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UNLOCKING THE POTENTIAL OF BIO-ELECTRONIC DEVICES WITH DNA THIN SOLID FILMS DEVELOPED VIA LASER MOLECULAR BEAM DEPOSITION

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Deoxyribonucleic acid (DNA) is one of the most important biomolecules that govern the genetic information of life, and recently it has attracted attention as a functional material for electronic device applications such as sensors [1]. In the application of DNA to electronic devices, it is necessary to form a flat thin film at the nanometer (nm) level for heterogeneous film stacking and patterning. We have been developing nm flat DNA thin films by laser molecular beam deposition (LMBD) method, and also fabricated a quartz crystal microbalance sensor (QCM) for volatile organic compound (VOC) detection and evaluated its VOC detection characteristics to explore the possibility of sensor applications of the DNA solid-state thin films [2].

A synthetic quartz and a non-doped Si substrates that had been organically cleaned were introduced into a high-vacuum LMBD apparatus, and then an infrared laser (wavelength: 808 nm, power: 1.8-2.5 W) was used to irradiate purified dry powder DNA material derived from salmon sperm at a position opposite the substrate to generate DNA molecular beams, which were used for film formation on the substrate. Using the same method, an LMBD-QCM sensor was fabricated, and for comparison, also a QCM sensor was prepared by the spin-coating (SC) method (SC-QCM), and the detection characteristics of both sensors were evaluated by using a VOC measurement system.

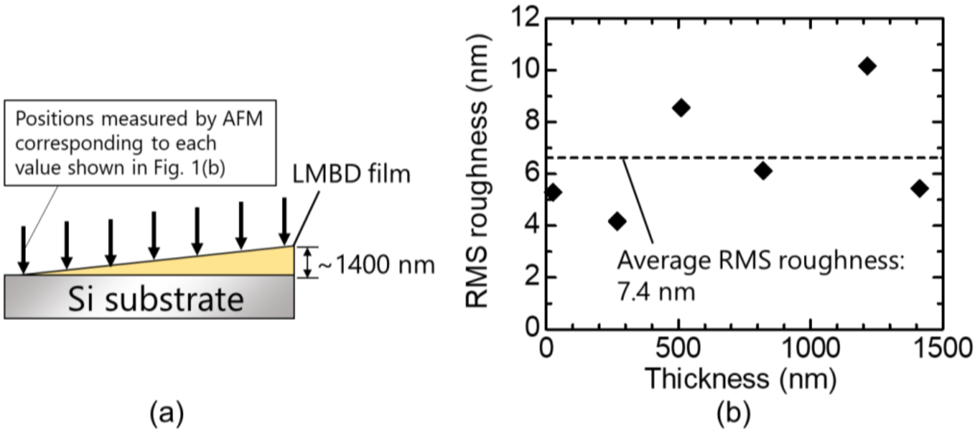

Figure 1. (a) A DNA thin solid film having a wide range of gradient thicknesses fabricated by LMBD. (b) Root-mean-square roughness of LMBD thin film measured by AFM.

A DNA thin solid film having a wide range of gradient thicknesses from approximately 30 nm to 1400 nm was formed on a single Si substrate by applying a continuously moving mask mechanism to the LMBD (figure 1(a)). Using atomic force microscopy, the root-mean square (RMS) roughness of the surface was evaluated, and its average value was 7.4 nm (figure 1(b)).

Figure 2 shows a graph obtained by normalizing the results of various VOC detection measurements using the SC-QC and LMBD-QCM by the resonance frequency change $|\Delta f|$ in methanol, taking into account the difference in DNA film thickness (100 nm and 300 nm, respectively) of the two sensors. This demonstrates that LMBD is a superior preparation method for forming flat DNA solid thin films at the nanometer level, which is suitable for electronic device applications.

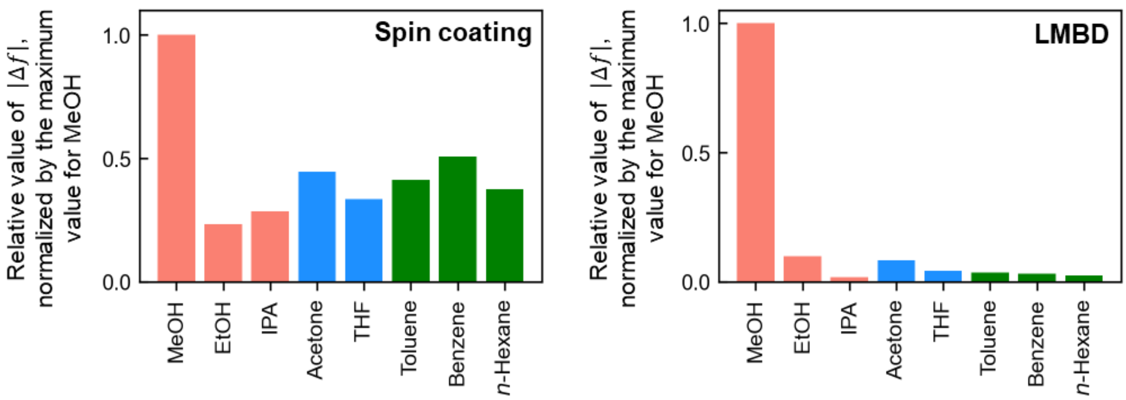

Figure 2. Relative values of change in resonance frequency of QCMs with DNA films prepared by spin coating (left) and LMBD (right) after exposure to VOCs: normalized by values for methanol

References

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