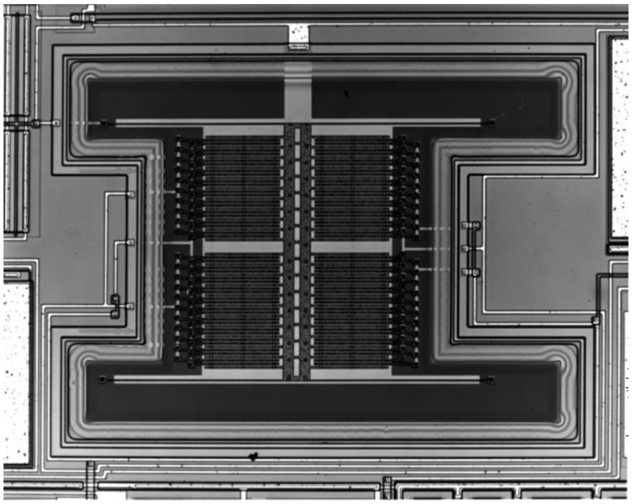

Figure 7-9 Closeup - micromachined PR accelerometer

7.1 Piezoelectric (PE) accelerometers

Let us now consider an entirely different approach to building accelerometers, PE or piezoelectric accelerometers. A few of the many shapes and sizes are shown in Figures 7-11 and 7-12.

"Compression" PE accelerometers are perhaps easiest to understand. See Figures 7-13 and 7-14.

A piezoelectric crystal element is compressed (either a bolt through the assembly or a sleeve surrounding the assembly to "preload" the device and to hold the parts together) between an inertial mass (usually tungsten) and the base.

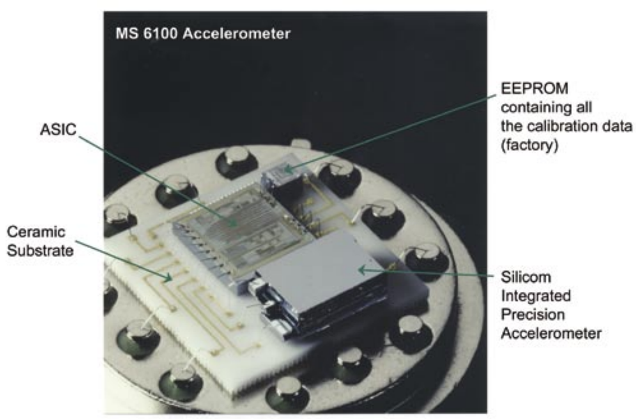

Figure 7-10 Accelerometer (MS 6100) on a chip
(courtesy CSEM, Switzerland)

Visualize the structure (that is being investigated) accelerating upward with acceleration a. The inertia force f will equal mass m × a, as in f = ma. That force will add to the preload on the crystal, forcing out a quantity q of electrons. q is measured in

Figure 7-11 Piezoelectric accelerometers
(courtesy Endevco)

picocoulombs (a millionth of a millionth of a coulomb). We divide q by the acceleration measured in g units, to obtain sensitivity in pC per g or pC/g.

Now visualize the structure (that is being investigated) accelerating downward with acceleration a. The inertia force f will again equal mass m × a, as in f = ma. But now that force acts upward, subtracting from the preload on the crystal, drawing in a quantity q of electrons.

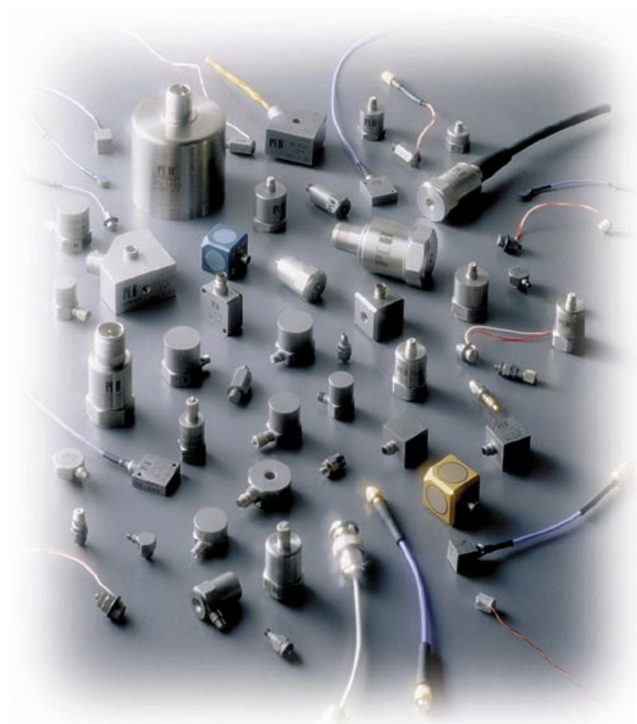

Figure 7-12 Piezoelectric accelerometers
(courtesy PCB)

Thus a cyclic acceleration will generate an alternating quantity of electrons which is an alternating electrical charge. Measuring that charge (or the

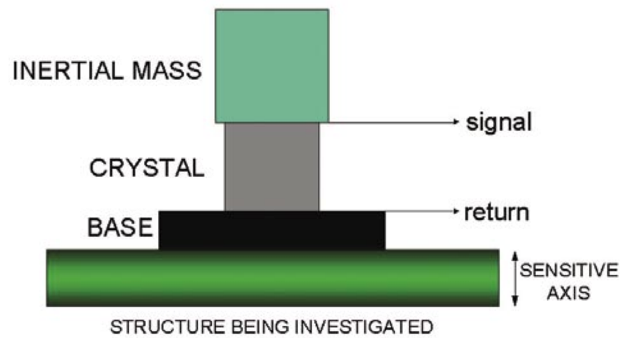

Figure 7-13 Compression piezoelectric accelerometer

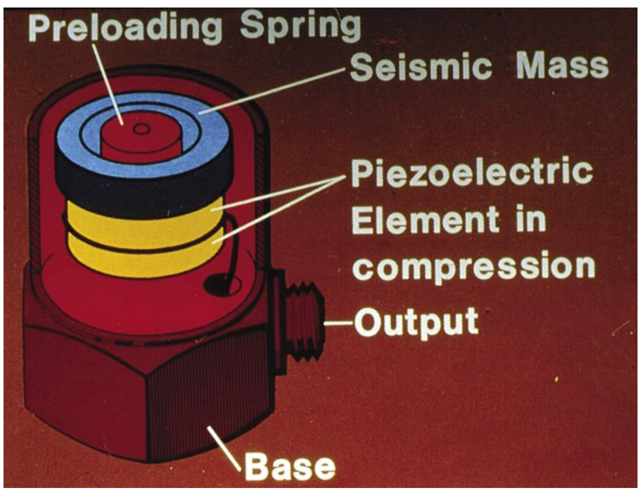

Figure 7-14 Compression piezoelectric accelerometer

accompanying voltage) enables us to measure the vibratory acceleration.

Shear PE accelerometers, per Figures 7-15 through 7-18 are also popular. Slabs or cylinders of crystal are surrounded by and acted upon by slabs or cylinders of inertial mass m. Acceleration a develops shearing force f = ma in the sensitive axis of the crystal, generating a quantity q of electrons.

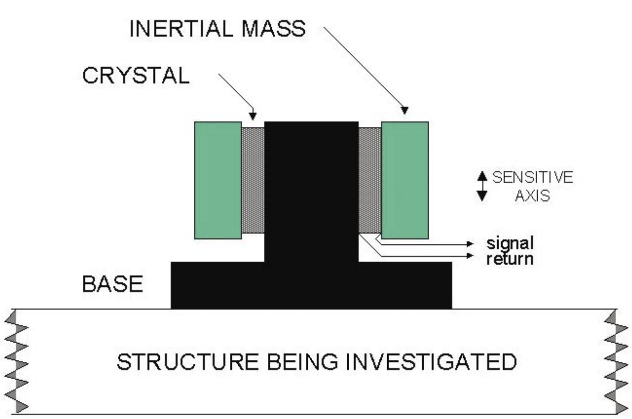

Figure 7-15 Shear piezoelectric accelerometer

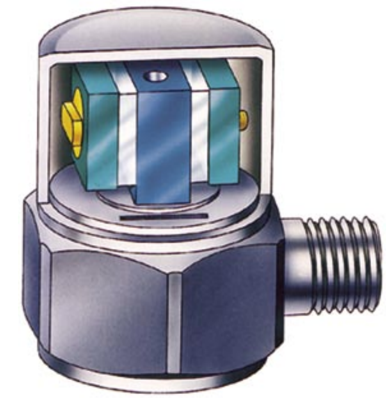

Figure 7-16 Shear piezoelectric accelerometer
(courtesy Kistler)

As before, q is measured in picocoulombs. As before, we divide q by the acceleration measured in g units, to obtain sensitivity in pC/g.

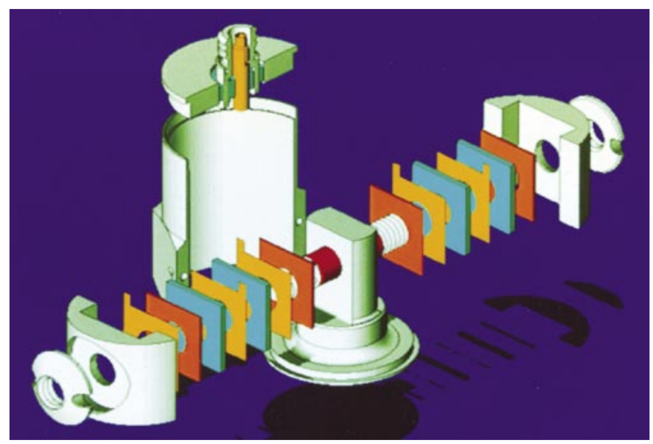

Figure 7-17 Shear piezoelectric accelerometer
(courtesy Endevco, Patrick L. Walter, S/V 6/99)

Without the manufacturer's catalog, the user can never tell whether his/her PE accelerometer is a "compression" or a "shear" design. For many applications, one approach is as good as the other.

The parts that comprise the accelerometer of Figure 7-19, by contrast, are simply epoxied together. The procedure is inexpensive, but the sensor can be destroyed by dropping onto a hard surface, or if it is struck a hard blow. Mechanical support is needed. Figures 7-16 and 7-17 show effective bolting-together. Figure 7-18 (courtesy B&K) shows a heat-shrunk ring holding parts together.

PE accelerometers are sometimes configured as a center-supported crystal beam (crystal is cut to respond to the beam being bent - greatly