Fabrication of Nano-biosensors Using Nano-sized Magnetostrictive Resonator

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Food pathogen contamination is critical to public health. Outbreaks of the food-borne disease and recalls of food products are usually originated from the food contamination by pathogens. To prevent these, biosensors for detecting/monitoring presence of pathogenic species in food sample have been developed. Among all existing detection technologies, it is found that the biosensors based on magnetostrictive resonators exhibit a high sensitivity and are suitable for in-situ detection of pathogens in food [1]. For example, a biosensor based on the magnetostrictive resonator in size of 1.0 mm × 0.3 mm × 15 μm exhibits sensitivity better than 10^2 cell/ml for in-situ detection of bacteria in water as shown in Figure 1. Additionally, it is experimentally demonstrated that the magnetostrictive resonators can be wirelessly driven in food sample using a magnetic field at frequency different than the resonator frequency [1]. Therefore, the biosensors based on magnetostrictive resonators can move in food sample. That is, these biosensors also have the sampling capability. Therefore, it is interest to fully develop the technology.

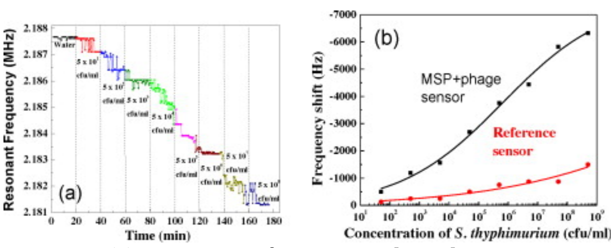

Figure 1. (a) Response of an MSP+phage biosensor in size of 1.0 mm × 0.3 mm × 15 μm for the detection of *S. typhimurium* in water. (b) The dose response of the biosensor.

It is well known that the detection sensitivity of a biosensor based on magnetostrictive resonator is strongly dependent on the size of the magnetostrictive resonator. The smaller the magnetostrictive resonator is, the higher/better the sensitivity of the biosensor is. Therefore, it is interest to develop magnetostrictive resonators in smaller size, such micrometer to nanometer. It should be mentioned that the smaller the magnetostrictive resonator is, the higher the resonant frequency is. In other words, the magnetostrictive materials with good resonant behavior at higher frequency are needed. We recently identified that the Fe-B and Fe-Co-B amorphous alloys are good candidate for the development of magnetostrictive resonators in micro/nano-meters with a higher resonant frequency [2].

Electrochemical processes are developed to fabricate the amorphous Fe-B and Fe-Co-B alloys as the magnetostrictive material and the electrochemical deposition is combined with microelectronic process to fabricate the magnetostrictive resonators in different shapes (i.e. strip, bar, and tube) and sizes (i.e. from nanometer to micrometer to sub-millimeter) as shown in **Figure 2**. The thin films have a smooth surface and the nano-bar/tubes have well controlled size. Using microelectronic process, strips in width from 20 μm to 200 μm and length from 50 μm to 1000 μm have been prepared. The thickness of the thin film can be up to 12 μm. The diameter of nano-bar/tubes is from 50 nm to 200 nm. These strips and nano-bar/tubes serve the magneto-strictive resonator – a new type of biosensor platform.

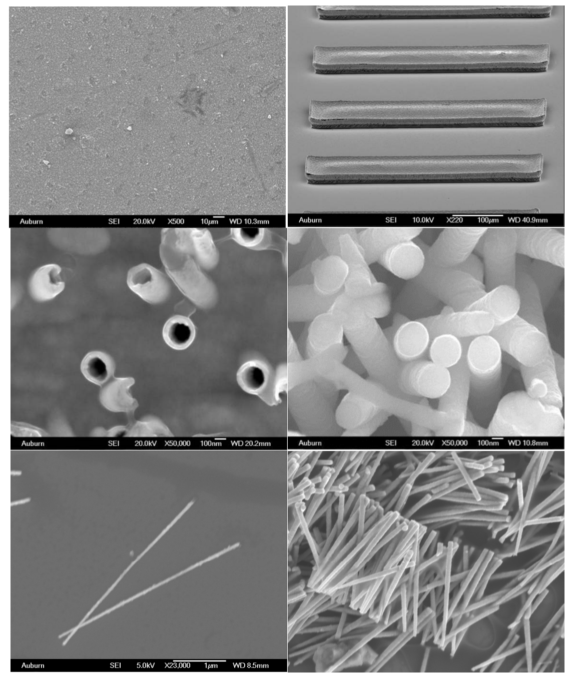

Figure 2. SEM pictures of Fe-B and Fe-Co-B thin film and nano-bars/tubes.

The magnetostrictive resonators prepared exhibit a good resonant behavior as shown in **Figure 3**, which indicates these resonators as sensor platform have a high sensitivity and Q value.

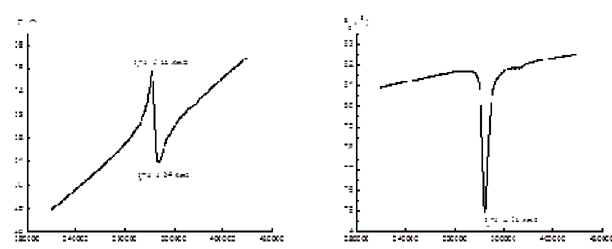

Figure 3. Resonant behavior of Fe-Co-B strips.

Due to its small size, these magnetostrictive nano-resonators provide some new opportunities for the development of sensors for applications like plant growth monitoring, water stress in plant and corps, and other in-situ monitoring.

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References:

[1] Z.-Y. Cheng, Applications of smart materials in the development of high performance biosensors, MRS Symposium Proc. Vol. 888, V10.6.1 (2005).
[2]. K.W. Zhang, Development of portable magnetostrictive biosensor system, Ph.D Dissertation, Auburn University (2010).