

## CLAIMS

What is claimed is:

1. A method for providing spatially positioned electrochemical reactions with an electrode array exposed on a surface of a semiconductor substrate, the method comprising:
  - selecting one or more electrodes in the electrode array; and
  - controlling circuitry in the semiconductor substrate to apply, at the one or more electrodes, one or more stimulus signals to initiate an electrochemical reaction at the selected one or more electrodes.
2. The method of claim 1, wherein the electrochemical reaction is a half reaction that generates a gas in a solution, and wherein the one or more stimulus signals comprise potentials that are above a redox potential for generation of the gas.
3. The method of claim 2, wherein the solution comprises a plurality of cells attached to the surface of the semiconductor substrate, and the method further comprises:
  - generating the gas at the selected one or more electrodes such that at least one cell of the plurality of cells that is disposed on the selected one or more electrodes is detached from the surface of the semiconductor substrate.
4. The method of any one of claims 2 or 3, wherein the gas comprises H<sub>2</sub>, Cl<sub>2</sub>, or O<sub>2</sub>.
5. The method of any one of claims 3 or 4, wherein the plurality of cells are a plurality of cells of a first type, and the method further comprises:
  - plating one or more cells of a second type on the surface of the semiconductor substrate at locations where the at least one cell of the first type has detached from.
6. The method of any one of claims 3-5, further comprising:
  - mapping a time sequence of regrowth of the plurality of cells on the surface at positions where the at least one cell has detached from; and
  - based on the mapping, determining a growth rate of the plurality of cells.

7. The method of any one of claims 1-6, wherein controlling circuitry to apply one or more pre-determined potentials comprises performing cyclic voltammetry at the selected one or more electrodes, and the method further comprises:

measuring, with the circuitry, a value of an electrical characteristic at each of some or all remaining electrodes in the electrode array that are outside the selected one or more electrodes;

generating a map of electrical characteristics based on the result of the measuring.

8. The method of claim 7, wherein the electrical characteristic is a characteristic of an open-circuit potential.

9. The method of claim 7, wherein the electrical characteristic is a current.

10. The method of claim 9, wherein the characteristic of the current is a maximum extent of a range of a cyclic current.

11. The method of any one of claims 1-10, wherein controlling circuitry to apply one or more pre-determined potentials comprises applying a pulsed voltage signal at an electrode of the selected one or more electrodes, wherein

during a first portion within the pulsed voltage signal, the electrode is being oxidized, and during a second portion of the pulsed voltage signal, an oxide on the electrode is being reduced, and the method further comprises:

measuring, with the circuitry, a current signal at the electrode during the second portion of the pulsed voltage signal;

based on a time rate of change of the current signal, determining an oxygen concentration at a position of the electrode; and

generating a map of oxygen concentration based on the result of the determining.

12. The method of any one of claims 1-11, wherein the one or more stimulus signals are potentials that are relative to a potential of a reference electrode.

13. A system comprising:

a semiconductor substrate comprising:

an electrode array including a plurality of individually addressable electrodes disposed on a surface of the semiconductor substrate; and

circuitry that is controllable by one or more processors to apply, at a group of electrodes in the electrode array, one or more potentials relative to a potential of an electrode in the electrode array or a potential of a reference electrode to initiate an electrochemical reaction at the group of electrodes.

14. The system of claim 13, wherein the electrode array comprises a plurality of pads disposed on an insulative surface of the semiconductor substrate.

15. The system of any one of claims 13 or 14, wherein the plurality of pads comprises Au or Pt.

16. The system of any one of claims 13-15, wherein the reference electrode is a Ag/AgCl reference electrode.

17. The system of any one of claims 13-16, wherein the electrode array comprises at least 1000, at least 4000, or at least 1,000,000 electrodes, and the circuitry comprises a plurality of recording circuits, each recording circuit configured to measure a current at an electrode of the electrode array.

18. The system of claim 17, wherein the plurality of recording circuits comprises at least 10 recording circuits, or at least 4000 recording circuits.

19. The system of claim 17, wherein each recording circuit comprises a transimpedance amplifier (TIA).

20. The system of claim 19, wherein the TIA comprises an impedance component having a resistance of at least 10 M $\Omega$ , wherein an output voltage of the TIA is proportional to a voltage across the impedance component.

21. The system of claim 20, wherein the impedance component comprises a switching capacitor.

22. A system for providing spatially positioned electrochemical reactions, the system comprising:

an electrode array exposed at a surface area of a semiconductor substrate;

circuitry disposed in the semiconductor substrate and coupled to the electrode array;

at least one non-transitory computer-readable medium having stored thereon executable instructions; and

at least one processor programmed by the executable instructions to perform a method comprising acts of:

selecting a pattern of electrodes in the electrode array; and

controlling circuitry to apply, at the pattern of electrodes, one or more pre-determined potentials relative to a potential of an electrode in the electrode array or a potential of a reference electrode, such that an electrochemical reaction is initiated at the pattern of electrodes.