On-Chip Electrochemical Impedance Spectroscopy for Membrane Protein Biosensors Array Microsystems

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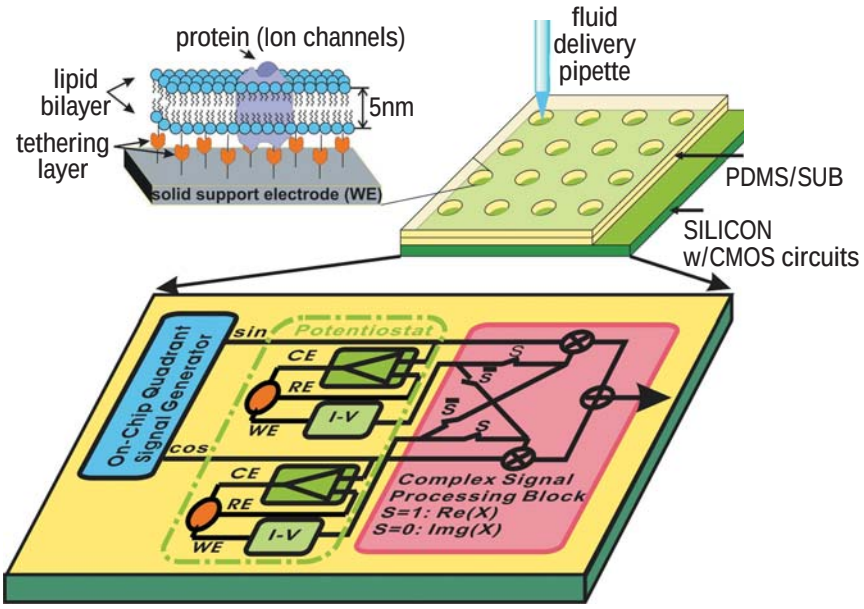
Membrane proteins are excellent biological recognition elements that can be embedded with synthetic tethered bilayer lipid membranes (tBLM) to form nanostructured biomimetic interfaces. In this research, we are developing electrochemical impedance spectroscopy (EIS) circuitry that will enable monolithic implementation of biomimetic sensor array microsystems, providing significant improvements in measurement resolution and throughput and manufacturing cost. For many membrane proteins, EIS provides tag-free, reversible analysis that permits fully electronic biosensor systems. However, entirely on-chip EIS systems have yet to be developed. Moreover, impedance analysis of tBLMs requires sub-Hertz excitation frequencies that must be accommodated by readout circuitry. Typically, EIS is performed by integrating circuits that suffer from very long measurement times for sub-Hertz signals compromising the throughput of array readings. Thus, we have introduced a new EIS algorithm and circuit that performs complex-domain (real and imaginary components) signal processing using analog electronics. The new approach requires only 20msec to read out each sensor element, independent of excitation frequency, significantly improving readout speed for tBLM-based biosensors. The new circuit enables the next generation of high-throughput biosensor array microsystems based on membrane proteins for biomedical studies, drug screening, or environmental and homeland security monitoring. ■



Protein-embedded tBLM sensor arrays are built on top of the silicon surface; the electrical system underneath generates quadrature signals for two identical sensor elements, and the responses are processed in complex signal domain to get the real and imaginary portions of impedance information.