The Development of Biosensors and Biochips in IECAS

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Abstract In this paper, the thin film electrode disposable biosensors capable with low cost, high reliability, robustness, low volume sample and hand-held multichannel meter were developed. Various biomolecules, such as glucose, lactate, b-hydroxybutyrate, cholesterol, hemoglobin and creatine kinase in low volume (less than 3 μL) have been detected. It is significant for the applications in home health care, clinical diagnostics and physiological identification and physical performance of athlete. Biochips based on micro-electro-mechanical-systems (MEMS) technology supply novel biochemical analytical technologies, which offer many advantages including high sample throughput, high integration, and reduced cost. Biochips are rapidly developed in recent years. This paper also will show the research results of biochips based on MEMS technology, including DNA purification chips, DNA-PCR chips, capillary electrophoresis chips, PCR-CE chips, LAPS (light addressable potential sensor) for DNA detection, DNA SPR (surface plasmon resonance) and DNA FET (field effect transistor) sensors. These biochips have potential applications in health care diagnosis, environment monitoring, gene sequencing and high through drug screening.

1. The research and development of biosensors in IECAS

It is known that biosensors will be integrated and miniaturized, and be used to replace existing, more time consuming analytical methods for monitoring and detecting [1, 2]. In this work, the thin film electrode biosensors with 2-electrode construction and hand-held meter were developed. The surface of the working electrode of the biosensor, modified with nanoscale materials of electrodeposited platinum or carboxymethylcellulose (CMC), has the porous performance and has excellent hydrophilicity, thus the electrode possesses huge surface and high catalytic activities for electrolytic processes.

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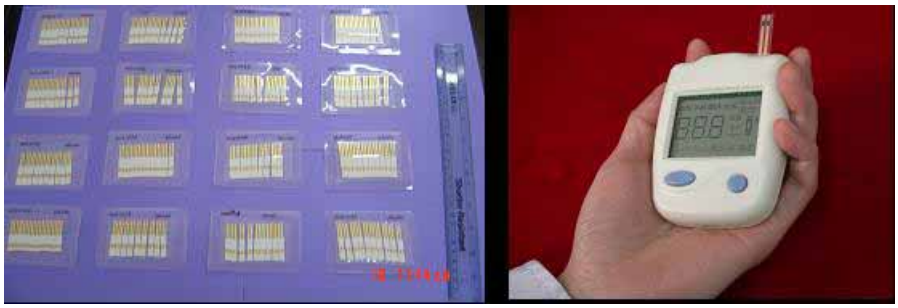
Various biomolecules, such as glucose [3], lactate [3], b-hydroxybutyrate [4], cholesterol [4], hemoglobin [7] and creatine kinase [8] in low volume were detected as shown in Table 1[5]. Compared with the strips in market and the existing analytical instruments, the produced disposable biosensors (Figure 1a) are capable with low cost, high reliability, robustness, low volume sample and the created portable multichannel meters (Figure 1b) can be used for test human metabolites without reagents. It is significant for the applications in home health care, clinical diagnostics and physiological identification and physical performance of athlete. Also it has the potential applications in food, beverage, environmental, pharmaceutical, bioprocess and antiterrorism.

Table 1. The biosensors characteristics achieved [5]

Test Molecules	Sample Solution	Nanoscale Materials	Test Time	Measurement Range	Correlation Coefficient
Glucose	Buffer	Pt nanoparticals	12 s	0.5～12 mM	0.998
	Serum	Pt nanoparticals	27 s	1～30 mM	0.965
Lactate	Buffer	Pt nanoparticals	15 s	0.5～15 mM	0.998
	Serum	Pt nanoparticals	25 s	0.5～10 mM	0.988
β-hydroxybutyrate	Buffer	Pt nanoparticals	20 s	0.01～4 mM	0.999
	Serum	Pt nanoparticals	20 s	0.01～6 mM	0.946
Cholesterol	Buffer	Pt nanoparticals	30 s	0.1～5 mM	0.995
Hemoglobin	Buffer	Nanoporous CMC	90 s	10μM～3 mM	0.995
Creatine kinase	Buffer	Nanoporous CMC	140 s	8～800 U/mL	0.980
			280 s	8～800 U/L	0.960



(a) **(b)**

Figure 1. The photos of the thin film electrode biosensors fabricated in laboratory throughput and the meter: (a) the disposable biosensors packed in vacuum; (b) the portable multichannel meter.

2. Current research on Biochips in IECAS

Biochips based on micro-electro-mechanical-systems (MEMS) technology supply novel biochemical analytical technologies, which offer many advantages including high sample throughput, high integration, and reduced cost. Biochips are rapidly developed in recent years [9]. The research results of biochips based on MEMS technology are described as below:

(1) Two types of DNA purification chips based on solid phase extraction (SPE) technology have been fabricated and studied. Both two chips were used to purify the DNA from PCR products. The silicon chip was also used to purify DNA from yeast bacteria.

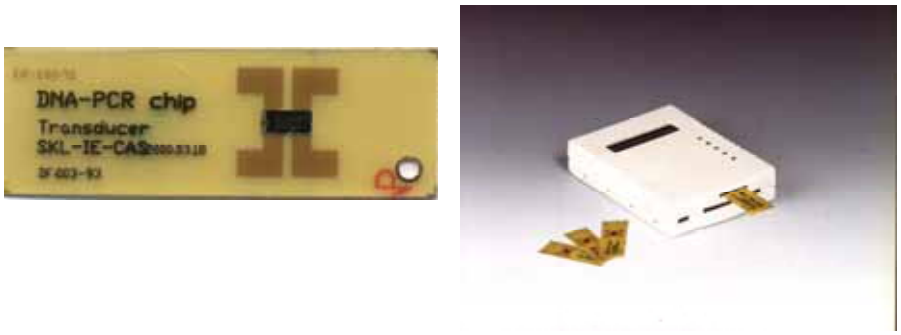
(2) DNA-PCR chip were fabricated on glass and silicon substrates using MEMS technology (Figure 2a), and a portable temperature controller (Figure 2b) for PCR chip has been developed [10]. PCR reaction has been realized successfully in this system.

(3) PDMS electrophoresis microchip was constructed by molding method. A novel method to fabricate PDMS sandwiched microfluidic chip was presented and the microchip has been demonstrated as a capillary electrophoresis device for double-stranded DNA (dsDNA) and amino acid separation (Figure 3) [11].

(4) Fundamental research of integrated chip, including materials compatibility and microfabricated process possibility has been done. PDMS sandwiched PCR-CE chip and PCR-CE electrochemical detection chip have been designed and microfabricated.

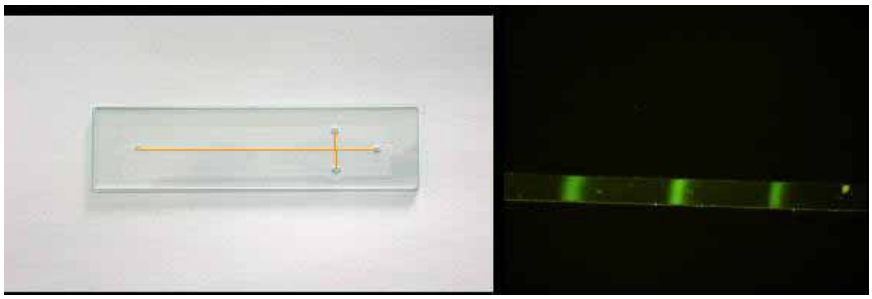
(5) Novel technologies for DNA detection, including light addressable potential sensor (LAPS), SPR sensors and DNA FET, have been developed and good results have been obtained.

The above research on biochips based on MEMS, has laid a foundation for potential applications in health care diagnosis, environment monitoring, gene sequencing and high through drug screening.



(a) **(b)**

Figure 2. (a) The mounted chip of DNA-PCR; (b) a photo of the thermal circler. [10]



(a) **(b)**

Figure 3. (a) The photo of PDMS microchip for DNA separation; (b) the separation image of DNA fragments labeled by SYBR Green I. [11]

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