Claims

1. A system to monitor a surface defect that extends for a defect depth from a surface of a structure, comprising:

a transmitter coupled at the surface, the transmitter being configured to generate an ultrasonic Rayleigh wave;

a receiver coupled at the surface, the receiver being configured to receive an incident Rayleigh wave from the transmitter and a reflected Rayleigh wave reflected by the surface defect, the receiver including a polymer piezoelectric film with a plurality of electrodes disposed on the polymer piezoelectric film;

a controller, the controller in signal communication with the receiver, the controller being configured to perform a method including:

performing a signal enhancement on the incident Rayleigh wave and the reflected Rayleigh wave to obtain an enhanced incident Rayleigh wave and an enhanced reflected Rayleigh wave respectively, the signal enhancement being based on a delay-and-sum method; and

calculating a depth value based on the enhanced incident Rayleigh wave and the enhanced reflected Rayleigh wave, wherein the depth value corresponds to the defect depth of the surface defect,

and wherein the transmitter and the receiver are arranged in a line with the surface defect, and wherein the receiver is positioned between the transmitter and the surface defect.

2. The system as recited in claim 1, wherein the receiver is coupled to the surface by one of the following: an epoxy bonding and an in-situ fabrication.

3. The system as recited in claim 2, wherein the receiver comprises at least three electrodes arrayed on the polymer-based piezoelectric film.

4. The system as recited in claim 3, wherein the at least three electrodes are interconnected to form a comb-shaped electrode element.

5. The system as recited in claim 3, wherein the at least three electrodes are discrete electrodes equally spaced apart from one another.

6. The system as recited in claim 4 or claim 5, wherein each of the at least three electrodes is characterized by a length-to-width aspect ratio greater than five, and each of the at least three electrodes is characterized by an electrode width determined by a minimum defect depth to be monitored.

7. The system as recited in claim 6, wherein the at least three electrodes are aligned with respective lengths perpendicular to a propagation direction of the Rayleigh waves.

8. The system as recited in claim 1, wherein the transmitter comprises an ultrasonic transducer coupled on a wedge at an angle relative to the surface.

9. The system as recited in claim 1, wherein the transmitter comprises one of a thickness-shear transducer coupled to the surface.

10. The system as recited in claim 1, wherein the transmitter comprises a comb-shaped electrode, the comb-shaped electrode including at least three interconnected electrodes on a

piezoelectric polymer layer, and wherein the piezoelectric polymer layer is coupled to the surface.

11. The system as recited in claim 1, wherein the signal enhancement is based on a delay-and-sum method comprising:

determining an arrival time for the incident Rayleigh wave and the reflected Rayleigh wave;

performing a Fast Fourier Transform (FFT) on the incident Rayleigh wave and the reflected Rayleigh waves to obtain respective frequency spectra;

summing the frequency spectra to obtain the enhanced incident Rayleigh wave and the reflected Rayleigh wave in a frequency domain.

12. The system as recited in claim 1, wherein the receiver is disposed in proximity of a weld line in the structure.

13. A method to monitor a surface defect that extends for a defect depth from a surface of a structure, comprising:

generating an ultrasonic Rayleigh wave using a transmitter coupled at the surface;

detecting Rayleigh waves using a receiver coupled at the surface, the receiver being a piezoelectric transducer array configured to receive an incident Rayleigh wave from the transmitter and a reflected Rayleigh wave reflected by the surface defect, the receiver including a polymer piezoelectric film with a plurality of electrodes disposed on the polymer piezoelectric film;

performing a signal enhancement on the incident Rayleigh wave and the reflected Rayleigh wave to obtain an enhanced incident Rayleigh wave and an enhanced

reflected Rayleigh wave respectively, the signal enhancement being based on a delay-and-sum method; and

calculating a depth value based on the enhanced incident Rayleigh wave and the enhanced reflected Rayleigh wave, wherein the depth value corresponds to the defect depth of the surface defect,

and wherein the transmitter and the receiver are arranged in a line with the surface defect, and the receiver is positioned between the transmitter and the surface defect.

14. The method as recited in claim 13, wherein the receiver is coupled to the surface by one of the following: an epoxy bonding and an in-situ fabrication.

15. The method as recited in claim 13, wherein the receiver comprises at least three discrete electrodes arrayed on a polymer-based piezoelectric film, the at least three electrodes being equally spaced apart from one another.

16. The method as recited in claim 15, wherein the at least three electrodes are interconnected to form a comb-shaped electrode element.

17. The system as recited in claim 15, wherein the at least three electrodes are discrete electrodes equally spaced apart from one another.

18. The method as recited in claim 15, wherein each of the at least three electrodes is characterized by a length-to-width aspect ratio greater than five, and wherein each of the at

least three electrodes is characterized by a width determined by a minimum defect depth to be monitored.

19. The method as recited in claim 18, wherein the at least three electrodes are aligned with respective lengths perpendicular to a propagation direction of the Rayleigh waves.

20. The method as recited in claim 13, wherein the signal enhancement is based on a delay-and-sum method comprising:

determining an arrival time for the incident Rayleigh wave and the reflected Rayleigh wave;

performing a Fast Fourier Transform (FFT) on the incident Rayleigh wave and the reflected Rayleigh waves to obtain respective frequency spectra;

summing the frequency spectra to obtain the enhanced incident Rayleigh wave and the reflected Rayleigh wave in a frequency domain.