Fine MEMS Pj

Selective Nanomachine Structure Formation Technology

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Modern-day Japanese society has come to place great emphasis on quality of life (QOL). One indicator of this is the fact that "metabo," a slang term for "metabolic syndrome" (which refers to a combination of medical disorders that increase one's risk for cardiovascular disease and diabetes) has become a buzzword. Another is that weather reports in Japan include daily predictions of the amount of pollen that will be dispersed in the atmosphere. There is now great interest in Japan in maintaining health and physical well-being. But in order to properly manage one's physical condition on a day-to-day basis, collection of data regarding the body and the surrounding environment is indispensable. If MEMS technology could be used to create this kind of sensor system in a single integrated microchip, it would open the path to constant real-time monitoring of both the status inside the body and the environment outside the body. At the Shimoyama-Matsumoto Lab of The University of Tokyo, researchers in the "Selective Nanomachine Structure Formation Technology" project (part of the Fine MEMS Project) are working to develop the manufacturing technologies that will be the key to achieving such miniature sensor systems.

Fig. 1 shows a specific example of a sensor used to monitor inside and outside the body. A method called Surface Plasmon Resonance (SPR) is used for sensing. This method is capable of detecting biomoleculer interaction in a "label-free" manner by using the resonance of metal. To construct an SPR sensing system, technology for manufacturing multiple components such as the SPR sensor, spectroscopic mechanism, light source unit, photoreceiver and so on is required. For this reason, the necessary component manufacturing technologies have been divided into four main areas and work to develop these technologies is underway.

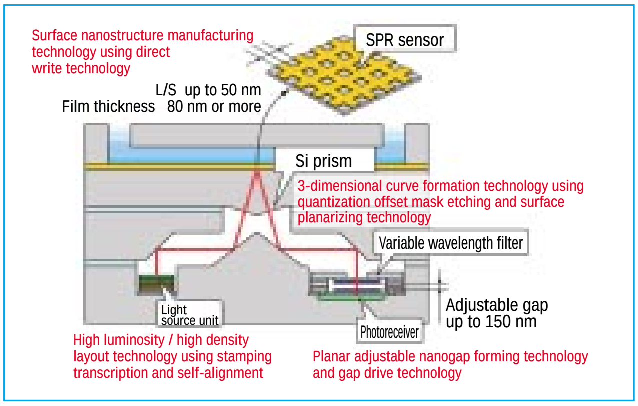

Fig. 1 SPR sensor system

SPR sensor

Normally, an SPR sensor has a metal film (gold, silver etc.) approximately 50 nm thick deposited on the base of the prism, etc. Glass is usually used as the material for the prism. However, if near infrared light is used as the light for the SPR sensor, it is also possible to use a prism made of silicon. Researchers are working to develop three-dimensional curve formation technologies to enable the inclined silicon surface to be machined to any desired angle through a combination of electron beam direct write (EBDW) technology and etching technology (**Component Technology 1**). Normally a flat film is used as the metal thin film, but nanosize structures are being created on the metal film in order to improve SPR performance (**Component Technology 2**).

Spectroscope

SPR sensors may use either of two methods: a fixed light source wavelength and a variable incident angle, or a fixed incident angle and a variable wavelength. With the latter method, the number of adjustable sections can be decreased, so this method is more suitable for creating smaller and thinner sensors. In this case, however, a filter to separate light is needed. For this reason, researchers are working to develop technologies for manufacturing a Fabry-Perot interferometer with nanosize adjustable gaps (**Component Technology 3**).

Light source unit and photoreceiver

The laser diodes and photodiodes used as the light source unit and photoreceiver are formed on top of compound semiconductor substrates (GaAs, GaN etc.), and most are provided in the form of bare chips. Research is underway to develop methods for precision batch placement of heterogeneous materials and a large variety of components on a sensor substrate (**Component Technology 4**).

Let us take a look at one achievement of this research: a batch placement technology for a large variety of components. **Fig. 2** shows an overview of the technology as well as photographs of the results. Up to now, when a large variety of components were integrated, a serial "pick and place" method had to be used for each component in sequence. In contrast, this method allows parallel integration of many different components at once. An elastic material such as silicon rubber is used as a stamping material, and the components are picked off the original substrate all at once in parallel. Transcription is complete when the components that have been picked from the original substrate are stamped onto the target substrate for integration. Furthermore, by repeating this process, it is possible to transcribe a large variety of components onto the same substrate, using the same procedure as in multicolor printing. In this way, three-dimensional integration of multiple microstructures and transcription of glass nanostructures onto a MEMS structure are possible. This method shows promise as an integrated placement technology.

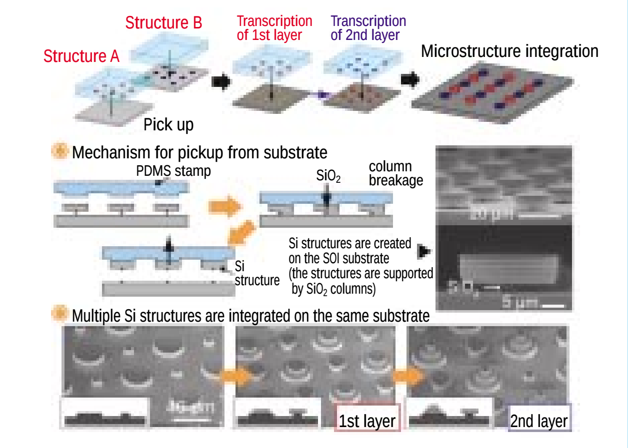

Fig. 2 Stamping transcription technology

The project is now in its second year and the research is steadily producing results. The researchers involved in the project are working steadily with the goal of developing technologies that will serve as the foundation for next-generation MEMS technologies, with a view toward practical application.