

A MICROMACHINED PICO-CALORIMETRIC SENSOR FOR BIOLOGICAL SYSTEMS

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Abstract

Highly sensitive chip calorimeters have great potential as biosensors due to their ability to make measurements on very small sample volumes, thus low output power but short thermal equilibrium time. However, the previously reported chip calorimeters are not yet sensitive enough to analyze sub-nano Watt power level corresponding to metabolic power of individual cells. This work aims to break through these current limitations by measuring pico-Watt power levels quantitatively through use of micromachined sensors and by controlling the wetting and evaporation of liquids. Individual sensors consist of a combination of thermistors and thermopiles on a thin silicon nitride membrane that allow direct differential measurements between a sample and a reference. To maximize sensitivity, sensor geometry and materials were optimized based on the temperature field that develops around a typical sample and on calculations of the corresponding noise equivalent power and minimum detectable power. This highly sensitive thermopile-based calorimeter offers particular promise for quantitative measurement of cellular bioenergetics in real time.