CLAIMS

1. A therapeutic ultrasound system for performing tissue ablation via cavitation, the therapeutic ultrasound system comprising:

a therapeutic ultrasound transducer assembly comprising:

a piezoelectric composite layer having a proximal surface and a distal surface;

an array of annular electrodes disposed on said proximal surface of said piezoelectric composite layer, the array of annular electrodes defining an array of annular ultrasound transducer elements;

a common electrode disposed on said distal surface of said piezoelectric composite layer;

an electrical isolation layer disposed on said array of annular electrodes on said proximal surface of said piezoelectric composite layer;

an elongate body, wherein said therapeutic ultrasound transducer assembly is supported at a location remote from a proximal end of said elongate body;

an electrical signal delivery assembly disposed along at least a portion of said elongate body, wherein said electrical signal delivery assembly is operatively connected to said therapeutic ultrasound transducer assembly such that electrodes of said array of annular electrodes are in electrical communication with respective electrical channels of said electrical signal delivery assembly, and such that said common electrode is in electrical communication with a common electrical channel of said electrical signal delivery assembly; and

control and processing circuitry operatively coupled to said therapeutic ultrasound transducer assembly through said electrical signal delivery assembly, said control and processing circuitry configured to generate electrical pulses that are

delivered, through said electrical signal delivery assembly, to said array of annular electrodes for generating focused ultrasound pulses suitable for generating cavitation in water; and

wherein a thickness of said electrical isolation layer is less than a wavelength of the focused ultrasound pulses within said electrical isolation layer; and

wherein the thickness of said electrical isolation layer and a dielectric breakdown strength of said electrical isolation layer are sufficiently high to prevent arcing, within a backing of said therapeutic ultrasound transducer assembly, among adjacent electrodes of said array of annular electrodes, during generation of the focused ultrasound pulses for cavitation.

2. The therapeutic ultrasound system according to claim 1 wherein said piezoelectric composite layer is configured such that between at least one pair of adjacent electrodes of said array of annular electrodes, a respective annular kerf extends from said proximal surface into said piezoelectric composite layer, and wherein an electrical insulating material forming said electrical isolation layer resides within each annular kerf.

3. The therapeutic ultrasound system according to claim 2 wherein at least one annular kerf extends from said proximal surface to said distal surface.

4. The therapeutic ultrasound system according to claim 2 wherein at least one annular kerf is a partial kerf that extends from said proximal surface into said piezoelectric composite layer without extending to said distal surface.

5. The therapeutic ultrasound system according to claim 4 wherein said partial kerf has a depth between 5% and 95% of the thickness of said piezoelectric composite layer.

6. The therapeutic ultrasound system according to any one of claims 2 to 5 wherein the thickness of said electrical isolation layer residing on each electrode of said array of annular electrodes exceeds a width of each annular kerf.

7. The therapeutic ultrasound system according to any one of claims 2 to 6 wherein said piezoelectric composite layer comprises an array of piezoelectric pillars embedded in a matrix, said piezoelectric pillars extending from said proximal surface to said distal surface, and wherein said piezoelectric pillars are arranged in a segmented annular array comprising a plurality of concentric arrays of piezoelectric pillars, such that each electrode of said array of annular electrodes is capable of electrically actuating one or more radially consecutive arrays of piezoelectric pillars, and such that each annular kerf is aligned with, and extends into, an annular matrix region residing between a respective pair of radially adjacent concentric arrays of piezoelectric pillars.

8. The therapeutic ultrasound system according to claim 1 wherein said piezoelectric composite layer comprises an array of piezoelectric pillars embedded in a matrix, said piezoelectric pillars extending from said proximal surface to said distal surface, and wherein said piezoelectric pillars are arranged in a segmented annular array comprising a plurality of concentric arrays of piezoelectric pillars, such that each electrode of said array of annular electrodes is capable of electrically actuating

one or more radially consecutive arrays of piezoelectric pillars, and such that and such that each annular inter-electrode gap is aligned with an annular matrix region residing between a respective pair of radially adjacent concentric arrays of piezoelectric pillars.

9. The therapeutic ultrasound system according to any one of claims 1 to 8 wherein said electrical signal delivery assembly is operatively connected to said therapeutic ultrasound transducer assembly via a plurality of wire bonds, and wherein each wire bond electrically connects a respective electrode of said array of annular electrodes with a corresponding conductive channel of said electrical signal delivery assembly though an aperture formed in said electrical isolation layer.

10. The therapeutic ultrasound system according to any one of claims 1 to 8 wherein said common electrode is electrically connected to said electrical signal delivery assembly via a ground ring extending along at least a portion of an outer circumferential edge of said piezoelectric composite layer.

11. The therapeutic ultrasound system according to claim 1 wherein said electrical signal delivery assembly comprises a flexible printed circuit board, and wherein said flexible printed circuit board is operatively connected to said therapeutic ultrasound transducer assembly via direct bonding of a distal region of said flexible printed circuit board to said therapeutic ultrasound transducer assembly though an aperture formed in said electrical isolation layer.

12. The therapeutic ultrasound system according to any one of claims 1 to 11 wherein the thickness of said electrical isolation layer is equal to a quarter of the wavelength of the focused ultrasound pulses within said electrical isolation layer.

13. The therapeutic ultrasound system according to any one of claims 1 to 11 wherein the thickness of said electrical isolation layer is equal to a half of the wavelength of the focused ultrasound pulses within said electrically isolation layer.

14. The therapeutic ultrasound system according to any one of claims 1 to 13 wherein said therapeutic ultrasound transducer assembly further comprises a fixed acoustic lens.

15. The therapeutic ultrasound system according to any one of claims 1 to 14 wherein said control and processing circuitry is configured to control said therapeutic ultrasound transducer assembly to scan the focused ultrasound pulses within an elongate axial region residing distalward from a distal energy emitting surface of said therapeutic ultrasound transducer assembly.

16. The therapeutic ultrasound system according to claim 15 wherein said control and processing circuitry is configured to unidirectionally scan the focused ultrasound pulses within the elongate axial region.

17. The therapeutic ultrasound system according to claim 15 or 16 wherein said control and processing circuitry is configured is configured to scan the focused ultrasound pulses at a scan rate between 0.3-1.3 m/s.

18. The therapeutic ultrasound system according to any one of claims 15 to 17 further comprising an imaging transducer assembly supported by said elongate body such that a distal surface of said imaging transducer assembly resides within a central aperture defined within said therapeutic ultrasound transducer assembly, and wherein said control and processing circuitry is operatively coupled to said imaging transducer assembly through said electrical signal delivery assembly; and

wherein said control and processing circuitry is configured to control said imaging transducer assembly to acquire ultrasound image data and to process the ultrasound image data to generate one or more ultrasound images characterizing an imaging region that spatially overlaps with the elongate axial region.

19. The therapeutic ultrasound system according to claim 18 wherein said control and processing circuitry is further configured to control said therapeutic ultrasound transducer assembly and said imaging transducer assembly such that scanning of the focused ultrasound pulses to perform line ablation is only initiated after detection of cavitation in the ultrasound images.

20. A therapeutic ultrasound device for performing tissue ablation via cavitation, the therapeutic ultrasound device comprising:

a therapeutic ultrasound transducer assembly comprising:

a piezoelectric composite layer having a proximal surface and a distal surface;

an array of annular electrodes disposed on said proximal surface of said piezoelectric composite layer, the array of annular electrodes defining an array of annular ultrasound transducer elements;

a common electrode disposed on said distal surface of said piezoelectric composite layer;

an electrical isolation layer disposed on said array of annular electrodes on said proximal surface of said piezoelectric composite layer;

an elongate body, wherein said therapeutic ultrasound transducer assembly is supported at a location remote from a proximal end of said elongate body;

wherein said piezoelectric composite layer is configured such that between at least one pair of adjacent electrodes of said array of annular electrodes, an annular kerf extends from said proximal surface into said piezoelectric composite layer, and wherein an electrical isolation material forming said electrical isolation layer resides within each annular kerf.