DYNAMIC ISOLATION OF ULTRASONIC TRANSDUCERS") relate to ultrasonic transducers and are herein incorporated by reference in their entirety. Ultrasonic bonding energy is typically applied using an ultrasonic transducer, where the bonding tool is attached to the transducer. The transducer typically includes a driver such as a stack of piezoelectric elements (e.g., piezoelectric crystals, piezoelectric ceramics, etc.). Electrical energy is applied to the driver, and converts the electrical energy to mechanical energy, thereby moving the bonding tool tip in a scrubbing motion. This scrubbing motion of the bonding tool tip is typically linear motion along the longitudinal axis of the transducer.

[0006] It would be desirable to provide improved transducers for use in connection with wire bonding machines, and improved methods of forming wire bonds using transducers.

SUMMARY OF THE INVENTION

[0007] ~~According to an exemplary embodiment of the present invention, a method of forming a wire bond using a bonding tool coupled to a transducer is provided. The method includes the steps of: (1) applying electrical energy to a driver of the transducer at a first frequency; and (2) applying electrical energy to the driver at a second frequency concurrently with the application of the electrical energy at the first frequency, the first frequency and the second frequency being different from one another.~~

[0008] ~~According to another exemplary embodiment of the present invention, another method of forming a wire bond using a bonding tool coupled to a transducer is provided. The method includes the steps of: (1) applying electrical energy to a driver of the transducer at a first frequency to drive a tip of the bonding tool in a first direction; and (2) applying electrical energy to the driver at a second frequency to drive a tip of the bonding tool in a second direction, the first direction being different than the second direction.~~

[0009] According to ~~another exemplary embodiment~~an aspect of the present invention, a transducer for use in a wire bonding operation is provided. The transducer includes an elongated body portion including an aperture configured to support a bonding tool. The transducer also includes a driver for providing vibration to the elongated body portion, the driver including a plurality of piezoelectric elements, each of the plurality of piezoelectric elements, each of the plurality of piezoelectric

elements being separated into at least two regions electrically isolated from one another.

[0010] According to another ~~exemplary embodiment~~aspect of the present invention, a transducer for use in a wire bonding operation is provided. The transducer includes an elongated body portion configured to support a bonding tool. The transducer also includes a driver for providing ultrasonic vibration to the elongated body portion, the driver being configured to receive electrical energy and to provide a non-linear scrub of a tip of the bonding tool.

[0011] According to another ~~exemplary embodiment~~aspect of the present invention, a transducer for use in a wire bonding operation is provided. The transducer includes an elongated body portion configured to support a bonding tool. The transducer also includes a driver for providing ultrasonic vibration to the elongated body portion, the driver including at least one piezoelectric element configured to deform in a first direction upon the application of electrical energy, and at least one piezoelectric element configured to deform in a second direction upon the application of electrical energy, the first direction and second direction being different from one another.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention is best understood from the following detailed description when read in connection with the accompanying drawing. It is emphasized that, according to common practice, the various features of the drawing are not to scale. On the contrary, the dimensions of the various features are arbitrarily deformed or reduced for clarity. Included in the drawing are the following figures:

FIG. 1 is a perspective view of a transducer of a wire bonding machine and related components useful in explaining various exemplary embodiments of the present invention;

FIGS. 2A-2B are front and back perspective views of a piezoelectric element for use in a transducer in accordance with an exemplary embodiment of the present invention;

FIG. 2C is a front view of the piezoelectric element of FIGS. 2A-2B;

FIG. 2D is a front view of an shim electrode for use in connection with a transducer in accordance with an exemplary embodiment of the present invention;