

CLAIMS

1. An apparatus for mapping one or more cells, the apparatus comprising:
 - a semiconductor substrate, comprising:
 - a plurality of electrodes exposed at a surface of the semiconductor substrate;
 - active circuitry coupled to the plurality of electrodes and configured to:
 - measure a set of cross-electrode currents between each electrode of the plurality of electrodes and some or all of the remaining electrodes; and
 - one or more processors configured to:
 - for each electrode, generate a representative value associated with an electrode position of the electrode based on normalized impedance values based on the set of cross-electrode currents associated with the electrode, and
 - generate a map of representative values on the surface based on generated representative values for the plurality of electrodes and respective electrode positions of the plurality of electrodes.
2. The apparatus of claim 1, wherein the active circuitry is further configured to apply a stimulus signal at an electrode of the plurality of electrodes, and to apply a reference voltage at the remaining electrodes where the cross -electrode currents are being measured from.
3. The apparatus of claim 2, wherein the stimulus signal has a frequency of less than 10 kHz and preferably between 0.1 and 5 kHz.
4. The apparatus of claim 1, wherein the plurality of electrodes are arranged in an array having a pitch of less than 30 μm and preferably less than 5 μm .
5. The apparatus of claim 1, wherein the semiconductor substrate comprises silicon.
6. The apparatus of claim 1, wherein the semiconductor substrate comprises a silicon

substrate, and wherein the active circuitry comprises complimentary metal-oxide semiconductor (CMOS) components in the silicon substrate.

7. The apparatus of claim 1, wherein the plurality of electrodes comprise a plurality of pads disposed on an insulative surface of the semiconductor substrate.
8. The apparatus of claim 1, wherein the active circuitry comprises a plurality of recording circuits, each recording circuit configured to measure a current at an electrode of the plurality of electrodes.
9. The apparatus of claim 8, wherein the plurality of recording circuits comprises at least 8 recording circuits, at least 10 recording circuits, or preferably at least 4000 recording circuits.
10. The apparatus of claim 8, wherein each recording circuit comprises a transimpedance amplifier (TIA).
11. The apparatus of claim 10, wherein the TIA comprises an impedance component having a resistance of at least 10 MW, at least 100 MW, or between 10 MW and 1 WW, wherein an output voltage of the TIA is proportional to a voltage across the impedance component.
12. The apparatus of claim 11, wherein the impedance component comprises a switching capacitor.
13. The apparatus of claim 1, wherein the one or more cells are disposed in a first well of a multi- well plate, and the plurality of electrodes is a first electrode array exposed to the first well, and wherein the apparatus further comprises a second electrode array exposed on the surface of the semiconductor substrate, and exposed to a second well of the multi-well plate.
14. The apparatus of claim 13, wherein the multi-well plate comprises at least 24, at least 96,

or at least 384 wells.

15. The apparatus of claim 1, wherein the plurality of electrodes are sized such that more than one electrode are configured to be in contact with one cell of the one or more cells.
16. The apparatus of claim 7, wherein the plurality of pads comprises Au.
17. The apparatus of claim 7, wherein the plurality of pads comprises Pt.
18. A method for mapping one or more cells in contact with an electrode array using the apparatus of claim 1, the method comprising:
 - for each electrode of at least one electrode of the electrode array:
 - applying a stimulus signal at the electrode;
 - measuring the set of cross-electrode currents between the electrode and some or all of the remaining electrodes in the electrode array;
 - generating the representative value associated with the electrode position of the electrode based on normalized impedance values based on the set of cross -electrode currents; and
 - generating a map of representative values on the surface based on the generated representative values and respective associated electrode locations of the at least one electrode.
19. A system for mapping one or more cells, the system comprising:
 - a plurality of electrodes exposed at a surface area of a semiconductor substrate; circuitry disposed in the semiconductor substrate that is controllable to apply a stimulus signal and measure a current at one or more electrodes of the plurality of electrodes;
 - 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:
 - for each electrode in the plurality of electrodes:

controlling the circuitry to apply a stimulus signal at the electrode;
controlling the circuitry to measure a set of cross-electrode currents between the electrode and some or all of the remaining electrodes in the plurality of electrodes;
generating a representative value associated with an electrode location of the electrode based on normalized impedance values based on the set of cross -electrode currents; and
generating a map of representative values on the surface area based on the generated representative values and respective associated electrode locations of the plurality of electrodes.