Ion-Gel-Gated Graphene Optical Switch

Jin Tae Kim
Hongkyw Choi

Creative Future Research Laboratory, Electronics and Telecommunications Research Institute (ETRI), Daejeon 34129, South Korea

jintae@etri.re.kr

In this work, we designed and fabricated a graphene-integrated polymer waveguide switch whose optical modulation was controlled by an ion-gel top-gate dielectric. Simple spin coating of a polymer resin and a dry-etching process allowed the fabrication of the photonic integrated circuit platform. Comparatively accurate positioning of the [6] transferred graphene and ion gel on the photonic platform allowed us to develop the all-dielectric in-line graphene photonic integrated circuits.

The electro-absorption characteristics of the fabricated photonic device were investigated by numerical simulations and experimental measurements. The ion-gel dielectric played a key role in modulating the power of the light wave as a transparent upper-cladding medium, increasing the light–graphene interaction ratio. By applying the gate voltage, the optical output power of the switch was tunable. Uniquely, the gate voltage-dependent optical properties of the device exhibit a large hysteresis, which originates from the slow polarization response time of ions.

The photonic device is applicable to both TE- and TM-polarized light waves, covering two entire optical communication bands, the O-band (1.26–1.36 μm) and the C-band (1.52–1.565 μm). The experimental results are in good agreement with theoretically simulated predictions. The temporal behavior of the ion-gel–graphene-integrated optical switch reveals a long-term modulation state because of the relatively low mobility of the ions in the ion-gel solution and formation of the electric double layer in the graphene–ion-gel interface. Fast dynamic recovery is observed by applying an opposite voltage gate pulse.

References

[1] J. Lee, et.al., J. Am. Chem. Soc. (2007) 4532–4533
[2] J. H. Cho, et.al., Adv. Mater. (2008) 686–690.
[3] E. O. Polat, et.al., Nano Lett. (2013) 5851–5857.
[4] V. Thareja, et. at., Nano Lett. (2015) 1570–1576.
[5] J. T. Kim, et. at., ACS Appl. Mater. Interfaces (2018) 1836–1845

Figures

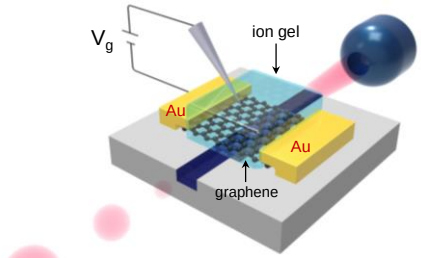

Figure 1: Bird's-eye view of the designed graphene–ion-gel-integrated optical switch

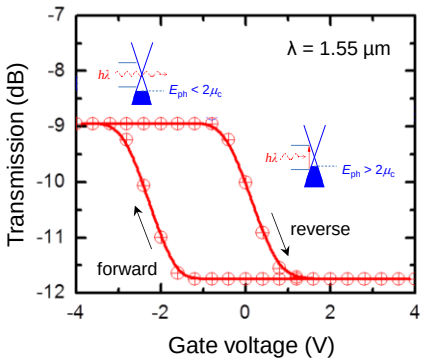

Figure 2: Optical transmission of the graphene–ion-gel-integrated optical waveguide switch according to the top-gate electric voltage, V_g.