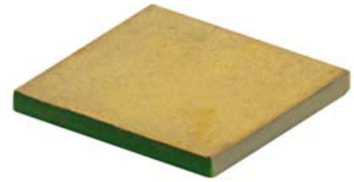
Shear Piezoelectric Chip, ±200V, 1.3 µm Travel

PL5FB

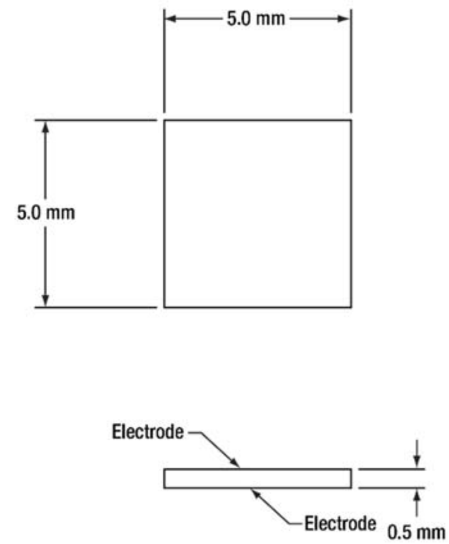


Description

The PL5FB shear piezoelectric chip consists of single piezoelectric ceramic layer with electrodes on the top and bottom surfaces. This shear piezo chip provides a maximum lateral displacement of 1.3 µm ± 20%. The green bar marking one side surface indicates the direction of lateral motion when a voltage is applied across the electrodes. The surface with the electrode that is positively biased translates over the side marked by the green indicator.

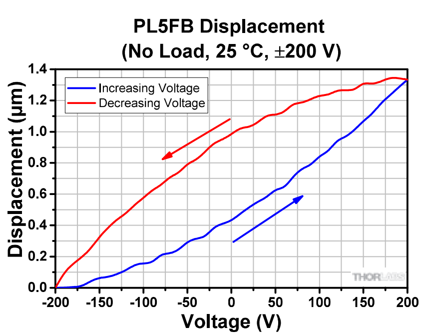
Specifications

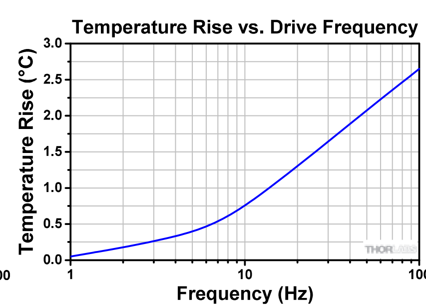
PL5FB[a]	
Drive Voltage Range	-200 to 200 V
Displacement (Free Stroke)[b]	1.3 µm ± 20%
Hysteresis	<40% (See Graph Below)
Max Shear Load[c]	50 N (11.3 lbs)
Max Axial Load[d]	1000 N (225 lbs)
Resonance Frequency	1800 kHz (No Load)
Impedance at Resonance Frequency	5000 mΩ
Anti-Resonance Frequency	2500 kHz
Dissipation Factor	0.02 ± 15%
Capacitance	1.7 nF ± 15%
Operating Temperature	-25 to 130 °C
Curie Temperature	230 °C
External Electrodes	Chemically deposited Au on Ni
Dimensions	Width 1: 5.0 mm ± 0.1 mm Width 2: 5.0 mm ± 0.1 mm Length: 0.5 mm ± 20 µm



a. All specifications are quoted at 25 °C, unless otherwise stated.
b. With no Load and over the Full Driving Voltage Range
c. Max Allowed Load Applied in the Direction Normal to the Plane of the End Plates, towards the Piezo Element
d. Max Allowed Load Applied in the Lateral Direction, Resisting Lateral Displacement

Typical Performance Plots





The temperature increase was measured after a sine wave driving voltage was applied, under conditions of no load, at the specified frequency for 10 minutes. Driving voltage amplitude extrema were -200 V and 200 V.

Operation

Electrical Bias and Shear Strain

Thorlabs' PL5FB shear piezo chip has chemically deposited gold electrodes on the top and bottom 5 mm x 5 mm surfaces. When a voltage (±200 V maximum) is applied across these electrodes, a shear strain is created in the piezo material. The deformation induced by the shear strain causes two parallel side surfaces to tilt in unison, which causes the top surface to translate laterally with respect to the bottom surface.

This lateral motion, which is characteristic of shear piezos, is a consequence of the applied electric field (E) being perpendicular the polarization (P) of the piezo material. The relationships among the polarization direction, the applied electric field, and the direction of the lateral displacement of the chip's surface is shown in Figure 1. When the electric field is applied so that the electrode on the top surface is positively biased, the top surface will translate over the side of the chip marked by the green bar; the top surface will move laterally in the direction indicated by the white arrow. Please note that using one 5 mm x 5 mm surface of the chip to translate a load requires the opposite surface to be mounted to a fixed surface. See the *Interfacing a Piezoelectric Element with a Load or Mating Surface* section below for more details.

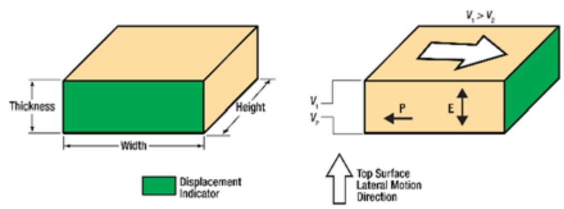


Figure 1 Shear piezos provide displacement in the lateral direction indicated by the white arrow. The positively-biased surface electrode is laterally displaced towards the side marked with the green bar.

These shear piezo chips have identical electrodes on their top and bottom surfaces, and the induced shear strain is symmetrical. Therefore, these chips can be driven by bipolar symmetrical electrical supplies. We recommend Thorlabs' HVA200 High-Voltage Amplifier.

Hysteresis and Lateral Displacement

The displacement of a piezo chip or stack depends on the instantaneous driving voltage as well as how the element was driven in the past. This hysteresis is a consequence of the intrinsic properties of the piezo element. The previous section's Displacement vs. Voltage graph shows the hysteresis exhibited the chip when the bottom surface is fixed and the driving voltage is varied from -200 V to 200 V. Hysteresis from the shear strain of piezo ceramics can be up to 40%, which is greater than that from the axial strain of piezos. This must be considered when driving shear piezo devices.

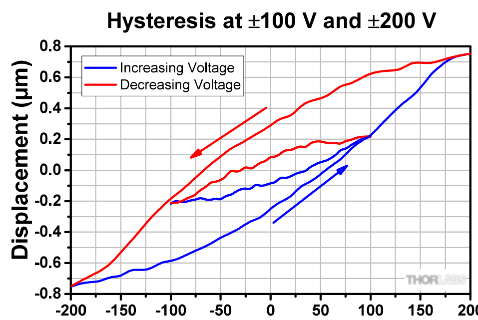


Figure 2 The stroke for a ±100 V driving voltage range is approximately 30% that for a ±200 V range. Relative hysteresis under both operating conditions is also shown.

Reducing the driving voltage range from ±200 V to ±100 V decreases the total displacement to approximately 30% of the rated stroke. This is illustrated by the plot shown above.

Adding an Electrical Connection

Electrical connection to the external electrodes on the PL5FB can be achieved by using mechanical contacts, gluing with electrically conductive glues, or wire bonding. Directly soldering to the contact surface will affect the flatness and load distribution, negatively impacting performance.

Caution: After driving, the piezo is fully charged. Directly connecting positive and negative electrodes has the risk of electric discharge, spark, and failure. A >1 kΩ resistor placed between the positive and negative electrodes is recommended to release the charge.

Interfacing a Piezoelectric Element with a Load or Mating Surface

As the top and bottom surfaces of shear piezo chips move relative to one another, one surface must be mounted to a fixed substrate to use the chip as an actuator. The shear piezo chips can be mounted either by mechanical clamping or gluing. Correct and incorrect examples are shown and described below.

The load should be centered on and applied uniformly over as much of the chip's mounting surface as possible. The direction of the loading should be normal to the loading surface of the chip. The mating surfaces of both the actuator and the load or surface must be highly flat and smooth with surface roughness less than 10 µm and a Mohs hardness higher than 6. We recommend using alumina endplates (item # PKFEP4), which have a Mohs hardness of 9 and will cap the contact surfaces with an insulating layer. Alternately, insulation can also be achieved using a polyimide film. Ensure good parallelism between the two mating surfaces before applying pressure.

When taking a mechanical clamping approach, the axial stress induced by the clamp must be well controlled. Too little pressure can lead to slippage, whereas too much pressure can damage the ceramic. With the appropriate contact surface, and in the case of low shear force, a pressure of 1 to 3 MPa is recommended. The stiffness of the loading mechanism in the actuation direction should be as low as possible in order not to hinder the movement of the piezo actuator.

When gluing the piezo in place it is important to apply a very thin glue layer between the shear chip and the substrate, as shown below. This is generally ensured by using low viscosity glue. A pressure (e.g. less than 3 MPa) should be applied during the curing process. To attach a load to the piezo chip, we recommend using an epoxy that cures at a temperature lower than 80 °C (176 °F), such as our 353NDPK, TS10, or G14250 epoxies or Loctite® Hysol® 9340. Loads should be mounted only to the faces of the piezoelectric chip that translate. Mounting a load to a non-translating face may lead to the mechanical failure of the actuator. Some correct and incorrect approaches to interfacing loads with piezoelectric actuators are shown in the diagrams below.

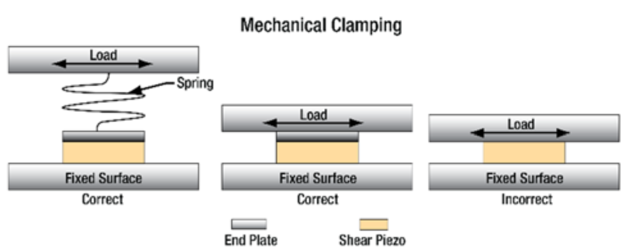


Figure 3 Correct mechanical clamping methods include using a spring to apply force. Note that the incorrect example on the right is missing an end plate between the chip and load.

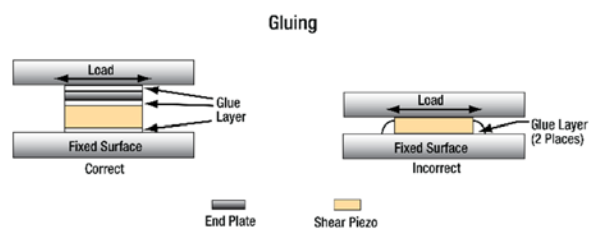


Figure 4 The piezo should be held in place using adhesives as shown on the left. Note that applying glue as shown on the right will impede the lateral translation of the piezo.

Storage and Usage Advisories

- Do not store the device at temperatures above 80 °C.
- Do not store the device in humid environments. The relative humidity (RH) should be less than 40%.
- Do not immerse the device in organic solvents.
- Do not use the device around combustible gases or liquids.