cement evaluation logs as the source still lacked azimuthal directivity to effectively detect the existence of small channels between the cement and the rock formation.

SUMMARY

[0007] An aspect of the present invention provides a method for investigating cement bonding or rock formation structure near a borehole. The method includes generating ~~an~~ a collimated acoustic ~~wave~~ beam by an acoustic beam source, the collimated acoustic beam having a frequency in the frequency range between approximately 15 kHz and 120kHz; directing at one or more azimuthal angles and at one or more inclination angles the collimated acoustic ~~wave~~beam towards a ~~seleteeted~~ selected location in a vicinity of a borehole; receiving, at ~~one or more receivers~~ an acoustic detector comprising a two-dimensional array of receiver elements, an acoustic signal, the acoustic signal originating from a reflection, a refraction or a surface wave propagation, or any combination thereof, of the collimated acoustic ~~wave~~beam by a material at the selected location in an azimuthal angular range, each receiver element in the two-dimensional array of receiver elements being configured to receive a portion of the acoustic signal corresponding to a portion of the azimuthal angular range, the two-dimensional array of the receiver elements being disposed on a surface of a cylindrical member and being spaced apart to provide a gap between neighboring receiver elements, the two-dimensional array of receiver elements comprising a piezo-electric film; and analyzing the received acoustic signal to characterize features of the material around the borehole.

[0008] Another aspect of the present invention provides a system for investigating cement bonding or rock formation structure near a borehole. The system includes an acoustic source configured to generate ~~an~~ a collimated acoustic beam and to direct the collimated acoustic beam at one or more azimuthal angles towards a selected location in a vicinity of a borehole, the collimated acoustic beam having a frequency in the frequency range between approximately 15kHz and 120kHz. The system also includes ~~a receiver~~an acoustic detector comprising a two-dimensional array of receiver elements, the two-dimensional array of receiver elements being configured to receive an acoustic signal in an azimuthal angular range, the acoustic signal originating from a reflection, a refraction or a surface wave propagation, or any combination thereof, of the collimated acoustic beam by a material at the selected location, the two-dimensional array of the receiver elements being disposed on a surface of a cylindrical member

and being spaced apart to provide a gap between neighboring receiver elements, the two-dimensional array of receiver elements comprising a piezo-electric film, wherein each receiver element in the two-dimensional array of receiver elements is configured to receive a portion of the acoustic signal corresponding to a portion of the azimuthal angular range. The system also includes a processor configured to perform data processing on the received signal to analyze the received acoustic signal to characterize features of the material around the borehole.

[0009] There is also disclosed an acoustic source for generating an acoustic beam. The acoustic source includes a housing; a plurality of spaced apart piezo-electric layers disposed with the housing; and a non-linear medium filling between the plurality of layers. Each of the plurality of piezoelectric layers is configured to generate an acoustic wave when excited with an electrical signal. The non-linear medium and the plurality of piezo-electric material layers have an acoustic matching impedance so as to enhance a transmission of the acoustic wave generated by each of plurality of layers through the remaining plurality of layers.

[0010] There is also disclosed an acoustic detector that includes a cylindrical support member and a plurality of receiver elements that are disposed