Final Report

Mixed-Signal VLSI Interface for High Aspect Ratio Optical/Electrochemical Hybrid Sensor Array

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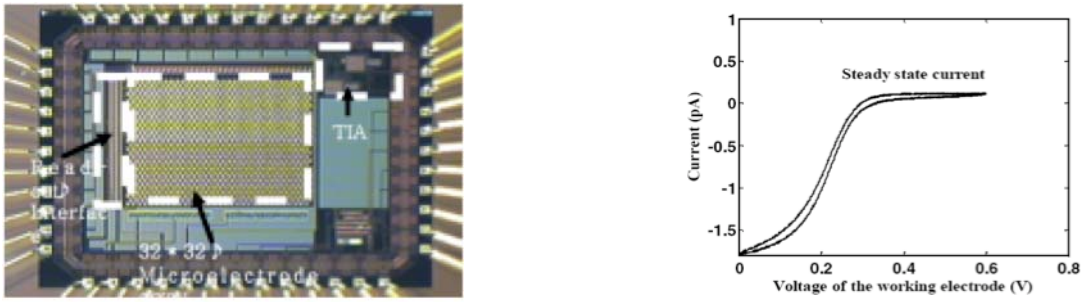
The goal of the supplemental funding project was to demonstrate a mixed signal VLSI interface circuit for an opto-electrochemical sensor array. In order to reach our goal, we wanted to first demonstrate that microelectrode arrays could be built using the native top layer metal in the CMOS process, and use these arrays for electrochemical measurements.

Microelectrode arrays (MEAs) offer numerous benefits over macroelectrodes due to their smaller sample size requirement, small form factor, low power consumption, and higher sensitivity due to increased rates of mass transport. These features make MEAs well suited for microfluidic lab-on-a-chip applications.

We fabricated an individually addressable 32 × 32 array of 7 um square microelectrodes with 37 um center-to-center spacing on a CMOS chip with built-in VLSI potentiostat for electrochemical analysis. The integrated CMOS MEA is post processed at the die level to coat the exposed Al layers with Au. To verify microelectrode array behavior with individual addressability, cyclic voltammetry was performed using a potassium ferricyanide ($K_3Fe(CN)_6$)) solution. The chip microphotograph and measurement results on a reference ferricyanide solution are shown below.



(a) (b)

Fig 1 (a) Microphotograph of single chip potentiostat with 32 X 32 microelectrode array and built-in potentiostat, (b) Cyclic voltammetry measurement at the array

Table 1: Summary of the single chip potentiostat with microelectrode array

AMI 0.5u CMOS Technology Die area	0.052 mm^2
Supply Voltage	5 V
# of the MEA	32 x 32
Size of the MEA	7 um x 7um
Pitch of the MEA	37 um
Test Solution	1mM $K_3Fe(CN)_6$
Transimpedance Gain	82 Kohms
Scan Rate	0.005 ~ 0.1 V/s
Power	74uW (for 0.1uA input)

Publications:

(1) S. Hwang, C. N. LaFratta, V. Agarwal, J. Yu, D. R. Walt, S. Sonkusale, "CMOS Microelectrode Array for Electrochemical Lab-on-a-Chip Applications", **IEEE Sensors Journal**, Vol. 9, No. 6, June 2009, pp. 609-615.

(2) Sungkil Hwang, Vinay Agarwal, Christopher Lafratta, David Walt, Sameer Sonkusale, "A Miniaturized CMOS Microelectrode Array System for Single Droplet Electrochemistry Applications", Proceedings of the International Conference on Miniaturized System for Chemistry and Life Sciences, **MicroTAS 2008.**