Application of Graphene in Electronic, Photonic and Biological Devices

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Because of its excellent electronic and photonic properties graphene has attracted enormous interest. Its charge mobility, electrical conductivity and optical transparency in addition to its flexibility, robustness and environmental stability make graphene a promising material for a wide range of applications ranging from electronics through photonics to plasmonics as well as biomedicine. However, its true potential application will not be attained until repeatable, production compatible methods of production are achieved.

In this talk I present the electronic application of graphene to simultaneous synthesis of large-scale high quality multi-layer and single-layer graphenes for transparent conductive electrode [1] and high-performance flexible and transparent graphene gas molecular sensor integrated with graphene heater [2]. Simultaneous growth of the multi-layer and single-layer graphenes changing continuously the electrical resistance and the optical transmittance is introduced. I also demonstrate a flexible and transparent gas molecule sensor consisting of a graphene sensor channel and a graphene heater. This combined structure leads to fully utilizing unique transparent and flexible functionalities of graphene with invariable sensing performance under a bending condition.

For the biomedicine application, I present a plastic polymerase chain reaction (PCR) chip incorporating graphene heater and natural convection for the disposable chip. Transparency of graphene heater allows the detection of fluorescence in the PCR chip using a light-path passing through the heater [3].

I also introduce the progress in graphene-based photonic and plasmonic devices such as thermo-optic mode extinction modulator [4] and planar lightwave circuit-type plasmonic photodetector [5] for all graphene-based photonic integrated circuits (PICs). A thermo-optic (TO) mode extinction modulator based on graphene plasmonic waveguide is introduced. The graphene plasmonic waveguide is served as a light signal guiding medium with a successful 2.5 Gbps optical signal transmission at a wavelength of 1.31 μm. The TO modulator demonstrates 30 dB optical attenuation with 12 mW electrical power injection at a telecom wavelength. Finally, I present a planar-type graphene plasmonic photodetector with the configuration of the graphene plasmonic waveguide and photodetector structure all-in-one to detect horizontally incident light for the easy and simple integration.

References

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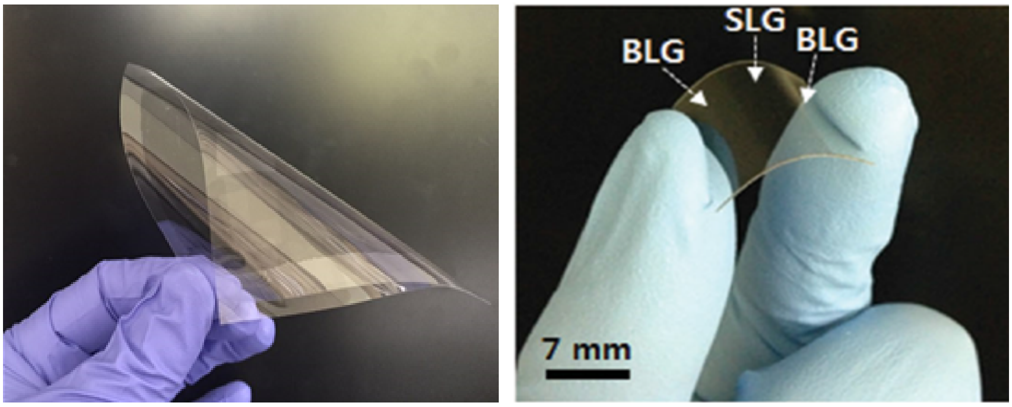

Figure 1: (left) Wafer-scale flexible graphene film and (right) flexible and transparent gas molecule sensor.

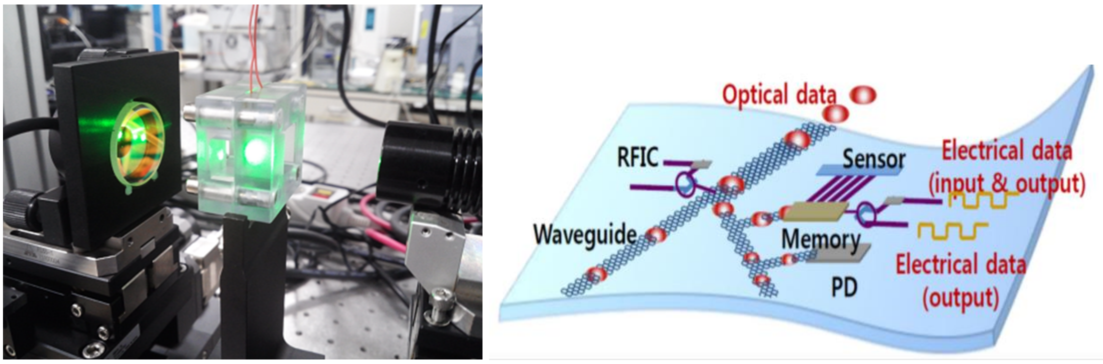

Figure 2: (left) Plastic PCR chip installed into its experimental setup and (right) schematic of graphene-based photonic integrated circuit.