CLAIMS

1. A catheter for treating an occlusion in a body lumen, the catheter comprising:

an elongated tube;

a shock wave electrode assembly at least partially embedded within the elongated tube, the electrode assembly comprising:

at least one discontinuous emitter band, the at least one emitter band forming a first electrode of an electrode pair, and

at least one wire, a distal end of the at least one wire forming a second electrode of the electrode pair,

wherein the shock wave electrode assembly is configured to emit a shock wave when a voltage pulse is applied across the electrode pair; and

an enclosure surrounding the shock wave electrode assembly.

2. The catheter of claim 1, wherein discontinuity of the at least one discontinuous emitter band enables the at least one emitter band to have circumferential flexibility.

3. The catheter of claim 1, wherein the at least one discontinuous emitter band comprises a first end and a second end separated by a gap, and wherein a connecting region between the first end and the second end at least partially encircles an inner layer of the elongated tube.

4. The catheter of claim 3, wherein the at least one discontinuous emitter band encircles at least 180 degrees of the inner layer.

5. The catheter of claim 1, wherein the at least one discontinuous emitter band comprises an outer edge, and wherein the outer edge of the at least one discontinuous emitter band forms the first electrode of the electrode pair.

6. The catheter of claim 5, wherein the distal end of the at least one wire is positioned proximate to the outer edge of the at least one discontinuous emitter band.

7. The catheter of claim 1, wherein the at least one discontinuous emitter band comprises a first enlarged region, a second enlarged region, and at least one connecting region extending therebetween.

8. The catheter of claim 7, wherein a width of at least one of the first enlarged region and the second enlarged region is greater than a width of the at least one connecting region.

9. The catheter of claim 7, wherein the at least one discontinuous emitter band comprises an aperture extending through the first enlarged region.

10. The catheter of claim 9, wherein the aperture has an elliptical shape.

11. The catheter of claim 9, wherein an edge of the aperture forms the first electrode of the electrode pair.

12. The catheter of claim 11, wherein the distal end of the at least one wire is positioned proximate to the edge of the aperture.

13. The catheter of claim 7, wherein the at least one discontinuous emitter band forms a spiral coil shape.

14. The catheter of claim 7, wherein at least one of the first enlarged region or the second enlarged region comprises one or more slots for attaching one or more wires to the at least one discontinuous emitter band.

15. The catheter of claim 1, wherein the elongated tube comprises an inner layer and an outer layer, the outer layer at least partially surrounding the at least one discontinuous emitter band.

16. The catheter of claim 15, wherein a hole in the outer layer provides a spark gap between the first electrode and the second electrode of the electrode pair.

17. The catheter of claim 15, wherein the outer layer overlays at least a portion of an outer surface of the at least one discontinuous emitter band.

18. The catheter of claim 15, wherein the outer layer encapsulates at least a portion of the at least one wire.

19. The catheter of claim 15, wherein an outer diameter of the outer layer is equal to an outer diameter of the at least one discontinuous emitter band.

20. The catheter of claim 15, wherein the inner layer is formed of a first polymer, the outer layer is formed of a second polymer, and the first polymer has a higher melting temperature than the second polymer.

21. The catheter of claim 1, wherein the at least one discontinuous emitter band forms electrodes of a plurality of electrode pairs.

22. The catheter of claim 1, wherein the elongated tube comprises a central lumen for accommodating a guide wire.

23. A system for treating an occlusion in a body lumen, the system comprising:

the catheter of claim 1; and

a voltage pulse generator electrically connected to the shock wave electrode assembly and configured for applying voltage pulses to the electrode pair to generate shock waves.

24. A catheter system for treating an occlusion in a body lumen comprising:

a catheter comprising, at a distal end portion of the catheter:

an inner catheter body,

at least one shock wave electrode pair comprising at least one discontinuous emitter band having an enlarged central region and one or more leg regions extending from the enlarged central region, the one or more leg regions at least partially encircling a circumference of the inner catheter body, and a wire located adjacent the at least one discontinuous emitter band,

an outer catheter body at least partially encapsulating the at least one discontinuous emitter band, and

an enclosure in fluid communication with a fluid lumen of the catheter and surrounding the at least one shock wave electrode pair; and

a power source electrically connected to the wire and configured to apply a voltage across the electrode pair to generate a shock wave within the enclosure.

25. The catheter system of claim 24, wherein the one or more leg regions comprise a pair of leg regions, each extending from the enlarged region.

26. The catheter system of claim 25, wherein each of the pair of leg regions has a leg end and the leg ends do not connect to each other.

27. The catheter system of claim 25, wherein each of the pair of leg regions has a leg end and the leg ends overlap each other.

28. The catheter system of claim 25, wherein the leg regions of the pair of leg regions are substantially the same in length.

29. The catheter system of claim 25, wherein the leg regions of the pair of leg regions have different lengths.

30. The catheter system of claim 24, wherein at least one of the enlarged central region or the one or more leg regions comprises one or more slots for attaching one or more wires to the at least one discontinuous emitter band.

31. The catheter system of claim 24, wherein the at least one discontinuous emitter band comprises a pair of discontinuous emitter bands connected therebetween by a connecting region, and a width of the enlarged central region of at least one of the pair of discontinuous emitter bands is greater than a width of the connecting region.

32. The catheter system of claim 31, wherein the connecting region is fixedly joined to at least one of the one or more leg regions of each of the pair of discontinuous emitter bands.

33. A catheter for treating an occlusion in a body lumen, the catheter comprising:
an elongated tube comprising an inner layer and an outer layer;

a shock wave electrode assembly at least partially embedded within the elongated tube, the electrode assembly comprising:

at least one emitter band comprising an enlarged region and an aperture extending through the enlarged region, an edge of the aperture of the at least one emitter band forming a first electrode of an electrode pair, and

at least one wire, a distal end of the at least one wire forming a second electrode of the electrode pair such that the electrode pair emits a shock wave when a voltage pulse is applied across the electrode pair,

wherein the at least one emitter band encircles the inner layer and the outer layer at least partially surrounds the at least one emitter band; and

an enclosure surrounding the shock wave electrode assembly.

34. The catheter of claim 33, wherein the enlarged region is a first enlarged region and the at least one emitter band further comprises a second enlarged region and at least one connecting region extending between the first enlarged region and the second enlarged region.

35. The catheter of claim 34, wherein a width of at least one of the first enlarged region or the second enlarged region is greater than a width of the at least one connecting region.

36. The catheter of claim 34, wherein at least one of the first enlarged region or the second enlarged region comprises one or more slots for attaching one or more wires to the at least one emitter band.

37. The catheter of claim 33, wherein the aperture has an elliptical shape.

38. The catheter of claim 33, wherein the outer layer overlays at least a portion of an outer surface of the at least one emitter band.

39. The catheter of claim 33, wherein the inner layer encapsulates at least a portion of the at least one wire.

40. The catheter of claim 33, wherein the inner layer is formed of a first polymer, the outer layer is formed of a second polymer, and the first polymer has a higher melting temperature than the second polymer.

41. The catheter of claim 33, wherein the at least one emitter band forms electrodes of a plurality of electrode pairs.

42. A catheter for treating an occlusion in a body lumen, the catheter comprising:

an elongated tube comprising an inner layer and an outer layer;

a shock wave electrode assembly at least partially embedded within the elongated tube, the electrode assembly comprising:

an emitter band that forms a first electrode of an electrode pair, and

a wire including a distal end that forms a second electrode of the electrode pair,

wherein the emitter band at least partially encircles the inner layer and the outer layer at least partially surrounds the emitter band,

wherein the shock wave electrode assembly is configured to emit a shock wave when a voltage pulse is applied across the electrode pair; and

an enclosure surrounding the shock wave electrode assembly.

43. The catheter of claim 42, wherein the emitter band is a discontinuous emitter band.

44. The catheter of claim 43, wherein the emitter band includes an inner surface that faces toward the inner layer, an outer surface that faces away from the inner layer, and an outer edge extending between the inner layer and the outer layer.

45. The catheter of claim 44, wherein the outer edge is spaced apart from the distal end of the wire to define a spark gap sufficient to generate the shock wave.

46. The catheter of claim 44, wherein the emitter band includes a first enlarged region, a second enlarged region, and a connecting region extending between the first and second enlarged regions.

47. The catheter of claim 46, wherein the emitter band comprises an aperture extending through one of the first enlarged region and second enlarged region.

48. The catheter of claim 47, wherein the aperture is partially defined by an edge, the edge forming the first electrode and being spaced apart from the distal end of the wire to define a spark gap sufficient to generate the shock wave.

49. The catheter of claim 42, wherein:

the emitter band includes a first discontinuous emitter band and a second discontinuous emitter band spaced longitudinally apart from the first discontinuous emitter band,

the distal end of the wire is positioned proximate to the first discontinuous emitter band,

the wire includes a proximal end positioned proximate to the second discontinuous emitter band,

the electrode pair includes a first electrode pair defined by the distal end of the wire and the first discontinuous emitter band and a second electrode pair defined by the proximal end of the wire and the second discontinuous emitter band, and

the shock wave electrode assembly is configured to emit a first shock wave when a voltage pulse is applied across the first electrode pair and a second shock wave when the voltage pulse is applied across the second electrode pair.

50. The catheter of claim 42, wherein the emitter band fully encircles the inner layer.

51. The catheter of claim 50, wherein the emitter band includes a first enlarged region, a second enlarged region, and a connecting region extending between the first and second enlarged regions.

52. The catheter of claim 51, wherein the emitter band comprises an aperture extending through one of the first enlarged region and second enlarged region.

53. The catheter of claim 52, wherein the aperture is partially defined by an edge, the edge forming the first electrode and being spaced apart from the distal end of the wire to define a spark gap sufficient to generate the shock wave.