Acoustic Transducer With Impedance Matching Layer

Background

[0001] Acoustic transducers are used for a variety of purposes, including in the oil field. A focused planar transducer, such as that described in United States Patent No. 5,044,462, which is owned by the assignee of the instant application, allow acoustic illumination with focus and depth of field. Transferring energy from an acoustic transducer to fluids in a borehole is a challenge.

Summary

[0001a] A first aspect of the present invention provides a device comprising: piezoelectric transducer, the transducer having N independent transducer regions wherein N is an integer, each of the N independent transducer regions having a thickness, each of the N independent transducer regions having an acoustic impedance AIT, each of the N independent transducer regions being independently excitable to oscillate in the thickness mode when electrically excited by a potential difference applied across the thickness; a first impedance matching layer having an acoustic impedance AI1 between AIT and a borehole fluid acoustic impedance AIBF, the first impedance matching layer being situated such that an acoustic signal emitted by the piezoelectric transducer will pass through the first impedance matching layer; and a second impedance matching layer having an acoustic impedance AI2 between AI1 and AIBF, the second impedance matching layer being situated in the device such that an acoustic signal emitted by the transducer will pass through the second impedance matching layer after it passes through the first impedance matching layer, wherein the first impedance matching layer has N independent first impedance matching layer regions that match and overlay the N independent transducer regions.

[0001b] A second aspect of the present invention provides a method comprising: emitting an acoustic pulse from a piezoelectric transducer, the transducer having N independent transducer regions wherein N is an integer, each of the N independent transducer regions having a thickness, each of the N independent transducer regions having an acoustic impedance AIT, each of the N independent transducer regions being independently excitable to oscillate in the thickness mode when electrically excited by a potential difference applied across the thickness; passing the acoustic pulse through a first impedance matching layer having an acoustic impedance AI1 between AIT and a borehole fluid acoustic impedance AIBF; and passing the acoustic pulse that has passed through the first impedance matching layer through a second impedance matching layer having an acoustic impedance AI2 between AI1 and AIBF, wherein the first impedance matching layer has N independent first impedance matching layer regions that match and overlay the N independent transducer regions.

[0001c] A third aspect of the present invention provides a device comprising: a piezoelectric transducer having an acoustic impedance AIT; a first impedance matching layer having an acoustic impedance AI1 between AIT and a borehole fluid acoustic impedance AIBF, the first impedance matching layer being situated such that an acoustic signal emitted by the piezoelectric transducer will pass through the first impedance matching layer, the first impedance matching layer having N independent impedance matching layer regions separated by cuts in the first impedance matching layer; and a second impedance matching layer having an acoustic impedance AI2 between AI1 and AIBF, the second impedance matching layer being situated in the device such that an acoustic signal emitted by the transducer will pass through the second impedance matching layer after it passes through the first impedance matching layer.

Brief Description of the Drawings

[0002] FIG. 1 is a sectional view through an acoustic measuring tool in accordance with the teachings of the present disclosure suspended in a well borehole and which incorporates a rotatable transducer antenna for sending and receiving acoustic pulses against the sidewall of the borehole

[0003] FIGS. 2A and 2B are enlarged views of the acoustic transmitter element having several grooves cut therein to define concentric rings for transmitting purposes.

[0004] FIGS. 3A and 3B are an alternate form of an acoustic transmitter element utilizing square cuts in the ceramic member showing the square elements connected in the manner shown in FIG. 3C to closely approximate the rings of the transmitter element of FIG. 2.

[0005] FIG. 4 is an electronic schematic block diagram showing the components of the transducer system and selected waveforms.

[0006] FIG. 5 is a block diagram showing the implementation of the phase contrast imaging process using digitized data and also shows a gain curve and a processing flow chart.

[0007] FIG. 6 is a graph showing beam widths as a function of range and chosen focusing distance.

[0008] FIG. 7 is a graph showing a comparison between amplitude, travel time, and phase contrast processing of data.

[0009] FIG. 8 is a sectional view through an acoustic transmitter element having an acoustic impedance matching layer.