ACOUSTIC WAVE TOUCH ACTUATED SWITCH WITH FEEDBACK

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. application Ser. No. 09/766,000 filed Jan. 18, 2001 entitled ACOUSTIC WAVE TOUCH ACTUATED SWITCH.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] N/A

FIELD OF INVENTION

[0003] The present invention relates to an acoustic wave touch actuated switch and more particularly to such a switch having an acoustic cavity that substantially traps acoustic wave energy so as to provide a high Q switch.

BACKGROUND OF THE INVENTION

[0004] There is a substantial need for finger touch actuated switches that are rugged and explosion proof, operate in the presence of liquids, have low power consumption, withstand aggressive sterilization procedures and are inexpensive. Known switches that attempt to meet these needs but fail include the following. A Qprox switch made by Quantum Research Group senses the presence of touch through a charge transfer effect. This switch is sensitive to conductive fluids and/or an ionizing atmosphere and can be made inoperable thereby. Further, the enclosure through which touch is sensed cannot be made of an electrically conducting material, so that metals and the like cannot be used. Piezoelectric switches such as supplied by Schurter or Wilson-Hurd, operate by transferring finger pressure via a metal overlay to a piezoelectric element which generates a voltage when compressed. This type of switch is expensive compared to a standard membrane switch and shares the disadvantages of membrane switches in that holes in the housing or enclosure are required to accommodate the switch. Further, the metal overlay is necessarily thin, so that the piezoelectric element is relatively unprotected against blows to the overlay. Another type of switch shown in U.S. Pat. No. 5,149,986 is based on the absorption of sound in a glass, ball-shaped button when the button is touched. In operation, a transducer sends sound waves into the glass balls and then receives back the echoes in a sonar type fashion. A circuit analyzes the echoes to determine whether the echoes have been reduced indicating a touch. This type of switch is relatively expensive and again requires openings in the housing or enclosure in which the switch is to be mounted.

[0005] An acoustic wave switch such as shown in U.S. Pat. No. 5,673,041 includes an ultrasonic piezoelectric transducer mounted on a surface of a substrate opposite a touch surface of the substrate. The transducer generates an ultrasonic wave that propagates in a direction across the thickness of the substrate to the touch surface and reflects off of the touch surface back to the transducer. The ultrasonic wave appears to be a compressional wave. A touch on the touch surface changes the acoustic reflectivity of the surface and changes the impedance of the transducer. The acoustic energy in this switch is not confined and spreads out into the plane of the substrate. As such, the ratio of the stored energy to lost or dissipated energy over a complete cycle, referred to as the Q of the switch, is inherently low and an extremely complex touch detection circuit is required to discriminate between a touch and the absence of a touch. Moreover, the use of compressional waves in this switch is undesirable due to their sensitivity to liquids and other contaminants which can render the switch inoperable.

[0006] Also known are acoustic wave touch panels that employ reflective gratings or arrays to reflect portions of an acoustic wave across a touch surface along parallel paths of differing lengths. These devices use a transparent substrate that can overlay a display to provide a touch screen or the like. Examples of such touch sensors are shown in U.S. Pat. Nos. 4,645,870 and 4,700,176 which utilize surface acoustic waves. These systems are undesirable, however, because surface acoustic waves are sensitive to liquids, sealing compounds and other contaminants that can render the panel inoperable and difficult to seal effectively. Another acoustic wave touch panel using reflective arrays is shown in U.S. Pat. No. 5,177,327. This touch panel uses shear waves and in particular the zeroth order horizontally polarized shear wave. Although this touch position sensor is insensitive to liquids and contaminants, touch position sensors that use reflective gratings or arrays and the associated touch detection circuitry are, in general, too expensive to use for an individual switch or for a small number of switches on a panel. Moreover, because the shear wave transducer in this latter system is mounted on a side of the panel to generate a shear wave that propagates in the plane of the substrate, an opening in the enclosure or housing is required to accommodate the panel. U.S. Pat. No. 5,573,077 also uses zeroth order horizontally polarized shear waves, but instead of reflective gratings, discrete transducers are used to propagate the shear waves along parallel paths extending across the substrate.

BRIEF SUMMARY OF THE INVENTION

[0007] In accordance with the present invention, the disadvantages of prior switches as discussed above have been overcome. In accordance with the present invention, acoustic wave energy is substantially trapped in an acoustic cavity so as to provide an acoustic wave switch with a high Q. Because the Q of the switch is high, a touch can be detected with extremely simple circuitry.

[0008] More particularly, the acoustic wave switch of the present invention includes a substrate with an acoustic wave cavity formed therein such that the mass per unit surface area of the acoustic cavity is greater than the mass per unit surface area of the substrate adjacent the cavity. An acoustic wave transducer is mounted on the acoustic cavity to generate an acoustic wave that is substantially trapped in the acoustic cavity. Even a light touch on a touch surface of the cavity produces a change in the impedance of the transducer that is easily detectable by a simple, low cost circuit.

[0009] In one embodiment of the switch, a thin mesa or plateau is formed on the substrate to define the acoustic cavity. Specifically, the acoustic cavity is formed of the mesa and the portion of the substrate below the mesa. The mesa may be formed on the touch surface side of the substrate or on a side of the substrate opposite the touch surface. The mesa can be an integral part of the substrate by mechanically or chemically machining the substrate. Alternatively, the