PIEZOELECTRIC TRANSDUCER WITH ELECTRICALLY CONDUCTIVE MOUNTING RODS

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ABSTRACT OF THE DISCLOSURE

Piezoelectric discs of ceramic are metal coated on both sides, a recess in each coating being left open to the periphery of the discs. Discs are all stacked with faces of like polarity together and with corresponding disc aligned. Two grooves are cut along the side of the stack, each groove being in the center of aligned recesses to expose in each groove the edge of the metal of all coatings of one polarity. A metal rod is laid in each of the grooves and is soldered in place. The rods then constitute the electrical terminals of the transducers.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND

Certain ceramics and crystals when properly polarized have the unique property of physically distorting when subjected to an electric field. The field is usually produced within the body by electrodes of metallic paint or foil deposited on opposite faces of the body. In the interest of reduced terminal voltage and increased power-handling capacity, it is desirable to make the piezoelectric elements as thin waferlike bodies and to stack a large number of wafers with all electrodes of one polarity connected to a common terminal. Since the electrodes are no more substantial than a thin film or a metallic coating, the mechanical problem of making the electrical connections to each electrode is formidable. Where large numbers of piezoelectric bodies are employed in a single transducer, the labor of making the electrical connections to the electrodes is costly.

Accordingly, an object of this invention is to provide an improved transducer.

A more specific object of this invention is to provide a transducer which is inexpensive to manufacture and which is inexpensive to manufacture and which has reliable electrical connections to all of the electrodes.

SUMMARY

After the piezoelectric wafers of the transducer of this invention have been stacked and clamped together, two parallel grooves are milled along the sides of the stack. Each groove is centered in a row of recesses provided in the electrode coatings. The edge of one electrode coating of each wafer is exposed by the milling operation so that when a rod is brazed or soldered in the groove, electrical connection is made from the rod to one of the two electrodes of each wafer.

Other objects and features of this invention will become apparent to those skilled in the art by referring to preferred embodiments described in the following specification and illustrated in the accompanying drawings in which:

FIG. 1 is an elevational view, partly in section, of one transducer constructed according to this invention.

FIG. 2 is an enlarged detailed view of a portion of one of the piezoelectric discs of FIG. 1.

FIGS. 3 and 4 are elevational views of opposite sides of one of the wafers of the transducer of FIG. 1.

FIGS. 5 and 6 are side and end views of a milling cutter employed in the construction of the transducer of FIG. 1.

FIG. 7 is a detail of the electrical connection between a rod and a metal coating of the transducer of FIG. 1.

FIG. 8 shows an alternative embodiment of the wafer of this invention, and

FIG. 9 shows in exaggerated detail a cross section of the wafer, electrodes and recesses of the transducer of FIG. 1.

DESCRIPTION

The transducer of FIG. 1 comprises a stack of wafers. It is contemplated that the wafers may be quite thin and relatively large in number. Each wafer, shown in greater detail in FIGS. 2, 3 or 4, is comprised preferably of a common piezoelectric ceramic, such as lead zirconate or lead titanate or combinations of these compounds. The central portion of the wafer is omitted to leave a flattened ring. After the ceramic is molded and partially fired to solidify the shape, a highly conductive non-corrosive metal, such as silver, is applied to each flat surface. Then, while a polarizing direct current voltage is applied between the coatings, the wafer is sintered at a high temperature to permanently fix the metal and polarize the ceramic. The electrode coatings on opposite sides of the wafers are identified throughout the drawings by the reference characters 12 and 14. In the elevation of FIG. 3, the coating 12 is shown. The coating may be applied by a spraying technique from dry or wet powdered metal, such as silver, or a metal foil cut to size may be applied adhesively to the ceramic. A recessed area 12a is provided in the edge of a metal, the recess being open to the periphery of the wafer.

In the elevation of FIG. 4, the metal electrode 14 on the other side of the wafer is shown. The recess 14a is provided at the edge of the electrode, open to the periphery of the wafer such as 180 degrees shown in FIGS. 3 and 4 or say 45 degrees shown in FIG. 8.

Next the wafers are stacked, care being taken to place face-to-face electrodes of like polarity. For this purpose, the electrical polarity of the faces of the wafers are identified by some indexing mark. Further, recess of coatings of one polarity must be aligned along the side of the stack. It is preferred that the stack be conditioned by the adhesive 20, FIG. 9, between the wafers. The adhesive can be electrically conductive or not. Preferably, each face is wetted and stacked and then fairly high pressure applied to expel most of the adhesive. The pressure should be sufficient to reduce joint thickness to less than .001 inch, preferably.

Upon curing the cement or while in clamps, the assembly is ready for the unique step, according to this invention, of exposing the metal edges of each electrode for electrical connection. According to an important feature of this invention this step is performed by cutting grooves 22 along the side of the stack. The milling cutter 18 of sufficient hardness to cleanly cut the ceramic is shown in FIGS. 5 and 6. One cut is made along the center of the aligned recesses 12a and another cut is made along the center of the aligned recesses 14a. Each cut exposes all electrodes of like polarity and leaves the electrodes of opposite polarity safely removed from the bottom of the cut. That is, the recesses 12a and 14a from the periphery of the discs is considerably more than the depth of the cuts 22.

Finally a coat 24 of solder or brazing metal in wet or dry form is applied liberally to the interior of the grooves and/or the rods 26 where it will flow into contact with the cut edges 28. The metal rods 26 are carefully selected as to diameter and are laid in the grooves. Upon
firing to the melting temperature of the solder, the rod is found to firmly bond to the ceramic and to permanent connect electrically to the newly cut edges of the electrodes 12 or 14.

Alternatively, the notches comprising the grooves 22 may be separately formed in each disc before assembly in the stack. Then, when the coatings 12 and 14 are applied, the recesses 12a and 14a are carefully centered over the notches to prevent short circuits between electrodes.

Conveniently, the rods 26 may be extended beyond the ends of the stack to provide terminals for the positive and negative terminals of the signal source. The finished transducer is particularly rugged and rough handling will not break the electrical connection to any of the fragile electrode foils or coatings. Because the wafers can be made very thin, the capacitance between the terminals can be made quite high and the voltage of the source can be materially lowered even at a high energy level. While silver paint has been used other non-corrosive metals may be employed.

A test stack made using silver foil .0004 inch thick and glue joints .0006 inch thick, and wafers 10 only 0.1 inch thick, operated well with an 800 volt signal source.

1 claim:

1. A piezoelectric transducer comprising:
   a stack of polarized piezoelectric discs, each disc being relatively thin and flat and of uniform predetermined outside size and shape,
   a thin metal electrode in good over-all contact with each face of each of said discs,
   a recess in each electrode open to the periphery of the associated disc, the discs in said stack being oriented to align the recesses of one polarity along the side of said stack,
   a cut groove along the side of said stack in the edges of said discs, said groove being cut centrally in the aligned recesses and being of a depth less than the depth of said recesses so as to expose in said groove the edge of one electrode of each disc, and
   a metal rod soldered in each groove to make electrical contact with the cut edges of all electrodes of said one polarity.

2. In the transducer defined in claim 1, the mentioned recesses in said electrodes of each disc being spaced a predetermined distance apart along the disc periphery.

3. In the transducer defined in claim 1, electrodes of like polarity being placed face-to-face in said stack.