Biosensor Based on Giant Magnetoresistance Material

Mitra Djamal, Institut Teknologi Bandung, Indonesia

Ramli, Institut Teknologi Bandung and Universitas Negeri Padang, Indonesia

Yulkifli, Institut Teknologi Bandung and Universitas Negeri Padang, Indonesia

Suprijadi, Institut Teknologi Bandung, Indonesia

Khairurrijal, Institut Teknologi Bandung, Indonesia

ABSTRACT

In recent years, giant magnetoresistance (GMR) sensors have shown a great potential as sensing elements for biomolecule detection. The resistance of a GMR sensor changes with the magnetic field applied to the sensor, so that a magnetically labeled biomolecule can induce a signal. Compared with the traditional optical detection that is widely used in biomedicine, GMR sensors are more sensitive, portable, and give a fully electronic readout. In addition, GMR sensors are inexpensive and the fabrication is compatible with the current VLSI (Very Large Scale Integration) technology. In this regard, GMR sensors can be easily integrated with electronics and microfluidics to detect many different analytes on a single chip. In this article, the authors demonstrate a comprehensive review on a novel approach in biosensors based on GMR material.

Keywords: Biomolecule, Biosensor, Giant Magnetoresistance, Magnetic Nanoparticles, Sensing

INTRODUCTION

The discovery of biosensors began in the early 1960s when Clark and Lyons first reported on amperometric glucose detection using the enzyme glucose oxidize (Clark & Lyons, 1962). Later, biosensors found a wide area of applications in industry, clinical diagnostics, and ecology. At the same time, biosensor science became an independent area of modern analytical chemistry involving approaches of biochemistry and physical chemistry. A biosensor is generally defined as an analytical device, which makes use of a biological molecular recognition component connected to a transducer to generate a quantifiable electronic output signal, in response to a biological or chemical analyte (Li, Sun, Wilson, White, Pourmand, & Wang, 2006).

Biosensors promise to provide analytically powerful and inexpensive alternatives to standard bacteriological methods used today for bacteria detection. Biosensors are analytical devices that respond selectively to analytes or bacteria by use of a combination of a biological

DOI: 10.4018/jehmc.2010070101

recognition system and a physical transducing element. The biological response is converted by the transducer to an electrical or optical signal that is directly related to the concentration of the analyte of interest or bacteria. A biosensor's recognition system may consist of one of many biological components including: enzymes, antigens, antibodies, nucleic acids, cells, cell organelles or receptor molecules. All of these biological components are capable of interacting very specifically with an analyte of interest or with bacteria and to give a biosensor its unique specificity.

Nowadays, accurate, rapid, cheap and selective analysis is required for clinical and industrial laboratories. Magnetoresistive biosensors seem to be among the best candidates to meet these criteria. Since the late 1990s, magnetoelectronics (Xu, Yu, Michael, Han, Osterfeld, White, Pourmand, & Wang, 2008) has emerged as one of several new platform technologies for biosensor and biochip development. This technology is based on the detection of biologically functionalized micrometer or nanometer-sized magnetic labels, using high-sensitivity microfabricated magnetic-field sensors.

Another concept for DNA detection was introduced by Baselt, Lee, Natesan, Metzger, Sheehan, and Colton (1998). It is based on detecting the stray field of magnetic labels by embedded magnetoresistive sensors. Such a technique, apart from being sensitive, flexible and compatible with standard CMOS fabrication, also has the advantage of directly providing an electronic signal that is suitable for automated on-chip analysis. Furthermore, the possibility to attract the magnetic labels by suitable gradient fields also opens up a completely new prospect that is not possible in such a way for any of the competing detection schemes, i.e., the selective on-chip manipulation of desired biomolecules (Leech, 1994). This option could be used, for example, to reduce incubation times during hybridization, or to test binding forces of adhered molecules (Prinz, 1998). Due to these opportunities, magnetoresistive biosensors represent a very promising alternative detection unit for lab-on-a-chip devices, and since the first publication in 1998, a number of research groups initiated work on that subject (Baselt, Lee, Natesan, Metzger, Sheehan, & Colton, 1998).

A group at the Naval Research Laboratory (NRL) and NVE Corporation in the US first demonstrated a magnetic biosensor system which they called BARC (Rife, Miller, Sheehan, Tamanaha, Tondra, & Whitman, 2003). Their detector employed a giant magnetoresistive multilayer stack that is less sensitive than properly designed spin valve (SV) or magnetic tunnel junction (MTJ) detectors (Wang & Taratorin, 1999). Another group in Germany demonstrated that giant magnetoresistive (GMR) multilayer biodetection was superior to fluorescent biodetection (Schotter, Kamp, Becker, Puhler, Reiss, & Brückl, 2004). Groups in Portugal and Netherlands have deployed SV sensors coupled with coils at proximity for rapid molecular detection (Graham, Ferreira, Bernardo, Freitas, & Cabral, 2002; Sandhu, 2007). The commercially available magnetic tags used by these groups tend to have a mean diameter in the range from 0.1 μm to 3 μm, including the paramagnetic polystyrene beads and similarly sized ferromagnetic particles.

The unique feature of the magneto-nano biochip were developed by Wang (2008) that it use magnetic nanoparticles (also called NanoTags or nanotags) with a mean diameter of only 100-1000 Å as the tags. Since the tag dimensions are more comparable to those of the target biomolecules to be assayed, they expect better performance in real biological assays.

GMR EFFECT

Magnetoresistance is defined as the change in the resistance of a material in response to an externally applied magnetic field. The first announcement of the GMR effect was reported in 1988 by Baibich and co-workers (Baibich, Broto, Fert, Dau, Petroff, Etienne, Creutz, Friederich, & Chazelas, 1998). They discovered that the resistance of a sandwich type multilayer with magnetizations aligned

Related Content

Building an Age Friendly Community: Strategies to Enhance Planning Through Online Communication

Dana Burr Bradley and Kelly G. Fitzgerald (2013). *International Journal of Reliable and Quality E-Healthcare (pp. 43-50).*
www.igi-global.com/article/building-age-friendly-community/76344?camid=4v1a