Synthesis and application of graphene and graphene nanoribbons

Shintaro Sato

Fujitsu Laboratories Ltd. and Fujitsu Limited, Atsugi, Japan

sato.shintaro@fujitsu.com

Graphene has excellent electrical properties, and is therefore a promising material for future electronic devices. Graphene nonoribbons (GNRs) can have not only excellent properties, but also intriguing properties that can be controlled by their width and edge structures. In fact, it has recently been reported that topological phases of GNRs can be controlled by their structures, attracting much attention [1]. We work on the growth of graphene and GNRs, and their application to electronic and quantum devices. We here describe some of our recent results.

We recently developed a gas sensor based on a graphene-gate transistor, where the gate of a Si transistor is replaced with monolayer graphene (Fig.1) [2]. If gas molecules adsorb on the graphene-gate surface, the Fermi level of graphene can change, thus shifting the transistor threshold. This causes changes in the drain current at a constant gate voltage. This graphene-gate sensor was found to be very sensitive to NO_2 and NH_3. In fact, the sensor can detect NO_2 with concentrations less than 1 ppb.

Graphene can also be utilized for high-frequency wave detection. We actually proposed a diode consisting of a GNR heterojunction (Fig. 2) for such a purpose [3]. The heterojunction consists of a hydrogen-terminated armchair-edge GNR (H-AGNR) and fluorine-terminated armchair-edge GNR (F-AGNR). Since there is a difference in electron affinity between them, we can construct a staggered-type lateral-heterojunction p-n diode. First principles simulations show that the voltage sensitivity of the GNR-based backward diode can be much better than that of a GaAsSb/InAlAs/InGaAs backward diode for terahertz wave detection [4].

For realizing GNR heterojunctions shown above, we try to form GNRs having various widths and edge-terminations using a bottom-up approach [5, 6]. Our recent experimental results regarding the GNR growth will be explained in the presentation.

This research was partly supported by JST CREST Grant Number JPMJCR15F1, Japan.

References

[1] D. Rizzo, et al., Nature, 560 (2018) 204.
[2] N. Harada, et al., IEDM 2016 (2016) 476.
[3] N. Harada, et al., Appl. Phys. Express, 10 (2017) 074001.
[4] M. Patrashin, et al., IEEE Trans. Electron Devices, 62 (2015) 1068.
[5] H. Hayashi, et al., ACS Nano, 11 (2017) 6204.
[6] M. Ohtomo, et al., ACS Appl. Mater. Interfaces, 10 (2018) 31623.

Figures

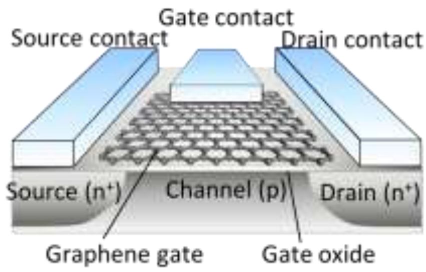

Figure 1: Schematic illustration of a gas sensor based on a graphene-gate transistor

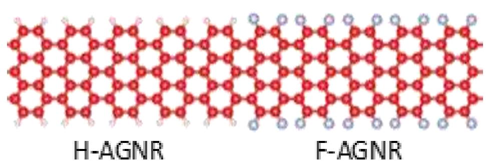

Figure 2: Heterojunction of F-AGNR and H-AGNR