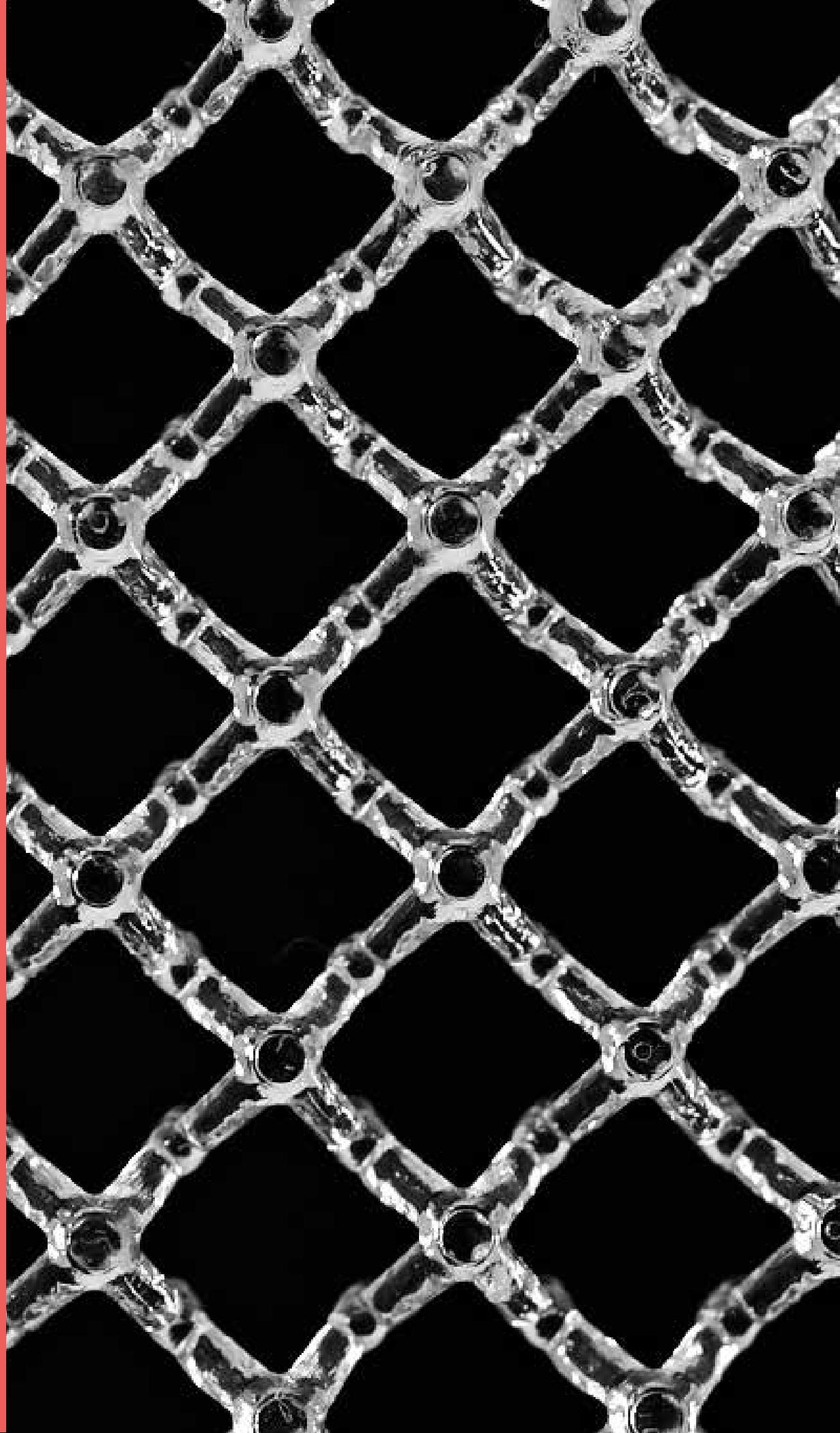


Piezoelectric Materials

101 Material
Report

Material ConneXion®
A SANDOW Company



What you need to know



01 Introduction

Piezoelectric materials have been used since the 1800s and ubiquitously in the late 20th century. We make use of them every day, but the process by which they work and how else they could be potentially used is not widely known. This report aims to serve as an introduction into the concept of piezoelectricity and how it can be used to harness useful energy. Through this introduction, you will also obtain an insight into how piezoelectricity can be integrated into your products and designs.

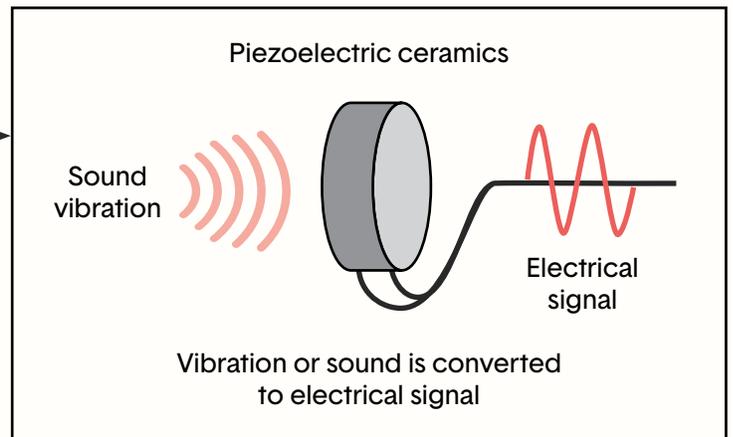
02 What are Piezoelectric Materials?

Piezoelectricity (piezo: pressure) is essentially electricity resulting from pressure. It is the ability of materials to produce an electrical current from mechanical stresses such as compression, flexing, or extension. This is called direct piezoelectric effect. This effect is typically reversible; piezoelectric materials can also mechanically change shape when an electric current is applied. This is called the reverse piezoelectric effect.

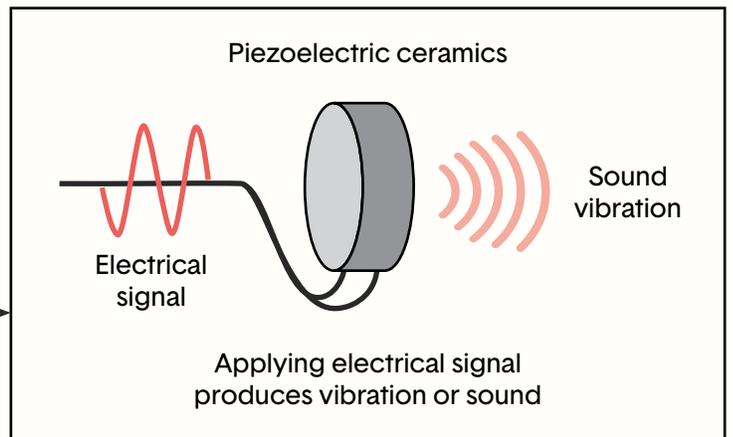
The Piezoelectric Effect

PIEZOELECTRIC EFFECT

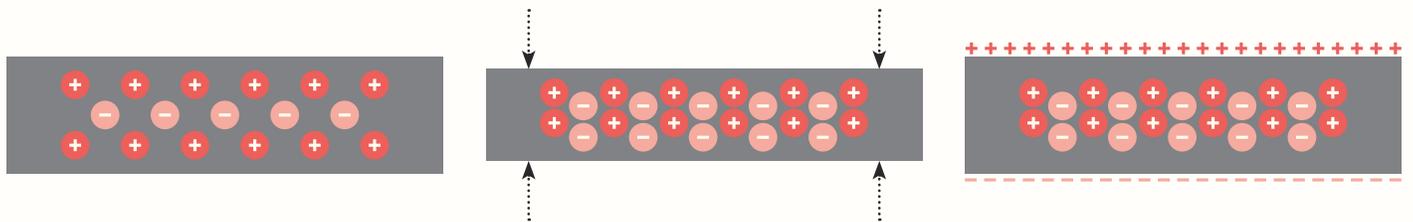
DIRECT EFFECT
Mechanical strain produces a voltage



REVERSE EFFECT
Applying a voltage produces a mechanical strain



How does it work?



The Piezoelectric Effect

The piezoelectric effect occurs in a material when the charge balance within it is disturbed. When there is no applied stress, charges within the material (because ceramics have both metallic and non-metallic elements, they have both ionic and covalent bonds and thus a potential for difference in electrical charge due to valence electrons) are evenly distributed and there is no potential difference and no current. A mechanical stress or force distorts the molecular arrangement of the material and upsets the charge balance, thereby creating a potential difference and small current in the piezoelectric material. The reverse effect occurs when an electric current causes the atoms in the material to move and deform slightly.

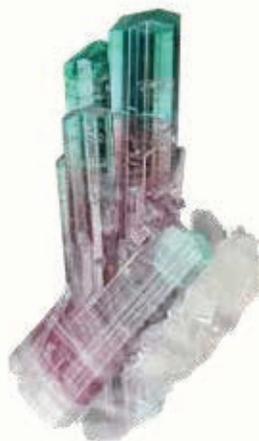
What Types of Mechanical Forces Can Generate Electricity?

In addition to compression, twisting, flexing, and stretching sound, which is actually the vibration of air molecules, can also power piezoelectric materials.

Types of Piezoelectric Materials

Piezoelectric materials can be categorized on the basis of source and type of material. Such materials can be of natural or synthetic origin. The material types are single crystals, ceramics, polymers, or composite variations of piezo ceramics or polymers.

Synthetic piezoelectrics include ceramics such as barium titanate or lead zirconate titanate (aka PZT, the most widely used and known piezo material), crystals such as gallium orthophosphate and langasite, and polymers such as polyvinylidene fluoride (PVDF). Natural piezoelectric crystals include cane sugar, quartz, and tourmaline.



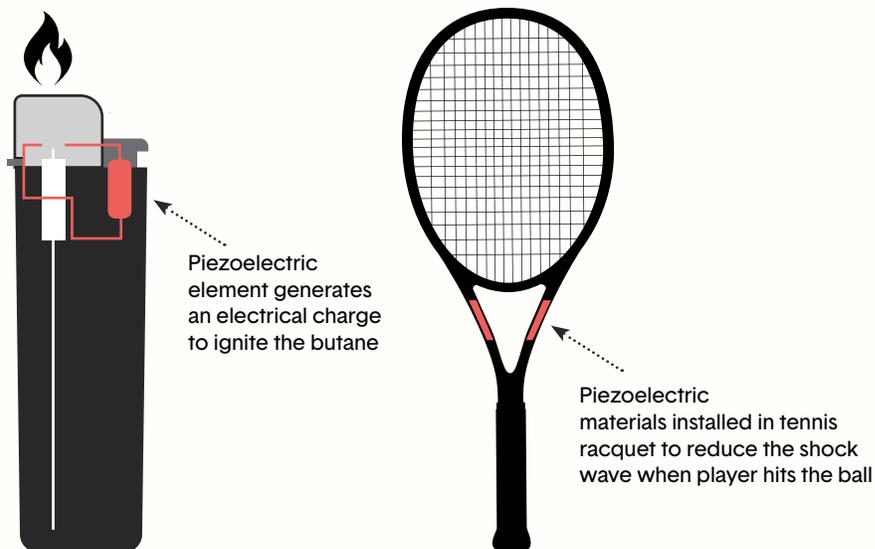
TOURMALINE



QUARTZ

The Piezo Effect in Everyday Products

Piezoelectric materials aren't just used in advanced applications. They're actually present in some products and devices we interact with on a daily basis. Some examples are cigarette lighters, wristwatches, ultrasound imaging, shock absorbing tennis racquets, and microphones.



Using Piezoelectric Materials

Piezoelectric materials can be integrated into your designs and products in many different ways. There are virtually no restrictions on the variety of potential geometries for piezoelectric materials. There are four formats in which piezoelectric materials and devices are created commercially: coatings and films, panels, beads, and foams.

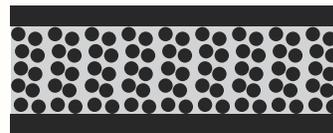
Coatings, Films, and Tapes



Touch panel with pressure detection (the capacitive touch panel and pressure detection piezoelectric film are integrated into a single unit)

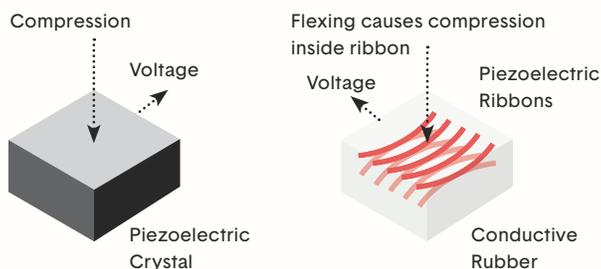
Most often used in pressure- and touch-sensitive hardware, such piezoelectric materials are primarily piezoelectric polymer- and composite-based. These material films or layers are often applied in combination with a metallic electrode layer.

Beads



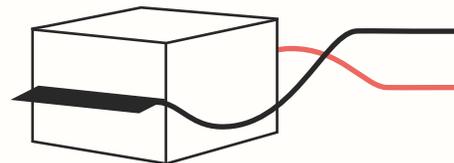
Beads are a form of piezoelectric composites where crystals are integrated in polymer or ceramic substrates, which are further used as part of other devices such as nano-generators.

Panels



Panels are the most common form for piezoelectric sensors and devices. These forms are available in flexible and rigid variants by embedding piezoelectric crystals and ceramic and rigid substrates respectively.

Foams



Piezoelectric crystals and particles are added to the base material and subsequently foamed to create such products. Their rigidity, base material, and density can be altered.

Power of Piezo



An important consideration in energy harvesting is to understand actually how much current a piezoelectric crystal or device can generate per unit of compression. This is also a measure of the efficiency of such devices. An average person weighing 60kg, in one step on a piezo-tile produces enough power to light a small LED, which is about 0.1 watts. Individually, piezoelectric crystals produce very small currents, but large-scale applications (such as a dance floor or a subway entrance) combined with energy storing can power fairly large,

energy-hungry applications. The potential of piezoelectricity in small applications is highly cost- and efficiency-dependent, but this concept does provide a green solution for power generation in large-scale projects.

References

***Piezoelectric Materials
and Devices: Applications
in Engineering and
Medical Sciences***

By M. S. Vijaya

***Piezoelectric Ceramics:
Principles and Applications***

By APC International, Ltd

Fundamentals of Piezoelectricity

(Oxford Science Publications)

By Takuro Ikeda

Learning Guide

Discussion Questions

What aspect of the report surprised you the most?

What is the difference between the Direct and Reverse Effect?

How much power can a single footfall on a piezo panel create?

How are piezo foams created?

Short Answer Questions

What does PZT stand for?

Name three types of naturally occurring piezoelectric materials.

What are four different commercially-used formats for piezo materials?

When was the first piezo used?

What are some forces that can be used to create electricity in piezo materials?

Name four products that use piezos.

Learning Guide

Long Form Essay

Provide ideas and justifications for a product range that uses piezoelectric materials to reduce environmental impact. Consider the short-term and long-term impacts of the technology and how this technology might be adapted for different situations.

Team Activity

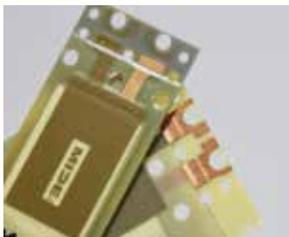
You are designing a product for office use that helps workers have better posture, either sitting or standing.

Design the product and show how the piezoelectric materials are used.

Ensure that the format is correct for each application.

Are there other areas where this technology could be used?

Materials relevant to this report



**PPA Energy Harvesting
MC 7741-01**

These transducers enable easy "energy harvesting", by using a piezo incorporated into stiff and springy glass fiber composite. Bend the composite, create the charge.



**CX6™
MC 7376-01**

Carbon fiber sheets that lend themselves to effect substrates for piezo performance. The ability to tailor stiffness in specific areas means that this material can be part of a larger construction.



Amazon 1

Piezoceramic disks that work as buzzers in electronic devices. The brass gasket ensures a durable product, with the central ceramic core that vibrates when charged electrically.



Amazon 2

Disks manufactured from piezoceramics that can be used as part of a product as a physical buzzer. The disk is charged and vibrates at a specific frequency, acting as an audible signal for alarms, beepers, and for consumer electronic devices.



Amazon 3

Naturally occurring piezoelectrics (from pure quartz) that, when struck together, elicit an electrical response, creating a spark.