January, 2021

Flat but bumpy?
Vibration technology with piezoelectric actuators enabling a flat design

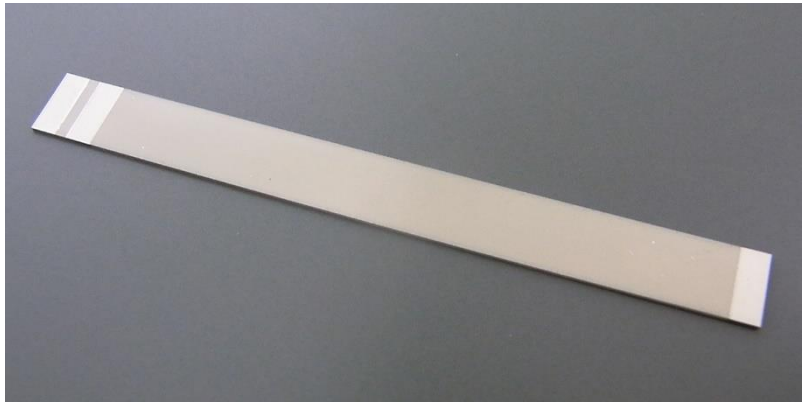
Featuring piezoelectric devices, this issue deals with their application in layered piezoelectric actuators. What is a piezoelectric device? What is the mechanism governing a layered piezoelectric actuator. We will introduce you to the wonder of this interesting material.

01 Piezoelectric device, a material with two aspects

Some of you are hearing this name for the first time. It sounds complicated, but it is just a component that generates vibrations.

A general component that creates vibrations is a motor vibrator used for smartphones. It uses an eccentric motor with a weight focus off the center of gravity. A layered piezoelectric actuator is also a vibration device, but its greatest feature is that the source of vibration is a piezoelectric element.

*** Actuator**
A device for converting electric energy to physical energy (rotation, vibration, etc.) such as a motor.



▲Layered Piezoelectric Actuator
A piezoelectric element and electrodes enclosed in a sheet

The piezoelectric element, the vibration source, has very interesting characteristics.

Depending on the type of energy applied, it represents two opposite effects: a piezoelectric effect and an inverse piezoelectric effect.

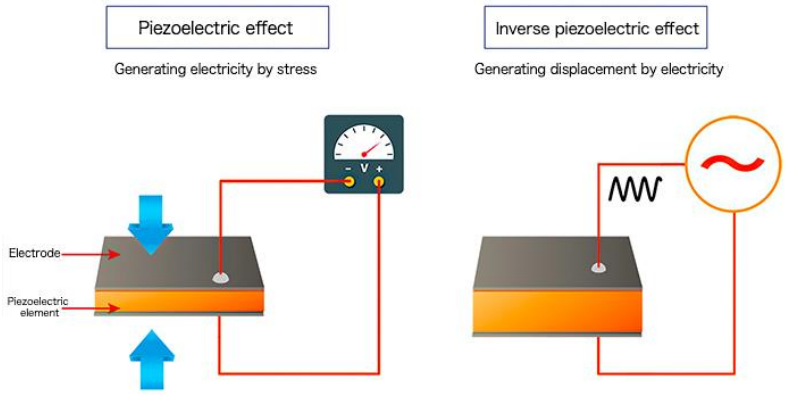
(1) Energy: pressure

Applying pressure to a piezoelectric element generates electricity, which is called a piezoelectric effect.

(2) Energy: voltage

Applying a voltage to a piezoelectric element generates a vibration, which is called an inverse piezoelectric effect.

A layered piezoelectric actuator is a vibration device that uses the inverse piezoelectric effect in which applying a voltage generates vibrations.

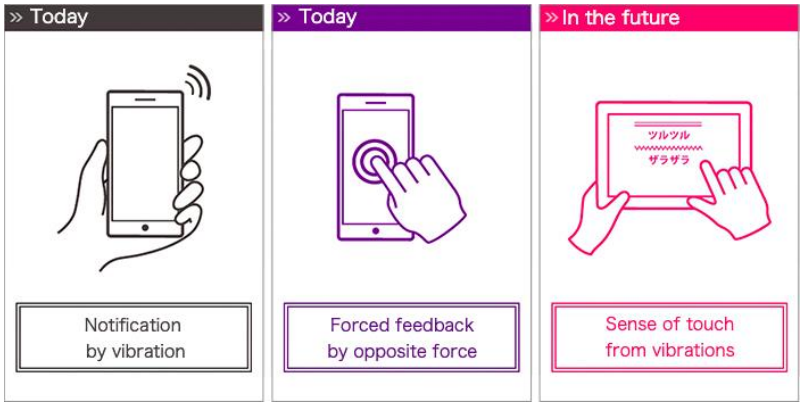


▲Piezoelectric Effect and Inverse Piezoelectric Effect (Schematic)
The inverse piezoelectric effect (right) generates vibrations from voltage.

02 Creating a sense of touch using vibration? Layered piezoelectric actuator technology

From the viewpoint of vibration, the eccentric motor used for a vibrator in a smartphone and a piezoelectric actuator are the same vibration device. However, the piezoelectric actuator has the potential to convert simple vibrations to higher technology.

One of the features of a piezoelectric actuator is forced feedback, which provides a sense of touch by opposing (pushing back) force.
For example, tapping a button indicated on the screen of a smartphone creates a local sense of touch by the layered piezoelectric actuator.
An eccentric motor vibrates the entire smartphone.
However, a layered piezoelectric actuator consists of many small piezoelectric elements, which provides a sense of touch only at the specific location that is pressed.



▲Three Patterns of a Sense of Touch from Vibrations
Forced feedback and sense of touch reproduced by a layered piezoelectric actuator

Forced feedback from opposite force is expected to have applications in different fields.
In addition to implementing it in a smartphone display, the combination of a glove with forced feedback and VR could create a sense of grabbing an object in the image. Moreover, beyond forced feedback, development is underway to reproduce touch senses such as 'rough' and 'smooth' on a display screen.

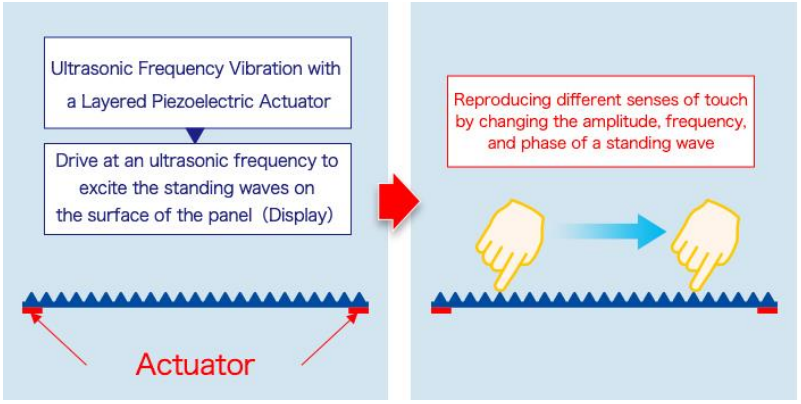
<Mechanism of Sense of Touch by Friction>

・Ultrasonic Frequency Vibration with a Layered Piezoelectric Actuator

・Drive at an ultrasonic frequency to excite the standing waves on the surface of the panel（Display）

・Reproducing different senses of touch by changing the amplitude, frequency, and phase of a standing wave

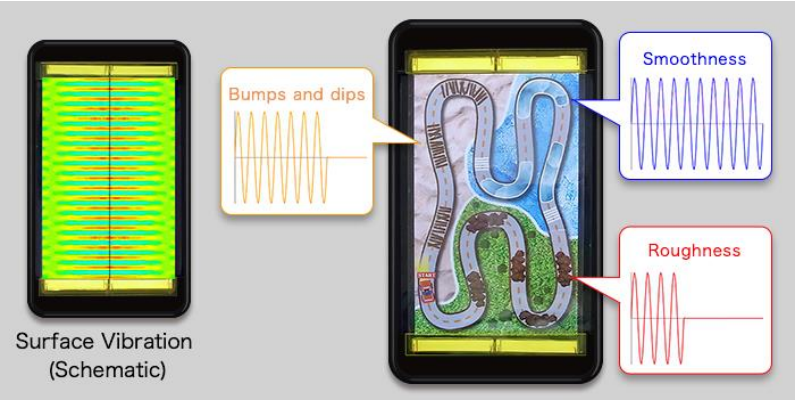
Generating fine vibrations with the layered piezoelectric actuator built in a panel can create a sense of roughness and smoothness.
Changing the intervals and intensity of vibrations reproduces a wide range of touch senses.



▲Standing Wave and Sense of Touch (Schematic)
Stroking the surface of a panel with a generated standing wave creates senses of touch.

There is a demonstration in which stroking the course with a finger creates a sense of bumps and dips, as well as smoothness.

In the future, the combination of a layered piezoelectric actuator and communication technology will enable simulation of senses of touch on a smartphone or tablet.



▲Left: Visualized Suface Vibration on a Panel with a Standing Wave (Schematic);
Right: Actual Demonstration Device and Senses of Touch

03 Millions of applications.
Future of layered piezoelectric actuators

What future will we see by combining the two features of a layered piezoelectric actuator—forced feedback and a sense of touch?

<Automobile Driving with Enhanced Safety>

Today, many physical switches on automobile dashboards are being replaced with a touch panel.
Moving to a touch panel enables integrating all operations, including navigation, audio, and air conditioning to a single location, which enhances operation and design.
However, unlike physical switches, a touch panel has a drawback in that it is difficult to identify the positions of the buttons and feel their operation.
A layered piezoelectric actuator eliminates this drawback and further raises its advantages.
Implementing a layered piezoelectric actuator to a touch panel provides forced feedback, which enables recognition of button operations.

Giving a different feel to each button will reproduce the unique feel of each button, which can be identified without actually seeing it.

▲Touch panel with a button touch (schematic)

<Flat Design of Home Electric Appliances>

Similar to automobiles, using a touch panel with layered piezoelectric actuators in home electric appliances enhances both design and functionality.

Today, most microwave ovens and clothes washers use physical switches. There is a demand for more buttons to provide rich menus. However, the number of buttons cannot be increased since downsizing and sleek designs are sought.

Therefore, like an automobile dashboard, a touch panel with a sense of touch enables both flat design and high functionality, resulting in a more stylish product.

Further enhancing the sense of touch could produce products with universal design such as a Braille touch panel with a sense of touch.

▲More flexible product development and enhanced usability (schematic)

Applications of layered piezoelectric actuators, which are constantly advancing, will expand in the future.

In addition to reproducing the touch of physical switches and applications in games, combining with various products is expected to create new solutions.

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