Electrochemical Microsystem Array for Functional Proteomics

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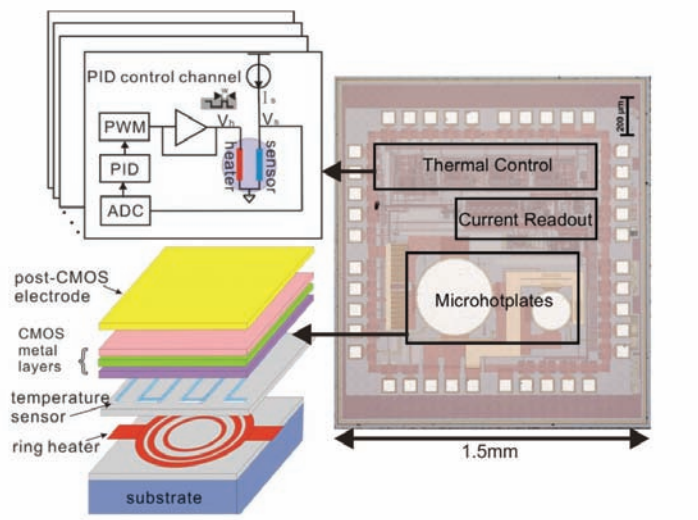
With the completion of the Human Genome Project and the sequencing of several other scientifically important genomes, emphasis has shifted to determining the structure and function of the gene products, i.e., the proteins. The goal of this multidisciplinary project is to develop an integrated microsystem platform that incorporates a protein-based bio-interface array into a continuous-use, cost-effective, electrochemical characterization system suitable for functional proteomics research. To achieve this goal, we have synergistically explored four technical challenges: 1) the development of novel nanostructured bio-interfaces appropriate for integration on the surface of a microelectronics chip; 2) the design of high-performance integrated circuits for multiple electrochemical assays; 3) the design of circuits, structures, and packaging for on-chip thermal control of individual bio-interface sites; and 4) the development of microfabrication techniques enabling a miniaturized, multi-protein, array-on-chip platform that incorporates fluid handling. Electrode arrays on silicon have been fabricated and functionalized with nanostructured enzyme and membrane protein interfaces. A new multi-channel electrochemical impedance spectroscopy circuit, with on-chip AC stimulus generator, has been implemented and provides a resolution of ~100fA and current range up to 100nA. An instrumentation circuit capable of multiple DC electrochemical techniques, including cyclic voltammetry and chronoamperometry, has also been implemented. Microhotplate arrays with thermal control circuitry have been realized in standard CMOS and verified to control the temperature of individual on-chip electrodes within the biological testing range. Several packaging options are now being explored to integrate all the elements of this microsystem platform and permit rapid functional characterization of a wide range of proteins. ■



Prototype thermal control microsystem chip with block diagram of the thermoelectric control system and cross section of CMOS microhotplate layers.