CLAIMS

What is claimed is:

1. A method for fabricating a nanopore at a particular location in a membrane comprised of at least one dielectric material, the method comprising:

directing a laser beam onto the particular location on the membrane while applying one of an electric potential or an electric current to the membrane;

monitoring an electrical property across the membrane while one of the electric potential or the electric current is being applied across the membrane;

detecting an abrupt change in the electrical property across the membrane while one of the electric potential or the electric current is being applied across the membrane; and

removing the electric potential or the electric current from the membrane in response to detecting the abrupt change in the electrical property.

2. The method of claim 1 further comprises removing the laser beam from the particular location on the membrane in response to detecting the abrupt change in the electrical property across the membrane.

3. The method of claim 1 wherein the one of the electric potential or the electric current is applied after the laser beam is directed onto the particular location on the membrane.

4. The method of claim 1 wherein the laser beam is directed onto the particular location on the membrane after the one of the electric potential or the electric current is applied.

5. The method of claim 1 further comprises directing the laser beam onto a second location on the membrane and thereby forming a second nanopore in the membrane, where the second location differs from the particular location.

6. The method of claim 1 wherein, with an electric potential being applied to the membrane, the electrical property being monitored is a leakage current, and the detecting the abrupt change in the electrical property further comprises detecting an abrupt increase in the leakage current across the membrane.

7. The method of claim 6 wherein the detecting the abrupt increase in the leakage current further comprises determining a rate of change of the leakage current and comparing the rate of change to a threshold, and the electric potential is removed when the rate of change of the leakage current is greater than the threshold, thereby stopping the fabrication of a nanopore.

8. The method of claim 6 wherein the detecting the abrupt increase in the leakage current further comprises comparing a value of the leakage current to a threshold, and the electric potential is removed when the value of the leakage current is greater than the threshold, thereby stopping the fabrication of a nanopore.

9. The method of claim 1 wherein, with an electrical current being applied to the membrane, the electrical property being monitored is a voltage across the membrane, and the detecting the abrupt change in the electrical property further comprises detecting an abrupt decrease in the voltage across the membrane.

10. The method of claim 1 further comprises:

disposing the membrane between two reservoirs filled with a fluid containing ions, such that the membrane separates the two reservoirs and prevents the fluid from passing between the two reservoirs;

placing an electrode into each of the two reservoirs; and

generating the one of the electric potential or the electric current using the electrodes.

11. The method of claim 1 further comprises:

disposing the membrane between two reservoirs filled with a fluid containing ions, such that the membrane separates the two reservoirs and prevents the fluid from passing between the two reservoirs;

placing at least one electrode in a pair of electrodes in direct contact with the membrane; and

generating the one of the electric potential or the electric current using the pair of electrodes.

12. A method for fabricating a nanopore at a particular location in a membrane, the method comprising:

directing a laser beam from a light source onto a surface of the membrane at the particular location on the membrane, wherein the membrane is comprised of at least one dielectric material;

applying one of an electric potential or an electric current to the membrane;

measuring an electrical property across the membrane while the one of the electric potential or the electric current is being applied to the membrane and the laser beam is being directed at the particular location, wherein the electrical property includes at least one of voltage or leakage current;

comparing value of the measured electrical property to a threshold; and

removing the one of the electric potential or the electric current to the membrane and removing the laser beam from the particular location on the

membrane in response to the value of the measured electrical property exceeding the threshold.

13. The method of claim 12 further comprises selecting a wavelength for the laser beam based on material composition of the membrane.

14. The method of claim 12 wherein the one of the electric potential or the electric current is applied after the laser beam is directed onto the particular location on the membrane.

15. The method of claim 12 wherein the laser beam is directed onto the particular location on the membrane after the one of the electric potential or the electric current is applied.

16. The method of claim 12 wherein the electrical property includes the leakage current across the membrane when an electrical potential is applied to the membrane, and the comparing value of the measured electrical property further comprises determining a rate of change of the leakage current and comparing the rate of change, as the value, to the threshold, and the electric potential and the laser beam are removed when the rate of change of the leakage current is greater than the threshold, thereby stopping the fabrication of a nanopore.

17. The method of claim 12 wherein the electrical property includes the leakage current across the membrane when an electrical potential is applied to the membrane, and the electric potential and the laser beam are removed when the value of the leakage current is greater than the threshold, thereby stopping the fabrication of the nanopore.

18. The method of claim 12 wherein the electrical property includes the voltage across the membrane when an electrical current is applied to the membrane, and the electrical current and the laser beam are removed when the value of the voltage is less than the threshold, thereby stopping the fabrication of the nanopore.

19. The method of claim 12 further comprises:

disposing the membrane between two reservoirs filled with a fluid containing ions, such that the membrane separates the two reservoirs and prevents the fluid from passing between the two reservoirs;

placing an electrode into each of the two reservoirs; and

generating the one of the electric potential or the electric current using the electrodes.

20. The method of claim 12 further comprises:

disposing the membrane between two reservoirs filled with a fluid containing ions, such that the membrane separates the two reservoirs and prevents the fluid from passing between the two reservoirs;

placing at least one electrode in a pair of electrodes in direct contact with the membrane; and

generating the one of the electric potential or the electric current using the pair of electrodes.

21. The method of claim 12 wherein, to form a plurality of the nanopores at predetermined locations on the membrane, at each of the predetermined locations, the laser beam is directed onto the surface of the membrane at the predetermined location on the membrane, the one of the electric potential or the electric current is applied to the membrane, the electrical property across the membrane is measured while the one of the electric potential or the electric current is being applied to the membrane and the laser beam is being directed at the predetermined location, the measured electrical property is compared to a threshold, and the one of the electric potential or the electric current and the laser beam are removed in response to the value of the measured electrical property exceeding the threshold.

22. The method of claim 12 wherein the directing the laser beam further comprises:

controlling a positional alignment between the membrane and the laser beam by controlling an optical direction of the laser beam, and

activating the light source to emit the laser beam toward the surface of the membrane at the particular location on the membrane.

23. The method of claim 12 wherein the directing the laser beam further comprises:

controlling a positional alignment between the membrane and the laser beam by adjusting a position of the membrane with respect to the light source; and

activating the light source to emit the laser beam toward the surface of the membrane at the particular location on the membrane.

24. An apparatus for fabricating a nanopore in a membrane that is comprised of at least one dielectric material, the apparatus comprising:

a fluidic device including two reservoirs, at least two electrodes, and a holder, wherein:

the reservoirs hold fluid that contains ions, the membrane separates the two reservoirs and prevents the fluid from passing between the two reservoirs,

the electrodes are electrically connected to a power source and are operable to apply one of an electric potential or an electric current to the membrane, and

the holder is configured to hold the membrane that is immersed in the fluid from the two reservoirs and includes a window that provides optical access to the membrane;

an optical device operable to emit a focused laser beam passing through the window of the holder and directed toward a particular location on the membrane, wherein the focused laser beam illuminates the particular location of the membrane as the one of the electric potential or the electric current is being applied to the membrane by the electrodes;

a sensor electrically coupled to one of the electrodes and operable to measure an electrical property across the membrane, wherein the electrical property includes at least one of voltage and leakage current; and

a controller interfaced with the sensor, wherein the controller detects an abrupt change in the measured electrical property and, in response to detecting the abrupt change in the measured electrical property, removes the one of the electric potential or the electric current applied to the membrane and removes the focused laser beam from the particular location on the membrane.

25. The apparatus of claim 24 wherein a wavelength for the focused laser beam is based on material composition of the dielectric material of the membrane.

26. The apparatus of claim 24 wherein the optical device is an inverted optical microscope.

27. The apparatus of claim 24 wherein one electrode of the at least two electrodes is disposed in each of the two reservoirs.

28. The apparatus of claim 24 wherein the at least two electrodes are in direct contact with the membrane.

29. The apparatus of claim 24 wherein:

the electrodes apply an electric current to the membrane,

the sensor measures a voltage across the membrane, as the electrical property, and

the controller compares the measured voltage to a threshold and removes the electric current to the membrane and the focused laser beam from the particular location on the membrane in response to the voltage being less than the threshold.

30. The apparatus of claim 24 wherein:

the electrodes apply an electric potential to the membrane,

the sensor measures a leakage current across the membrane, as the electrical property, and

the controller compares the measured leakage current to a threshold and removes the electric potential to the membrane and the focused laser beam from

the particular location on the membrane in response to the measured leakage current being greater than the threshold.

31. A method of increasing size of a nanopore in a membrane comprising at least one dielectric material, the method comprising:

directing a laser beam onto the nanopore in the membrane while one of an electric potential or an electric current is applied to the membrane;

measuring a leakage current across the membrane;

determining an increase in size of the nanopore based on the measured leakage current; and

removing the one of the electric potential or the electric current to the membrane in response to detecting an increase in size of the nanopore.

32. The method of claim 31 wherein the membrane comprises a plurality of nanopores and the laser beam is directed onto a first nanopore.

33. The method of claim 31 further comprising directing the laser beam onto a second nanopore.

34. The method of any one of claims 31-33 further comprises:

disposing the membrane between two reservoirs filled with a fluid containing ions, such that the membrane separates the two reservoirs and prevents the fluid from passing between the two reservoirs;

placing an electrode into each of the two reservoirs; and

generating the one of the electric potential or the electrical current using the electrodes.