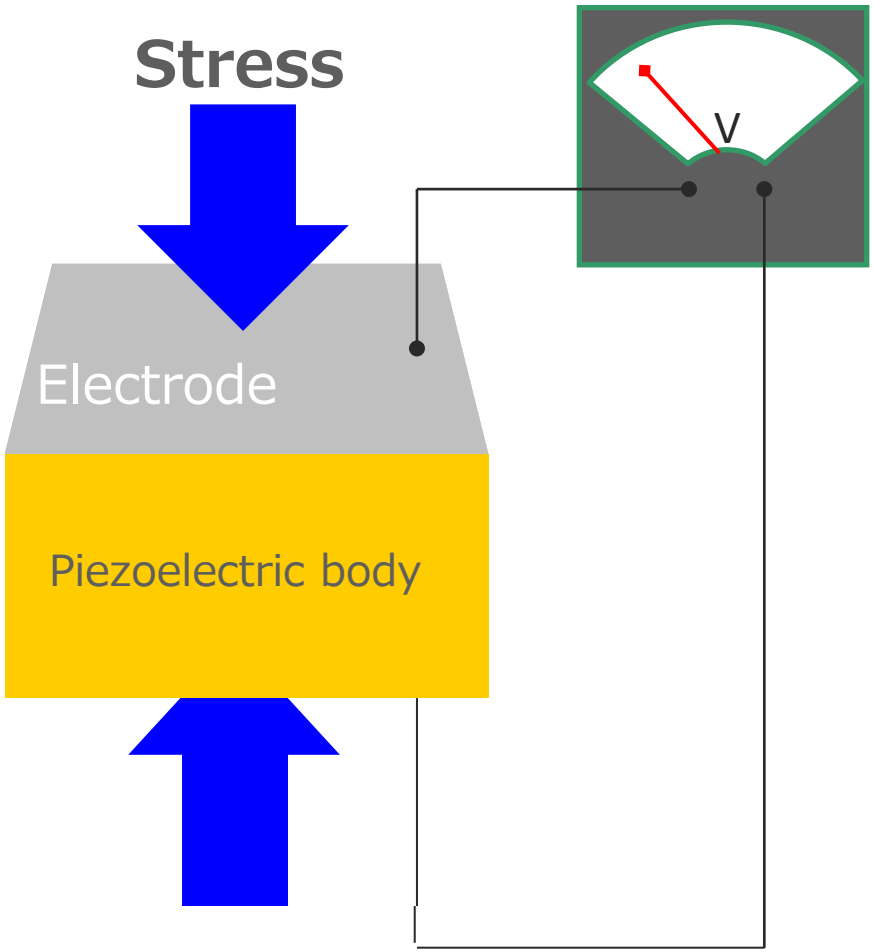
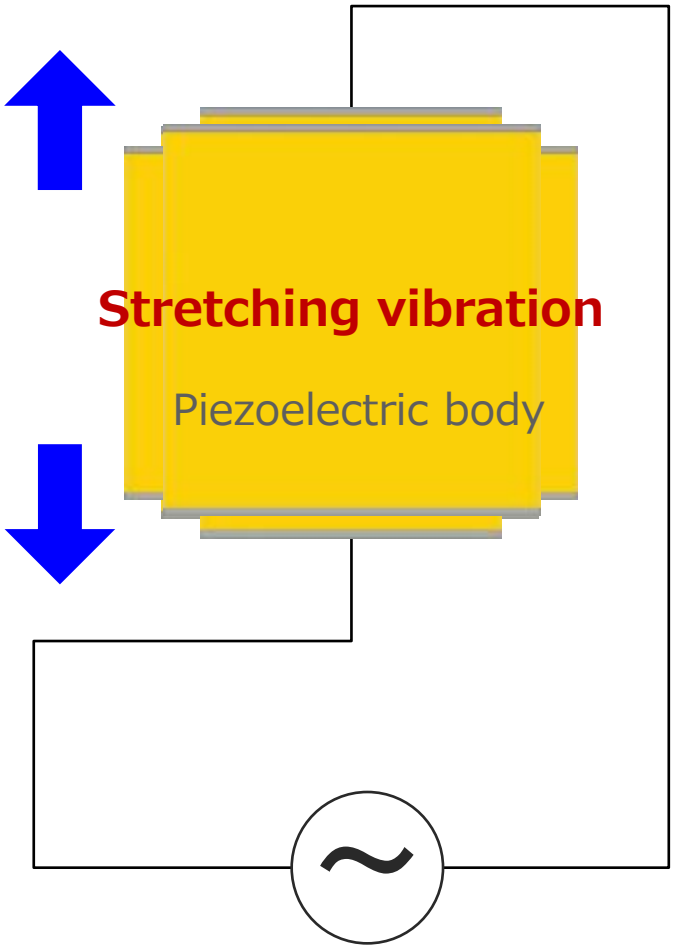
Multi-Layer Piezoelectric Actuators for Haptic Technology

What is a Piezoelectric Body?

Piezoelectric effect:
Voltage is generated when stress is applied to a piezoelectric body

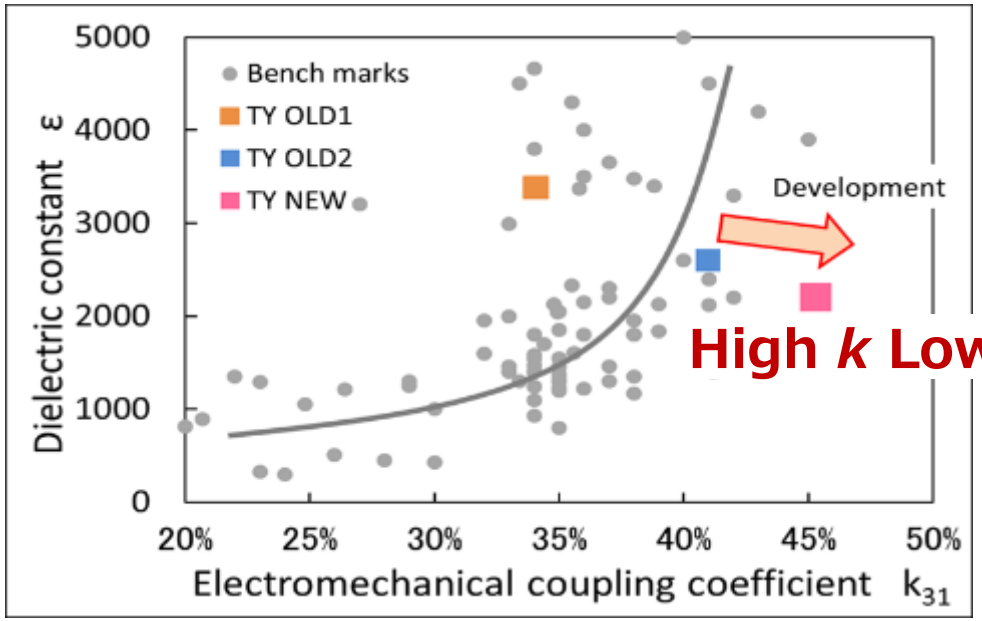


Inverse piezoelectric effect:
When an AC voltage is applied to a piezoelectric body, it is subject to a stretching vibration



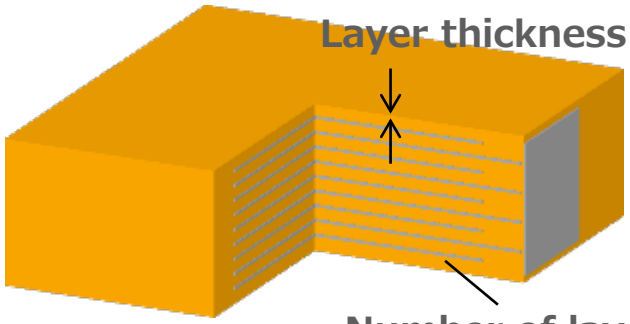
Multi-Layer Piezoelectric Actuator - Features

TAIYO YUDEN's proprietary in-house development of materials

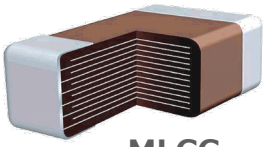


High *k* Low *ε*

Multi-layering technology



Thin-layering technology/ multi-layering technology for MLCC



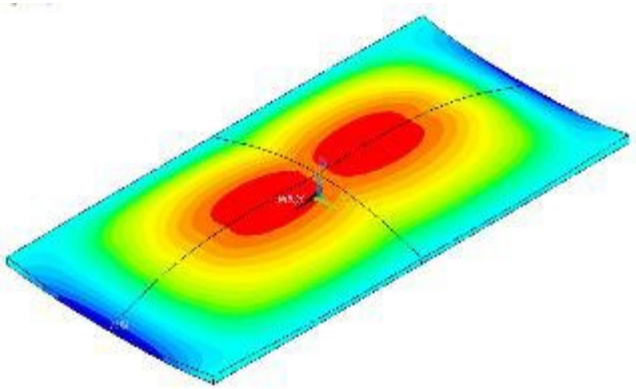
MLCC

High k: Electromechanical coupling factor (conversion efficiency)

Low ε: Permittivity (capacitance)

Multi-Layer Piezoelectric Actuator - Features

Techniques for optimum design



Vibration simulation to select the best-suited element structure

In-house development of materials

Techniques for optimum design

Multi-layering technology

$$"Performance" \propto k^2 \varepsilon \frac{n}{t}$$

Material

Multi-layering

Optimal design for panel/driving signal

High displacement and low power consumption

Haptic Function: Types and Applications

What is a haptic function?

Vibration:
“Notification”

Reaction:
“Force Feedback”

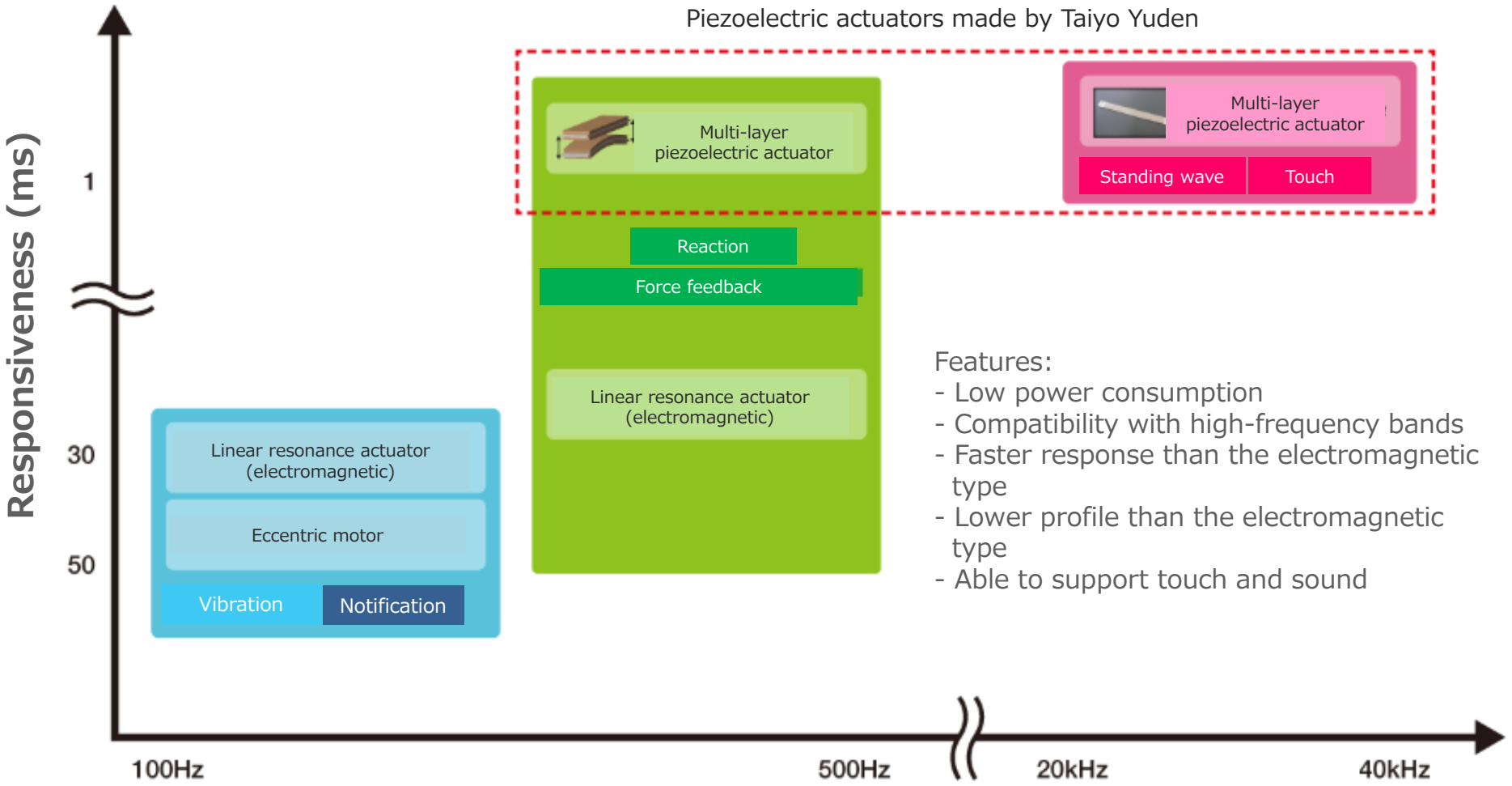
Friction:
“Touch”

----------At present---------- **In future**

Demand for touch-type haptic functions will continually increase in the future.

Actuator Types by Type of Haptic Function

Our multilayer piezoelectric actuators have realized precise and realistic touch with ultrasonic frequencies



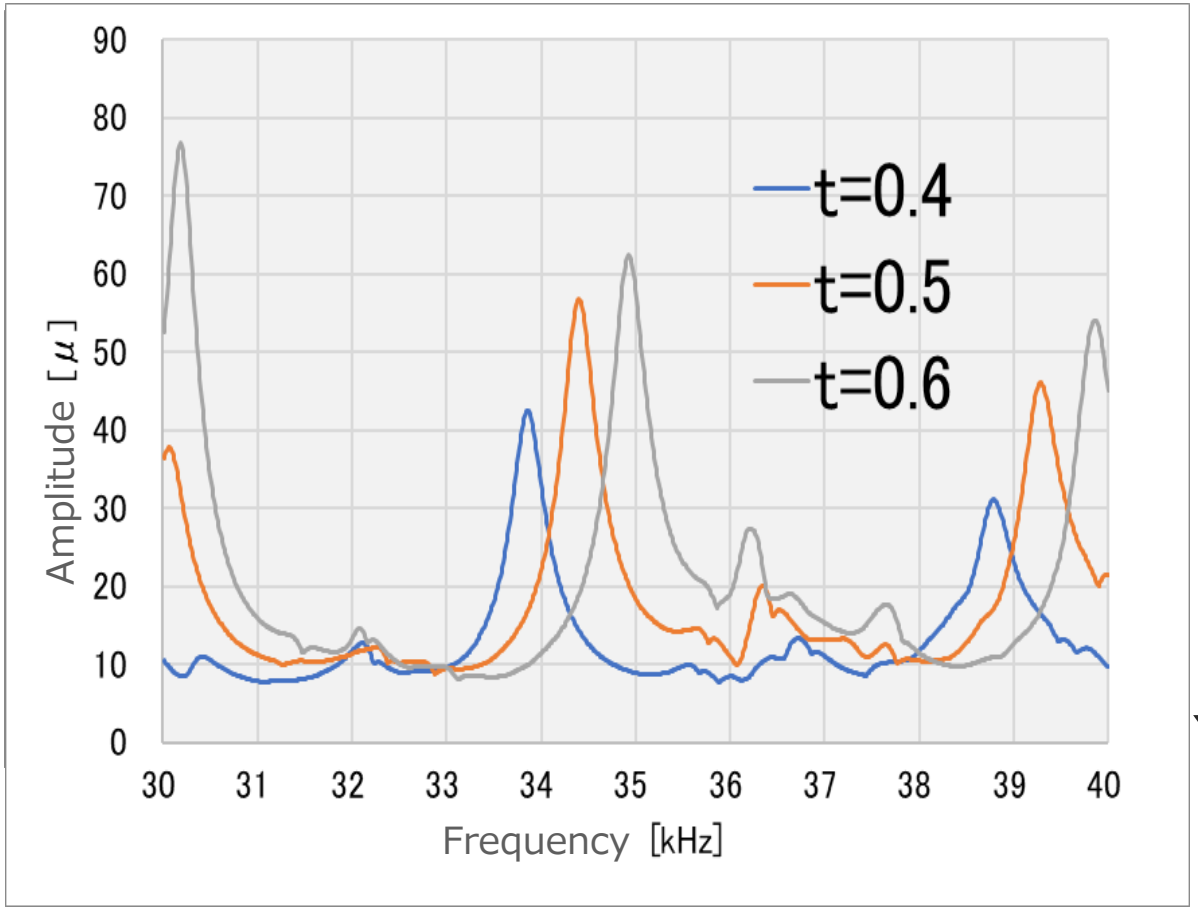
Features:
- Low power consumption
- Compatibility with high-frequency bands
- Faster response than the electromagnetic type
- Lower profile than the electromagnetic type
- Able to support touch and sound

Simulation (Element Structure): Element Thickness

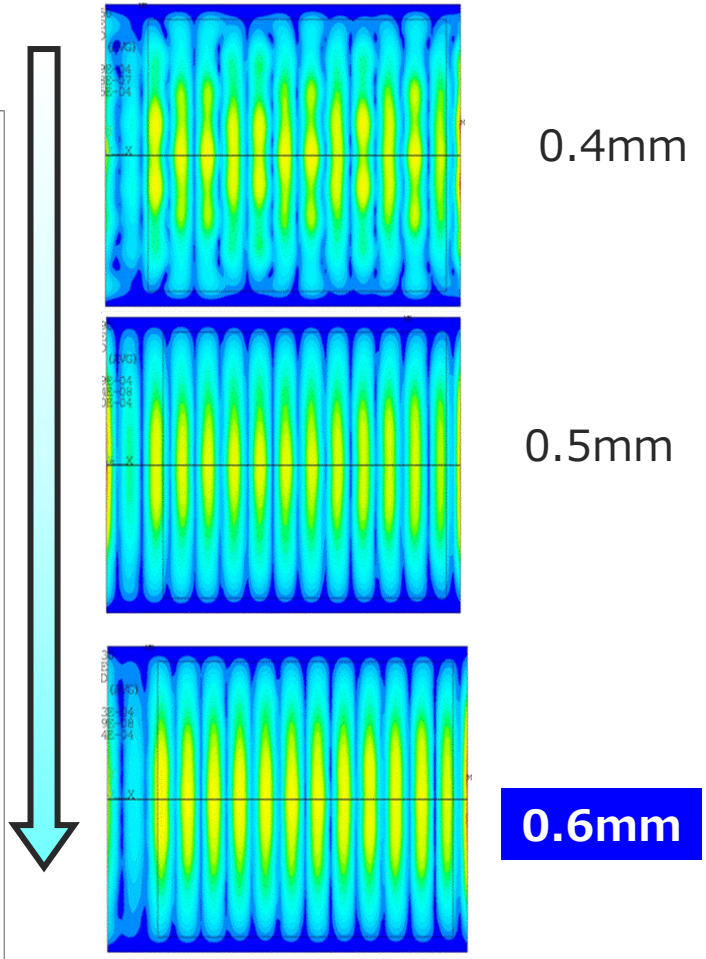
Element thickness of 0.6mm has excellent amplitude and distribution (better when striped and uniformed)

Frequency characteristics of amplitude

Element thickness : **0.6mm**＞0.5mm＞0.4mm

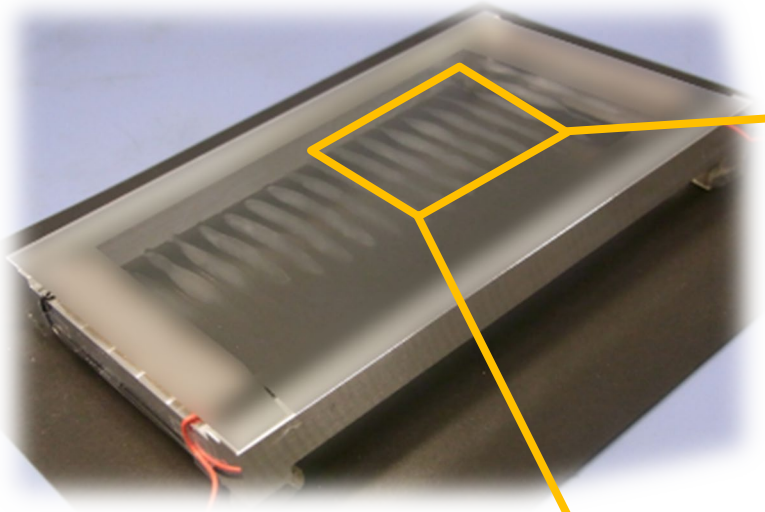


Distribution of amplitude

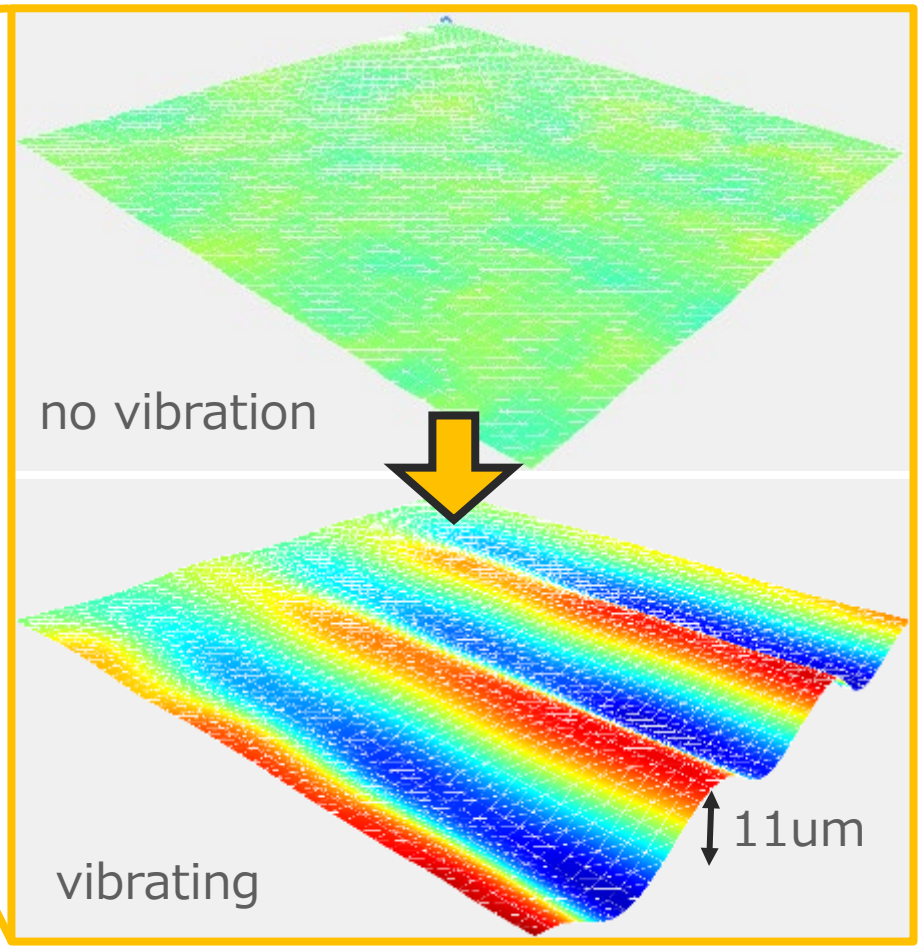


better distribution
(striped and uniformed)

Vibration Measurements of an Actual Panel



Animation of out-of-plane vibration measurements by a laser Doppler vibrometer



Measurements of out-of-plane vibration help analyze the vibration mode and amplitude distribution.

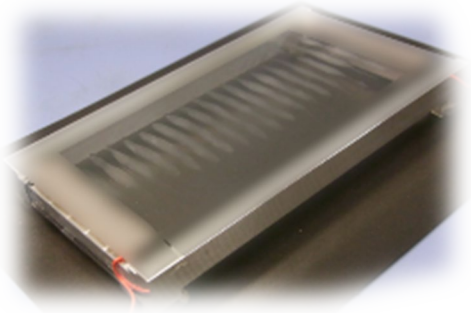
The panel achieved a maximum amplitude of 11 um.

Originality of Piezo Haptics: Minute Haptics with High Frequency

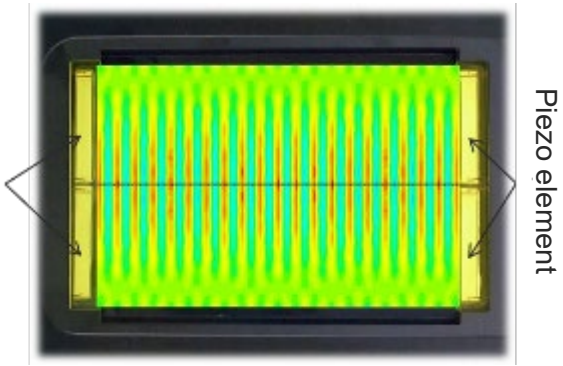
High frequency enables multiple minute haptic sensations with changes in friction factors by standing waves (not achieved with electromagnetic actuators)

Principle: haptics with changing finger friction factors

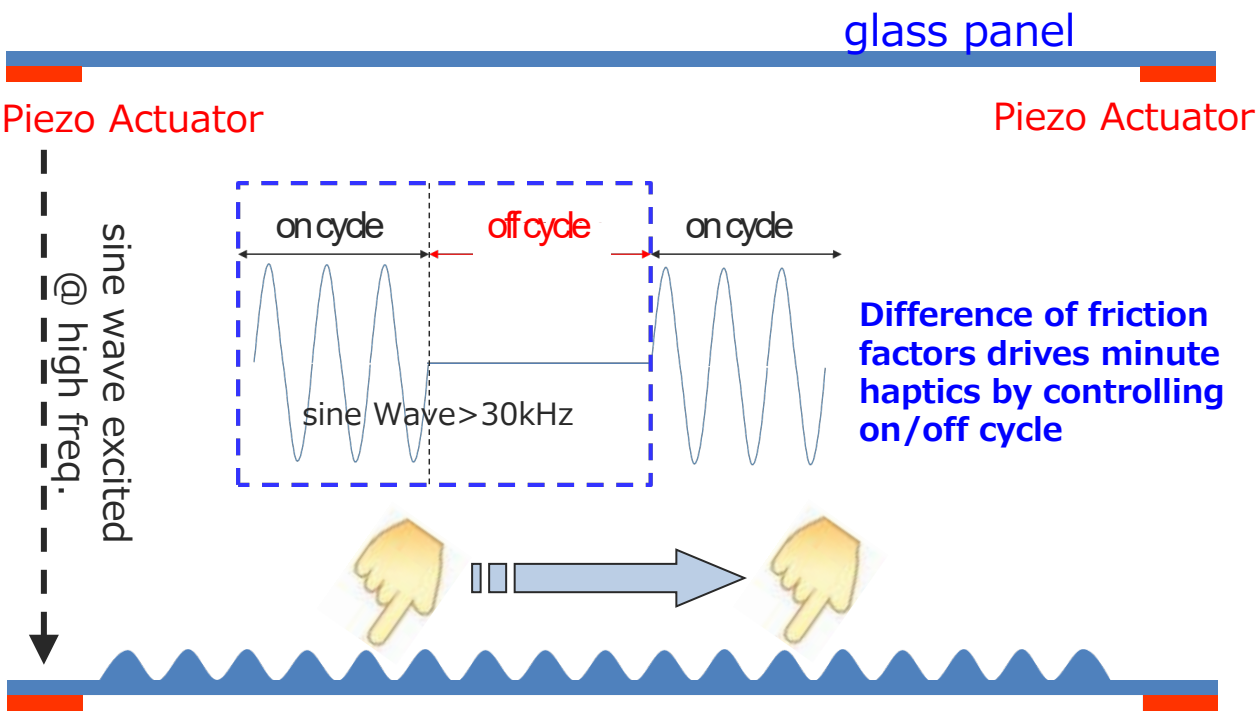
glass panel



simulation



Surface vibration



Piezo actuators driven with high frequency
→ Standing waves are excited on the panel surface

Visualization of Amplification by Ultrasonic Waves

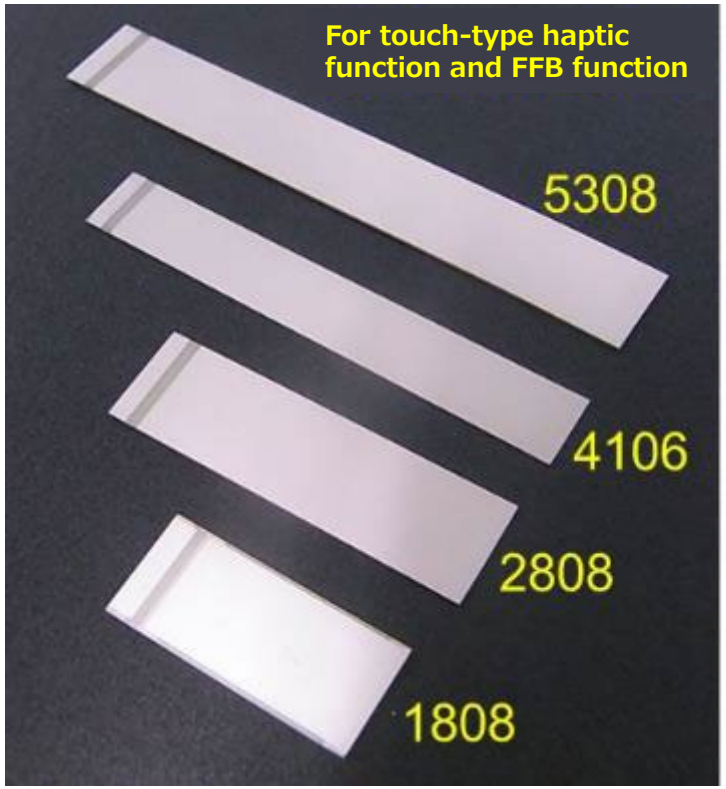
glass panel for 12.3 inch monitor

Amplification on a panel with a sine wave of 36 kHz - 25 Vpp is applied to piezoelectric actuators.
The entire surface generates consistent vibration that can be felt when touched.

glass panel for 17 inch monitor

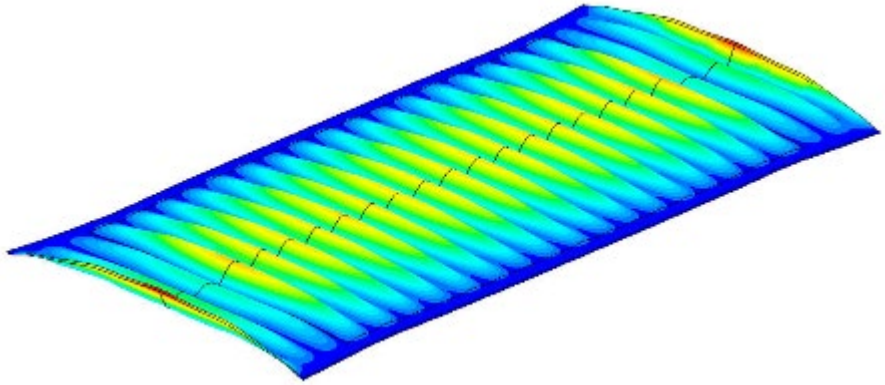
Multi-Layer Piezoelectric Actuator (Developed In-House)

Variations



Application	Driving voltage		
	24 Vpp or less	48 Vpp or less	96 Vpp or less
FFB (1 to 500 Hz)	◎	◎	◎
Touch function (20 to 40 kHz)	◎	○	

Structural design through simulation



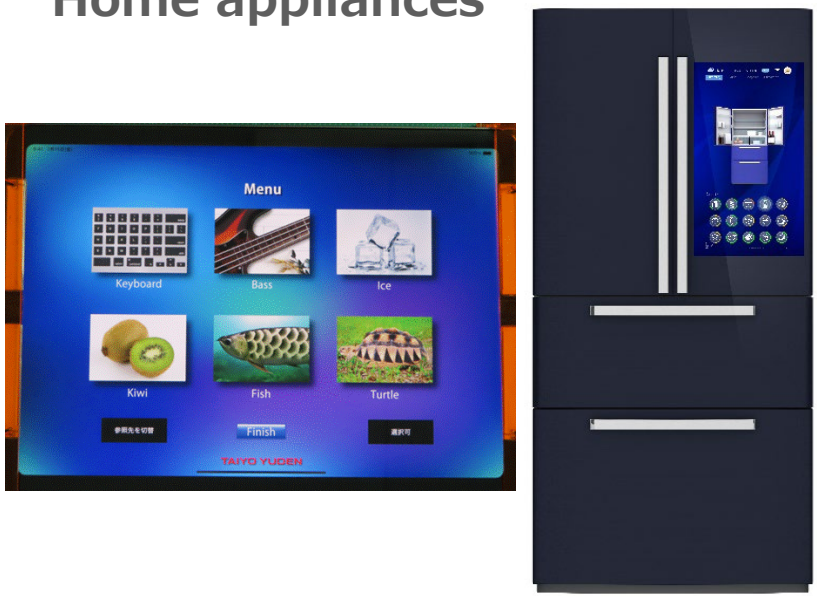
Ceramic design:
Panel displacement mode

Examples of Piezoelectric Actuator Applications

On-board systems

On-board switches
Flat panel + Touch sensors
・Feedback-driven controls

Home appliances



Home appliances
equipped with touch sensors

Future applications:
・VR
・Smartphone

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