Investigation of electrolytes for graphene optical modulators

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Abstract

Notably, atomically thin 2 dimensional (2d) crystals provide new perspective for novel optoelectronic devices. Since the thickness of 2d crystals is much shorter than the wavelength of light, their response originates from the free charge carriers. Recently graphene provides new opportunities for optoelectronic devices. Ability to tune the free carrier on graphene through electrostatic doping, enables to control optical absorption in a very broad spectrum. Controlling optical properties in the visible spectra, however, remains as a challenge due to requirements of very large charge densities in the order of 10^{14} cm^{-2}.

Recently [1] we discovered a very simple device structure to control optical properties of graphene using a supercapacitor structure (Figure 1a). In this device architecture, we used two graphene electrodes and electrolyte medium. Application of a voltage bias polarized the electrolyte and yield large shift in the Fermi energy in the order of 1.5 eV with corresponding charge densities of 10^{14} cm^{-2}. The electrical and chemical properties of the electrolyte are the key parameters that define the performance of these optical modulators. In this report, we will talk about our investigation of various organic electrolytes (EL) for graphene optical modulators: liquid EL - PC/LiBOB (propylene carbonate/lithium bis(oxalato)borate), gel EL - PVA/LiBOB (polyvinyl alcohol/lithium bis(oxalato)borate) and solid EL - p(VDF-HFP)/IL (poly (vinylidene fluoride-co-hexafluoropropylene) fluoroelastomer/ionic liquid).

Thereby, based on electrical and optical results we have established higher capacitance at 78 μF in the case of a gel EL, using during the changing of the transmission versus the wavelength for various bias voltages. Also, we have found the increasing of transmission at 3 times for solid EL (Figure 1b) in comparison with liquid and gel Els and have detected the possibilities of gel EL to work in negative region. Analyzing obtained results we suggest the best and most suitable solid EL for fabrication graphene-based SC devices permitting to increase the modulation efficiencies by increasing the interaction of light with graphene electrodes. We anticipate that using namely of solid EL, except getting the desired electro-optical properties, will allow us to minimize the size of the SC and to vary the its form.

References

[1] E.O. Polat and C. Kocabas, Nano Lett, 13 (2013) 5851−5857.

Figures

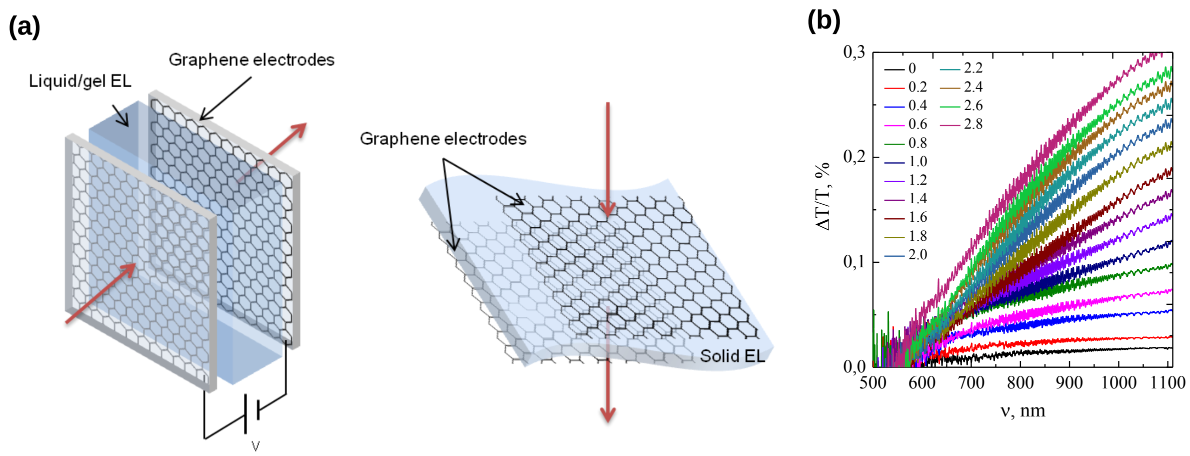

Figure 1. Schematic representation of graphene optical modulators (a); optical spectra of graphene optical modulators (b) based on solid electrolyte (p(VDF-HFP)/IL).