ducer Products Ltd. These transducers are preferred due to their combination of high coupling factors, low acoustic and electrical losses and impedance levels.

[0049] For most switch applications, the acoustic wave cavities **20** operate between 1 and 3 MHz so that the minimum wavelength is approximately 40 mils. At these wavelengths, bonding of the transducer is not a particularly critical element because standard assembly procedures produce bond lines that are less than 0.2 mil thick. The adhesive, typically an epoxy that is operable over a wide temperature range, should be fairly rigid to reduce acoustic wave losses and provide bond shear strengths high enough to tolerate stresses at the epoxy interfaces due to differential thermal expansion rates between the material of the transducer **26** and the material of the substrate **14** or mesa **22** onto which the transducer is mounted. A conducting epoxy is not necessary. It has been found that reliable, low impedance bonds do not require a conducting epoxy. This is advantageous because most conducting epoxies have greater acoustic losses than non-conducting epoxies. A suitable epoxy is, for example, Epotek 301 and 301-2 manufactured by Epotek Corporation which operate over a temperature range of at least −40° C. to 85° C.

[0050] A number of different methods can be used for connecting the transducer **26** to the touch detection circuit. For example, wires can be soldered onto the transducer. If this method is used, the amount of solder on the transducer should be minimized since solder is a significant absorber of acoustic energy and will reduce the Q of the switch **12**. Further, the wire should be aligned along the transducer in the shear direction to minimize wire flex which can be a source of acoustic losses. A preferred method uses a "Zebra Strip" manufactured by FujiPoly America Corporation Series 5000 silver zebra connector for example. The zebra connector is a rubbery material that conducts current in the thickness direction. In accordance with this method, the zebra connector is interposed between the transducer **26** and conductive pads formed in the conductor board for the touch detection circuitry such that the pads are aligned with the transducer. When vertical pressure is applied, a connection is formed between the transducer and the pads via the zebra strip connector. In this method, the printed circuit board may be directly mounted over the mesa **22**. In a further embodiment, conducting silicones are used to connect the transducer **26** to the touch detection circuitry.

[0051] The substrate and thus the acoustic wave cavity can be formed of any material such as metal, plastic, glass, ceramic, etc., in which an acoustic wave can propagate. If the substrate on which the transducer is mounted is metal, it has been found that an electrical lead does not need to be formed on the bottom surface **71** of the transducer in order to connect the transducer to ground. The bonding layer between the transducer **26** and the surface of the acoustic wave cavity is so thin that the transducer can be connected to ground via the metal surface on which the transducer is mounted.

[0052] The mesas **22** can be formed integrally with the substrate as shown in **FIG. 3** by mechanical machining or chemical processing such as milling, diecasting, stamping, sandblasting or etching, etc., the substrate to form the raised area of the mesa **22** having a greater mass per unit area than the adjacent area of the substrate surrounding the mesa. Alternatively, as shown in FIGS. **10-12**, the mesa **22** can be formed by adding a material in a localized area defining the length and width of the acoustic cavity. The material may be added to the substrate to form the mesa by plating, thick film screening or firing frit or the like onto the substrate. Small decals may also be adhered to the substrate to very inexpensively form the mesas **22**. The material forming the mesa in this embodiment can be the same as or different than the material forming the substrate **14**. For transparent substrate materials, the mesas **22** can be formed with decals of a contrasting color and bearing indicia to identify a particular switch, i.e. touch position. The thickness or height $h_c$ of the mesa **22** is very thin. For example, a 1/16 of an inch thick aluminum plate having a typical shear wave velocity of 124.5 mils per microsecond has a cavity cutoff frequency that is very close to 1 MHz. Mesas step heights $h_c$, of 3 mils ±1 mil can readily be machined, stamped, sandblasted or the like into the aluminum. In general, it is desirable to keep the mesa height $h_c$ as low as possible even if the ratios of cavity length to cavity thickness and cavity width to cavity thickness satisfy the above described cavity geometry conditions. This is because those equations assume that the boundary conditions across the cavity-substrate boundary can be matched with a single anti-symmetric mode. In practice, this cannot be accomplished and some fundamental mode energy is generated which cannot be trapped. As such, the mesa height or step height should be minimized. In practice, it is desired that the mesa height $h_c$ be less than or equal to 10% of the acoustic cavity thickness and preferably $h_c$ is less than or equal to 5% of the acoustic cavity thickness. Along with the length and width requirements of the cavity, the height requirement of the mesa provides satisfactory conditions for operation in substantially a single mode trapped resonance.

[0053] Although the mesa **22** shown in the drawings of FIGS. **2-8** and **10-15** is depicted as rectangular, resulting in a rectangular cavity, other shapes can be used as well. For example, FIGS. **17-19** illustrate circular mesas and FIGS. **20-21** illustrate a dome mesa. For an acoustic wave switch **12** with a circular mesa **22** as shown in FIGS. **17-19**, the transducer **26** is preferably placed along a diameter of the circular mesa in any orientation. For a circular mesa, the transducer **26** need not extend across the entire width of the mesa so that the transducer length can be less than the mesa width or diameter. Preferably, however, the ratio of transducer length to mesa diameter is 67% or greater. The transducer **26** can be positioned on the circular mesa as shown in **FIGS. 17 and 19**. Alternatively, the transducer **26** can be positioned on a surface opposite the circular mesa **22** as shown in **FIG. 18**. In this embodiment, the mesa **22** identifies the switch position. Because the mesa **22** is circular, it more closely matches the contact area of a finger than other mesa shapes. Further, because the circular mesa is isoperimetric, i.e. the largest area is enclosed for a given perimeter length, a greater packing density can be achieved than with mesas of other shapes.

[0054] **FIGS. 19 and 20** illustrate mesas **22** that are formed by removing material from the substrate so as to form a moat **77** surrounding the mesa **22**. In order to acoustically isolate the mesa **22** defined by a moat **77**, the moat width is preferably greater than or equal to 2 times the thickness of the acoustic cavity **20** or greater than or equal to the wavelength $\lambda$ of the acoustic wave that is trapped in