

CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus for treating an eye, the apparatus comprising:
a housing comprising a fluid-filled chamber and an eye-contacting surface configured to contact a surface of an eye;
a first electrode disposed within the housing; and
a second electrode disposed within the housing and coaxially aligned with the first electrode, wherein a distal tip of the first electrode and a distal tip of the second electrode are separated by a gap,
wherein the first electrode and the second electrode are configured to generate an electric arc across the gap when energized and produce a shockwave in a fluid of the fluid-filled chamber.
2. The apparatus of claim 1, wherein an inner surface of the housing is configured to focus the shockwave to a predetermined location on or below the surface of the eye.
3. The apparatus of claim 1 or 2, further comprising a reflector disposed within the housing and configured to focus the shockwave to a predetermined location on or below the surface of the eye.
4. The apparatus of any of claims 1-3, further comprising a fluid inlet and a fluid outlet in fluid communication with the fluid-filled chamber.
5. The apparatus of any of claims 1-4, further comprising one or more wires coupled to the first electrode or second electrode and configured to provide energy thereto.
6. The apparatus of any of claims 1-5, wherein the first electrode and the second electrode comprise a first tip of a first wire and a second tip of a second wire.
7. The apparatus of any of claims 1-6, wherein the fluid comprises saline or water.
8. The apparatus of any of claims 1-7, wherein the first and second electrodes are coated with graphene to reduce erosion during use shockwave production.
9. The apparatus of any of claims 1-8, wherein the housing is ellipsoidal.
10. The apparatus of any of claims 1-9, wherein the housing further comprises a fluid-filled wave guide disposed between the fluid-filled chamber and the eye-contacting surface and configured to fluidly couple the fluid-filled chamber and the eye-contacting surface.

11. The apparatus of any of claims 1-10, further comprising an acoustic lens disposed within the housing and configured to focus the shockwave to one or more predetermined locations on or below the surface of the eye.
12. The apparatus of any of claims 1-11, further comprising a conductivity sensor at least partially disposed within the fluid-filled chamber and configured to measure a conductivity of the fluid within the fluid-filled chamber.
13. The apparatus of claim 12, wherein the conductivity sensor comprises a pair of platinum electrodes.
14. The apparatus of any of claims 1-13, further comprising a light source at least partially disposed within the fluid-filled chamber and configured to emit light towards the surface of the eye.
15. A system for treating an eye, the system comprising:
the apparatus of any of claims 1-14; and
an energy source operably coupled to the first electrode and the second electrode by one or more wires.
16. The system of claim 15, wherein the first electrode is coupled to a positive terminal of the energy source and the second electrode is coupled to a negative terminal of the energy source.
17. The system of claim 15 or 16, wherein the energy source comprises a high voltage pulse generator.
18. The system of any of claims 15-17, further comprising a current sensor coupled to the first electrode or the second electrode configured to determine a current level flowing to the first electrode or the second electrode.
19. The system of any of claims 15-18, further comprising a conductivity sensor fluidly coupled to the fluid outlet and configured to measure a conductivity of the fluid as it flows out of the fluid outlet.
20. The system of any of claims 15-19, further comprising a fluid recirculation system fluidly coupled to the fluid outlet and the fluid inlet and configured to recirculate fluid from the fluid-filled chamber and remove cavitation bubbles from the fluid.
21. The system of any of claims 15-20, further comprising a reservoir disposed on or under the eye-contacting surface.
22. The system of claim 21, wherein the reservoir comprises oxygen.
23. The system of claim 21, wherein the reservoir comprises riboflavin.
24. The system of claim 21, wherein the reservoir comprises a therapeutic agent.

25. An apparatus for treating an eye, the apparatus comprising:
a housing comprising a fluid-filled chamber and an eye-contacting surface configured to contact a surface of an eye; and
an optical fiber disposed within the housing,
wherein the optical fiber is configured to generate shockwave in a fluid of the fluid-filled chamber when optical energy is emitted therefrom.
26. The apparatus of claim 25, wherein an inner surface of the housing is configured to focus the shockwave to a predetermined location on or below the surface of the eye.
27. The apparatus of claim 25 or 26, further comprising a reflector disposed within the housing and configured to focus the shockwave to a predetermined location on or below the surface of the eye.
28. The apparatus of any of claims 25-27, further comprising a fluid inlet and a fluid outlet in fluid communication with the fluid-filled chamber.
29. The apparatus of any of claims 25-28, wherein the fluid comprises saline or water.
30. The apparatus of any of claims 25-29, wherein the fluid comprises graphene to reduce light emission from the housing when the shockwave is generated.
31. The apparatus of any of claims 25-30, wherein the housing is ellipsoidal.
32. The apparatus of any of claims 25-31, wherein the housing further comprises a fluid-filled wave guide disposed between the fluid-filled chamber and the eye-contacting surface and configured to fluidly couple the fluid-filled chamber and the eye-contacting surface.
33. The apparatus of any of claims 25-32, further comprising an acoustic lens disposed within the housing and configured to focus the shockwave to one or more predetermined locations on or below the surface of the eye.
34. A system for treating an eye, the system comprising:
a plurality of shockwave generators; and
a contact lens disposed around the plurality of shockwave generators, the contact lens comprising a fluid-filled chamber and an eye-contacting surface configured to contact a surface of an eye.
35. The system of claim 34, wherein the contact lens further comprises a suction mechanism configured to contact the surface of the eye and maintain contact between the surface of the eye and the eye-contacting surface.

36. The system of claim 34 or 35, wherein each of the plurality of shockwave generators comprises an optical fiber.
37. The system of claim 34 or 35, wherein each of the plurality of shockwave generators comprises a pair of coaxially-arranged electrodes and a reflector.
38. The system of any of claims 34-37, wherein the contact lens comprises an inflatable outer housing comprising the eye-contacting surface.
39. The system of any of claims 34-38, wherein the contact lens comprises an imaging port configured to receive an imaging apparatus.
40. The system of any of claims 34-39, wherein the plurality of shockwave generators comprises a plurality of electrohydraulic, piezo-electric, laser, or magneto-electric shockwave generators.
41. A method for treating an eye, the method comprising:
coupling an eye-contacting surface of a shockwave generator to a surface of an eye;
generating a shockwave with the shockwave generator; and
focusing the shockwave to a pre-determined location on or below the surface of the eye.
42. The method of claim 41, further comprising inducing microporation, cavitation, vasodilation, neovascularization, disaggregation, and upregulated growth factor production at the pre-determined location with the focused shockwave.
43. The method of claim 41 or 42, wherein the pre-determined location comprises one or more of trabecular meshwork, Schlemm's canal, limbus, eyelid, meibomian gland, retina, and perifovea.
44. The method of any of claims 41-43, further comprising seeding microbubbles at the pre-determined location prior to generating the shockwave.
45. The method of any of claims 41-44, wherein the shockwave generator comprises an optical fiber and wherein generating the shockwave comprises emitting optical energy from the optical fiber into a fluid surrounding the optical fiber.
46. The method of any of claims 41-44, wherein the shockwave generator comprises a first electrode and a second electrode and wherein generating the shockwave comprises energizing the first and second electrodes to form an electrical arc across a gap between tips thereof.
47. The method of any of claims 41-46, further comprising coupling an eye-contacting surface of a second shockwave generator to the surface of the eye, generating a

second shockwave with the second shockwave generator, and focusing the second shockwave to a second pre-determined location on or below the surface of the eye.

48. The method of any of claims 41-47, wherein the shockwave generator is disposed within a fluid-filled chamber of a contact lens.

49. The method of any of claims 41-48, wherein the shockwave generator is coupled to a trial frame.

50. A system for treating an eye, the system comprising:
a shockwave generator configured to generate shockwave; and
a fluid-filled wave guide fluidly coupled to the shockwave generator and configured to direct the shockwave to an eye-contacting surface configured to contact a surface of an eye.

51. The system of claim 50, wherein the wave guide comprises a stainless steel tube.

52. The system of any of claims 50-51, wherein the wave guide has a length of 12 mm or more.

53. The system of any of claims 50-52, wherein the wave guide has a diameter within a range of about 1 mm to about 8 mm.

54. The system of any of claims 50-53, further comprising a contact lens coupled to a distal end of the wave guide, the contact lens comprising a fluid-filled chamber and the eye-contacting surface.

55. The system of any of claims 50-54, wherein the shockwave generator and at least a portion of the wave guide are coupled to a trial frame.