Magnetostrictive Biosensors with Sampling Capability

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Food pathogen contamination is critical to public health. In recent years, many foodborne disease outbreaks and product recalls are originated from the food contamination by pathogens. To prevent the outbreaks of foodborne diseases, it is highly desirable to have devices/technologies to monitor the food contamination at an earlier stage, such as harvesting and/or food processing stages. Based on the nature of the problem, it is required that the devices/technologies for the detection of pathogens have a rapid response and a high sensitivity. From economic and practical point of view, it would be better to have these devices/technologies with in-situ detection capability and suitable for in-field detection.

Biosensors based on magnetostrictive resonators, magnetostrictive cantilever and magnetostrictive particles (MSPs), have been developed in recent years [1]. Due to their magnetic nature, these biosensors are wireless, which makes them to a great candidate for in-situ detection. Both phage and antibody, which are immobilized onto the surface of the magnetostrictive resonator, have been used as biological molecular recognition elements. The performance characterization of these biosensors shows that these biosensors work well in liquid and exhibit a high sensitivity for the detection of bacteria in water as shown in Figure 1 and Figure 2.

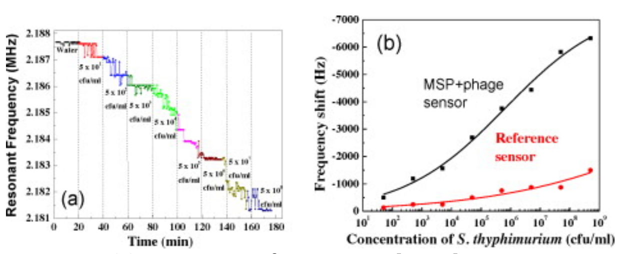

Figure 1. (a) Response of an MSP+phage biosensor in size of 1.0 mm × 0.3 mm × 15 µm for the detection of *S. typhimurium* in water. (b) The dose response of the biosensor.

The results shown in Figure 1(a) indicate that the MSP biosensors have a rapid response in minutes. The dose response shown in Figure 1(b) and Figure 2 demonstrate that the MSP sensors exhibit a high sensitivity. For the MSP in size of 1.0 mm × 0.3 mm × 15 µm, a detection limit less 10^2 cell/ml is obtained.

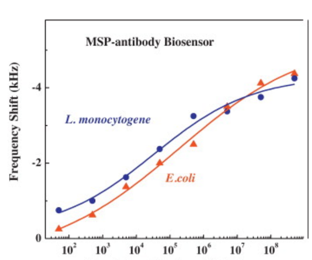

Figure 2. The dose response of MSP+antibody biosensors in size of 1.0 mm × 0.3 mm × 15 µm for the detection of *E. coli* and *L. monocytogene* in water, respectively.

It is well known that the sensitivity of MSP increases with reducing size of the MSP. Therefore, a much better sensitivity is expected for the MSPs with a smaller size.

The above results demonstrate that the biosensors based on the magnetostrictive resonators are suitable for in-situ detection of pathogens in liquid media. To fully develop the detection technology based on magnetostrictive resonators for in-field detection, a small size interrogation unit/device is required. A new methodology was developed recently [2]. Based on this technology, a handheld device is developed to characterize the response of the biosensors based on magnetostrictive resonators.

For the detection of pathogenic species in food samples, sampling is always a key issue, since the locations of the target species are unknown and the biosensors have to be brought into reaction with the target species. It is experimentally found that an MSP biosensor can act as an actuator when it is driven under a frequency different than the resonant frequency. Actually, the MSP sensors can move along both directions, which can be controlled by the frequency of the driving magnetic field. The physics of this motion is illustrated in Figure 3.

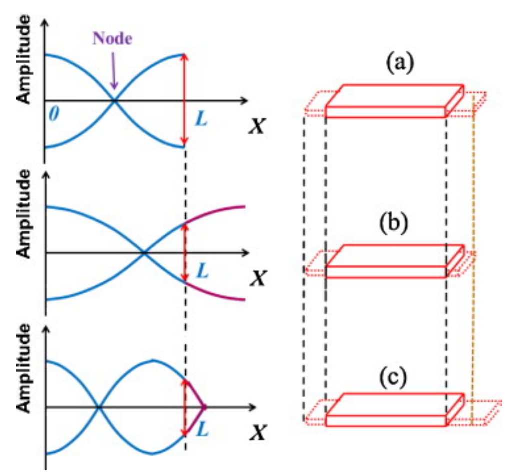

Figure 3. Schematic illustration of strain in an MSP and displacement of the MSP at different frequencies: (a) resonant frequency, (b) lower than resonant frequency, (c) higher than resonant frequency..

The displacement of the MSP under a driving magnetic field is only limited by the magnetic field. That is, as long as the driving magnetic field exists, the MSP biosensors can move. In other words, the displacement of the MSP biosensor is unlimited. Therefore, when many MSP biosensors are displayed in a food sample, a magnetic field can be used to move the MSP biosensors around so that the MSP biosensors can find the target species in the food sample,. In other words, the MSP biosensors have the sampling capability besides the detection capability. A high sensitivity with a sampling capability makes the MSP biosensors ideal for in-situ detection of food contamination with pathogens.

References:

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