Nanomechanical Membrane-type Surface Stress Sensor (MSS) as a Practical Sensing Platform

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The demands for new sensors are rapidly growing in various fields; medicine, security, and environment. Nanomechanical sensors have potential to contribute to these global demands owing to their intrinsic versatility—detecting fundamental parameters, such as "volume" or "mass". Since all molecules have "volume" and "mass", nanomechanical transduction of them into detectable signals can realize label-free and real-time measurements of virtually any kind of target specimen. Based on the newly developed platform "Membrane-type Surface stress Sensor (MSS)" (Fig. 1) [1], we are now trying to realize useful nanomechanical sensors which can fulfill the practical requirements, such as portability, low-cost, ease of use, in addition to the basic specifications e.g. high sensitivity.

To demonstrate the capability of MSS for the multi-dimensional array, we fabricated the second generation MSS (2G-MSS) with a two dimensional array (Fig. 2. (a)) [2]. In addition, the implementation of various modifications in design and microfabrication led to further enhancement of sensitivity, reaching a limit of detection of ~0.1 mN/m, which is even better than that of common optical read-out cantilever sensors (0.15~0.90 mN/m) [2].

For practical applications, one of the major issues of nanomechanical sensors is the difficulty in coating receptor layers on their surface to which target molecules adsorb or react [3]. The MSS also provides an effective solution to this coating issue by means of double-side coating [4]. While a cantilever-type sensor requires a single-side coating to have measurable deflection, MSS has been found to yield reasonable signals even with double-side coatings, allowing almost any kind of coating technique, including dip-coating methods. As the double-side coating is compatible with batch protocols, such as dip coating, the double-side-coated MSS represents a new paradigm of "one-chip-one-channel (channels on a chip are all coated with the same receptor layers)" shifting from the conventional "one-chip-multiple-channel (channels on a chip are coated with different receptor layers)" paradigm [4].

As for the measurement system, the latest version of the MSS setup can be operated all by USB-connected/powered devices. This setup provides an opportunity for anybody to start nanomechanical sensing with high sensitivity and stability, including the coating of MSS chips by e.g. simple hand-operated dip-coating. Further, the robustness of the MSS structure against both the morphological fluctuation of the receptor layer [5] and the self-heating issue [6] has been also confirmed by experiments and finite element analyses.

References

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[3] G. Yoshikawa, Appl. Phys. Lett. 98, 173502 (2011).
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Figures

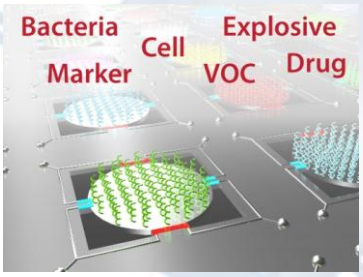

Fig. 1: Membrane-type Surface stress Sensor (MSS) in array and the examples of possible targets.

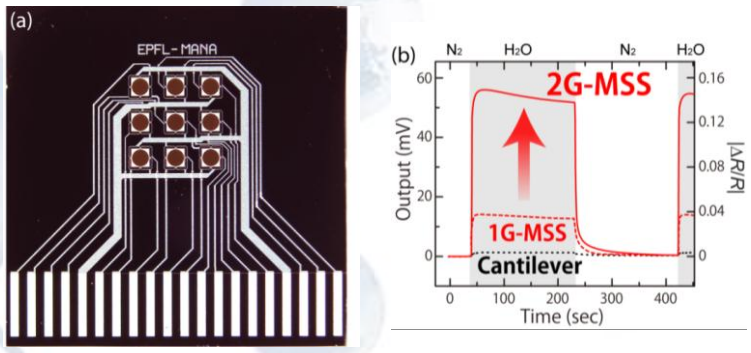

Fig. 2: (a) Photograph of the fabricated 2G-MSS chip with a 2D array. (b) Obtained output signals from each sensor.