CLAIMS

1. A microneedle array for use in sensing an analyte, comprising:

a plurality of solid microneedles, wherein at least one microneedle comprises:

a tapered distal portion having an insulated distal apex; and

an electrode on a surface of the tapered distal portion, wherein the electrode is located proximal to the insulated distal apex.

2. The microneedle array of claim 1, wherein the electrode is a working electrode configured to sense at least one analyte and the at least one microneedle comprises a biorecognition layer arranged over the working electrode, wherein the biorecognition layer comprises a biorecognition element.

3. The microneedle array of claim 2, wherein the biorecognition element comprises an enzyme.

4. The microneedle array of claim 3, wherein the enzyme is glucose oxidase.

5. The microneedle array of claim 2, wherein the at least one microneedle comprises at least one of a diffusion-limiting layer and a hydrophilic layer arranged over the biorecognition layer.

6. The microneedle array of claim 2, wherein the microneedle array comprises at least one microneedle comprising a counter electrode configured to source or sink current to sustain an electrochemical reaction on the working electrode.

7. The microneedle array of claim 2, wherein the microneedle array comprises at least one microneedle comprising a reference electrode configured to provide a reference potential for the working electrode.

8. The microneedle array of claim 1, wherein the entirety of the electrode is on the tapered distal portion of the at least one microneedle.

9. The microneedle array of claim 1, wherein a distal end of the electrode is offset from the distal apex by an offset distance of at least about 10 μm, wherein the offset distance is measured along a longitudinal axis of the at least one microneedle.

10. The microneedle array of claim 1, wherein the electrode is annular.

11. The microneedle array of claim 1, wherein a portion of the working electrode is recessed into the tapered distal portion.

12. The microneedle array of claim 1, wherein the electrode is on only a segment of the tapered distal portion.

13. The microneedle array of claim 1, further comprising an electrical contact, wherein the at least one microneedle comprises a body portion providing a conductive pathway between the electrical contact and the electrode.

14. The microneedle array of claim 13, wherein the body portion is formed from a conductive material.

15. The microneedle array of claim 13, wherein the body portion is insulated.

16. The microneedle array of claim 1, wherein each of the microneedles in the plurality of microneedles comprises a

a tapered distal portion having an insulated distal apex; and

an electrode on a surface of the tapered distal portion, wherein the electrode is located proximal to the insulated distal apex.

17. The microneedle array of claim 1, wherein the microneedles of the plurality of microneedles are electrically insulated from one another.

18. The microneedle array of claim 17, wherein the microneedle array is configured to detect multiple analytes.

19. The microneedle array of claim 1, wherein the microneedles of the plurality of microneedles are arranged in a periodic grid.

20. The microneedle array of claim 1, wherein the at least one microneedle is configured to puncture skin of a user and sense an analyte in interstitial fluid in a dermal layer of the user.

21. An analyte monitoring system comprising the microneedle array of claim 1 and a wearable housing, wherein the microneedle array extends outwardly from the housing.

22. The system of claim 21, wherein the at least one microneedle extends from the housing such that a distal end of the electrode is located less than about 5 mm from the housing.

23. The system of claim 21, wherein the housing encloses an electronics system comprising at least one of a processor and a wireless communication module.

24. The system of claim 23, wherein the electronics system comprises a wireless communication module and the system further comprises a software application executable on a mobile computing device to be paired with the wireless communication module.

25. The system of claim 21, wherein the housing comprises one or more indicator lights configured to communicate status information.

26. The system of claim 25, wherein at least one of the indicator lights is configured to be selectively illuminated in accordance with an illumination mode corresponding to an analyte measurement status.

27. The system of claim 26, wherein at least one of the indicator lights is configured to be selectively illuminated to communicate a current analyte measurement level.

28. The system of claim 25, wherein the user interface is further configured to communicate information indicative of a status of the analyte monitoring device.

29. The system of claim 21, further comprising an adhesive configured to couple the housing to the skin of a user.

30. The system of claim 21, further comprising an applicator configured to apply the at least a portion of the analyte monitoring system to the skin of a user.

31. A method for monitoring a user, comprising:

accessing a body fluid of the user with an analyte monitoring device; and

quantifying one or more analytes in the body fluid using the analyte monitoring device,

wherein the analyte monitoring device comprises a plurality of solid microneedles, wherein at least one microneedle comprises:

a tapered distal portion having an insulated distal apex; and

an electrode on a surface of the tapered distal portion, wherein the electrode is located proximal to the insulated distal apex.

32. A microneedle array for use in sensing an analyte, comprising:

a plurality of solid microneedles, wherein at least one microneedle comprises:

a tapered distal portion having an insulated distal apex; and

an electrode on a surface of the tapered distal portion, wherein a distal end of the electrode is offset from the distal apex.

33. A microneedle array for an analyte monitoring device, the microneedle array comprising:

a plurality of solid sensing microneedles, wherein each sensing microneedle comprises:

a tapered distal portion comprising a working electrode configured to sense an analyte; and

a body portion providing a conductive connection to the working electrode,

wherein the body portion of each sensing microneedle is insulated such that each working electrode is individually addressable and electrically isolated from every other working electrode in the microneedle array.

34. A method for monitoring a user, comprising:

accessing a dermal interstitial fluid of the user at a plurality of sensor locations with an integrated analyte monitoring device comprising a single microneedle array;

quantifying one or more analytes in the dermal interstitial fluid using a plurality of working electrodes in the microneedle array, wherein each working electrode is individually addressable and electrically isolated from every other working electrode in the analyte monitoring device.

35. A body-worn analyte monitoring device, comprising:

a wearable housing; and

a microneedle array extending outwardly from the housing and comprising at least one microneedle configured to measure one or more analytes in a user wearing the housing,

wherein the housing comprises a user interface configured to communicate information indicative of the measurement of the one or more analytes.

36. A method for monitoring a user, comprising:

measuring one or more analytes in the user using a body-worn analyte monitoring device comprising a wearable housing and one or more analyte sensors;

communicating information indicative of the measurement of the one or more analytes through a user interface on the housing.

37. A microneedle array for use in sensing an analyte, comprising:

a semiconductor substrate;

a plurality of solid microneedles extending from the substrate, wherein at least one microneedle of the plurality of microneedles is configured to sense an analyte in dermal interstitial fluid of a user and comprises:

a columnar body portion;

a tapered distal portion having an insulated distal apex; and

an annular working electrode coupled to a surface of the tapered distal portion, wherein a portion of the working electrode overlies and extends beyond an annular recess formed in the surface of the tapered distal portion, wherein the working electrode extends onto the surface of the tapered distal portion on each side of the annular recess.

38. A microneedle array for use in sensing an analyte, comprising:

a first microneedle comprising a working electrode, wherein the working electrode comprises a first electrode material and a biorecognition layer on the first electrode material, wherein the biorecognition layer comprises a biorecognition element configured to react with the analyte;

a second microneedle comprising a counter electrode, wherein the counter electrode comprises a second electrode material; and

a third microneedle comprising a reference electrode, wherein the reference electrode comprises a third electrode material and a redox-couple layer on the third electrode material, and

wherein a redox reaction occurs between the working electrode on the first microneedle and the counter electrode on the second microneedle.

39. A microneedle array for use in sensing glucose, comprising:

a first microneedle comprising a working electrode, wherein the working electrode comprises a platinum layer and a biorecognition layer on the platinum layer, wherein the biorecognition layer comprises a conducting polymer-entrapped glucose oxidase configured to react with the glucose;

a second microneedle comprising a counter electrode, wherein the counter electrode comprises a platinum layer; and

a third microneedle comprising a reference electrode, wherein the reference electrode comprises silver/silver chloride, and

wherein a redox reaction occurs between the working electrode on the first microneedle and the counter electrode on the second microneedle.

40. A method for sensing an analyte via a microneedle array, comprising:

providing a first microneedle comprising a working electrode, wherein the working electrode comprises a first electrode material and a biorecognition layer on the first electrode material, wherein the biorecognition layer comprises a biorecognition element configured to react with the analyte;

providing a second microneedle comprising a counter electrode, wherein the counter electrode comprises a second electrode material;

providing a third microneedle comprising a reference electrode, wherein the reference electrode comprises a third electrode material and a redox-couple layer on the third electrode material;

applying a bias potential between the working electrode and the reference electrode; and

measuring a current value between the working electrode and the counter electrode, the current value being proportional to a concentration of the analyte,

wherein a redox reaction occurs between the working electrode and the counter electrode.

41. A microneedle array for use in sensing an analyte, comprising:

a semiconductor substrate;

a plurality of solid microneedles extending from the substrate, wherein at least one microneedle of the plurality of microneedles is configured to sense an analyte in dermal interstitial fluid of a user and comprises:

a columnar body portion;

a tapered distal portion having an insulated distal apex; and

an annular working electrode on a surface of the tapered distal portion, wherein the working electrode comprises a proximal edge and a distal edge and is on only a segment of the surface of the tapered distal portion of the microneedle, and wherein the distal edge of the working electrode is proximate a proximal edge of the insulated distal apex.

42. A method for monitoring a user, comprising:

accessing a dermal interstitial fluid of the user with an analyte monitoring device; and

quantifying one or more analytes in the body fluid using the analyte monitoring device,

wherein the analyte monitoring device comprises a microneedle array comprising a semiconductor substrate and a plurality of solid microneedles extending from the substrate, wherein at least one microneedle of the plurality of microneedles comprises:

a columnar body portion;

a tapered distal portion having an insulated distal apex; and

an annular working electrode on a surface of the tapered distal portion, wherein the working electrode comprises a proximal edge and a distal edge and is on only a segment of the surface of the tapered distal portion of the microneedle, and wherein the distal edge of the working electrode is proximate a proximal edge of the insulated distal apex.