Bio-MEMS Chip for Bacteria Detection
-A Challenge of Si Technology to Biomedical Field-

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Integrating microelectromechanical systems (MEMS) seamlessly with LSIs and other active devices on a Si platform is attracting a great deal of interest for realizing high functional devices as one of "More than Moore" approaches in various kinds of technology fields (Fig. 1). They include, for example, sensor applications, ultrahigh speed millimeter-wave devices and RF-MEMS devices in wireless communications, and optical MEMS devices in photonic networks, etc. The key to making these high functional devices in various kinds of technology fields is a combination with LSIs. Biomedical field is also becoming within the scope of such technological fusion.

This work describes the Bio-MEMS chip with high-aspect-ratio Si-pillar structure for trapping a bacterium, *Legionella pneumophila* (*L. pneumophila*) toward a bacteria sensor that can be integrated with LSIs and Si photodetectors.

Bacterial infections have been serious social problems as indicated by a recent outbreak of *Escherichia coli* O104 infection in Europe, 2011 [1]. To avoid such an outbreak of bacterial infection, one possible solution is an early-warning by finding harmful bacteria before infectious disease spreads. To do so, the ubiquitous sensing of bacteria is necessary, in which sensors that can detect bacteria in a short time and give an alarm, are located at microbial niche in suspicious places. Furthermore, such a ubiquitous sensing of bacteria can help conventional diagnoses within its short detection time and in its high spatial resolution of sensing area. The sensors used for this purpose should have at least two functions in a small volume: trapping bacteria and detecting them.

This work shows a micro-fluidic Bio-MEMS chip with Si-pillar structure for trapping and detecting *L. pneumophila*. The schematic of the chip is shown in Fig. 2, in which Si-pillars work as a kind of sieve where entered *L. pneumophila* cells from the inlet are captured.

This Bio-MEMS chip was fabricated as follows: The process started with a 4-inch-dia. Si (100) wafer. The substrate was first oxidized to a thickness of 400 nm (Fig. 3(a)). The photolithography and the deep-RIE of Si with the SiO_2 mask made the micro-channel and Si-pillars (Fig. 3(b)). The glass lid was attached by anodic bonding followed by dicing (Fig. 3(c)). This completed the fabrication process. Figure 4 is a fluorescence microscopic image of Si-pillar area after injecting culture suspension of *L. pneumophila* at the concentration of 10^8 cells/mL. Strong blue fluorescence is observed at the inlet side of Si-pillars, showing that *L. pneumophila* is trapped in the Si-pillar structure. Spectroscopic analyses found that this fluorescence has a broad peak at around 450 nm and the peak intensity is roughly proportional to the square root of *L. pneumophila* concentration. This relationship enables us to make a *L. pneumophila* sensor that gives an early alarm when the concentration becomes higher than its criterion by detecting the fluorescence of *L. pneumophila* in this simple Si-pillar structure. Thus the Si technology paves the way for ubiquitous sensing of bacteria in biomedical applications.

Reference

[1] For example, http://www.euro.who.int/en/what-we-do/health-topics/emergencies/international-health-regulations/news/news/2011/06/ehec-outbreak-update-15.

Acknowledgement

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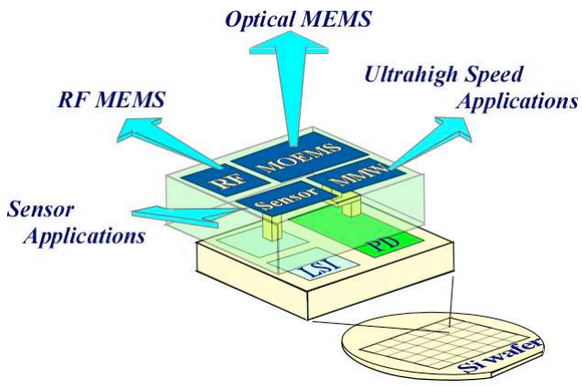

Fig. 1. Conceptual schematic of the technological fusion

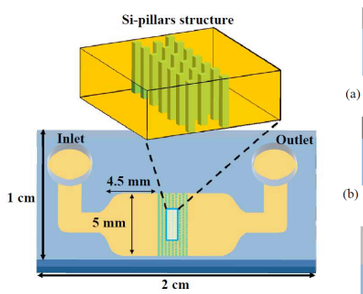

Fig. 2. Schematic of Bio-MEMS chip and Si-pillar structure

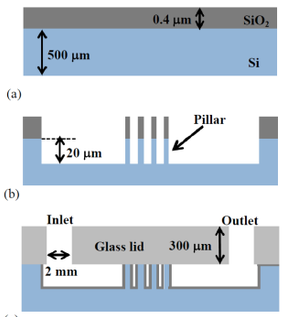

Fig. 3. Fabrication processes

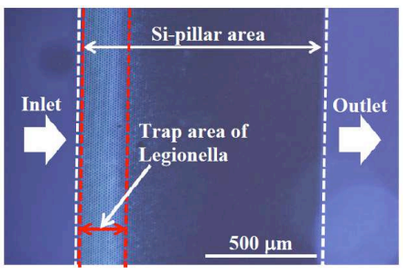

Fig. 4. Fluorescence microscopic image of trapped *L. pneumophila*