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PRESS RELEASE

Source: Toyohashi University of Technology, Japan, Committee for Public Relations

Release Title: Success in specific detection of molecules using deformation of a single atomic sheet
Release Subtitle: Towards diagnostic techniques using smartphones

Overview

Associate Prof. Kazuhiro Takahashi and Mr. Shin Kidane (Master's Program) of the Department of Electrical and Electronic Information Engineering at Toyohashi University of Technology and others developed a test chip using graphene, a sheet material with a thickness of one carbon atom. The chip has a trampoline structure with a narrow gap of 1 micrometer or less formed under a monoatomic graphene film, and can specifically trap a biomarker, a protein included in bodily fluids such as blood, urine or saliva which is derived from a disease, on graphene. The biomarker adsorbed by the graphene generates force which deforms the graphene into a dome shape. The group thus succeeded in detecting the amount of deformation as changes in color using the interference properties of light. It is expected that viruses and diseases will be able to be simply and quickly examined using the developed test chip.

Details

A measuring device to simply and quickly examine a disease is extremely important for accurate diagnosis, verification of therapeutic effects, and investigation of recurrence and metastasis. If diseases can be examined using a very minute amount of body fluid such as blood or urine, physical condition can be simply, quickly and cheaply controlled. A test technique for determining the presence or absence of a disease by specifically trapping a biomarker on a flexibly deformable thin film formed using semiconductor micromachining techniques, has been investigated. The research group has developed a sensor technique for detecting film deformation caused when a marker molecule is adsorbed as changes in color. As the thickness of the film to adsorb the biomarker decreases, the sensitivity of this sensor element can be increased. It is thus expected that the sensitivity of the sensor will be improved by 1000 times or more using a material called graphene, a material with a thickness of 1 nanometer or less, formed from a single atomic layer.

In a previous report using suspended graphene in a bridge shape, however, changes at the time of physical adsorption of a molecule to suspended graphene were measured, and it was difficult to specifically detect the molecule to be measured. As for the reason for this, it is thought that since modification using an antibody to recognize and specifically bind a molecule is commonly carried out in a solution, the suspended structure of graphene was destroyed during the solution treatment.

The research team, therefore, made a trampoline structure in which the unevenness of the substrate was covered with a graphene sheet, as a suspended structure of graphene which could withstand the solution treatment, and were able to modify graphene with an antibody molecule. The surface of the graphene was functionalized with an antibody molecule to provide the ability to recognize a molecule, and an ultrasensitive biosensor which could specifically detect a biomarker was able to be produced. A light detection technique unique to the research team was used as a technique for detecting a biomarker bound to the surface of the graphene. In a gap of 1 micrometer or less between the suspended graphene and the semiconductor substrate, color is changed depending on the length of the gap by the interference action of light. Using this effect, the appearance of a molecule adsorbed to suspended graphene in a test solution was revealed by changes in color. According to the biosensing technique developed this time, it is expected that sensitivity per unit area will be improved to 2000 times that of conventional sensors.

Future Outlook

In addition to blood tests, the research team has also investigated a chemical sensor to detect odors and chemical substances, and feels that the sensor can be applied to a novel compact sensor device contributing to IoT society. The sensor can be applied to the detection of various biomarkers and also to the detection of viruses by changing the probe molecules modifying the surface of the graphene.

Reference

Shin Kidane, Hayato Ishida, Kazuaki Sawada, Kazuhiro Takahashi, A suspended graphene-based optical interferometric surface stress sensor for selective biomolecular detection, Nanoscale Advances, 2, 1431-1436 (2020) DOI: 10.1039/C9NA00788A

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Further information

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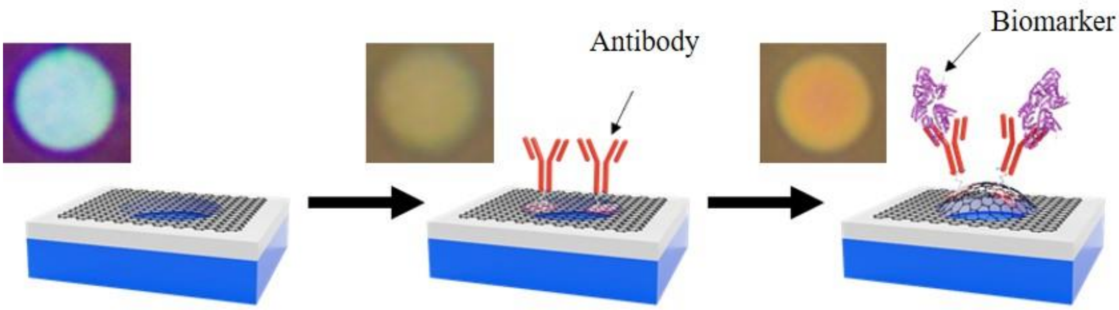
Figure:



Caption: Film deformation and changes in interference color by adsorption of molecule to suspended graphene

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