

Pyro-resistive infrared detector using graphene on LiNbO₃

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Abstract

There is great interest in developing sensitive photo-detectors (PDs) for the mid-infrared (mid-IR) wavelength region (3-25 μm). They are essential components in many applications, ranging from vibrational spectroscopy to thermal imaging. Because of its electrical transport properties, graphene is a promising material for mid-IR PDs, especially when combined with light sensitive substrates. Indeed, Hsieh et al. used it in an opto-thermal field effect transistor (FET) on lead-zirconate-titanate (PZT) substrate [1]. Baeumer et al. recently reported spatial carrier density modulation in graphene on periodically poled LiNbO₃ (LN) and demonstrated a p-n junction PD by gating graphene across the domain inverted structure [2]. Moreover, Kulkarni et al. used graphene as transparent electrode in a conventional pyroelectric detector based on PVDF working from 1.9 to 7.5 μm [3]. Among the graphene-substrate combinations, graphene on pyroelectric materials is particularly attractive. In fact, when the temperature changes due to the heat generated by light absorption, surface charges are generated in the pyroelectric substrate producing a pyroelectric-induced resistance change of graphene (fig. a). This “pyro-resistive” effect can be characterized as shown in fig b. for graphene on LiNbO₃ by varying the temperature of the substrate, in this way sweeping across the Dirac point. PDs were realized by patterning CVD graphene on LiNbO₃ (fig. c) and their photo-response was mapped upon incidence mid-IR radiation demonstrating operation both in DC (fig. d - left) and AC (fig. d - right). This confirms that photo-induced pyro-resistive effect can be used to realize uncooled mid-IR PDs operating in the 5 to 10 μm wavelength region by leveraging the high absorption, pyroelectric response of LiNbO₃, high optical transparency and doping sensitivity of graphene.

References

[1] C. Hsieh, Y. Chen, W. Tan, Y. Chen, W. Y. Shih, W. Shih, *Appl. Phys. Lett.*, **100**(2012) 113507

[2] C. Baeumer, D. Saldana-Greco, J. M. P. Martirez, A. M. Rappe, M. Shim, and L. W. Martin, *Nat. Commun.*, **6** (2015) 6136

[3] E. S. Kulkarni, S. P. Heussler, A. V. Stier, I. Martin-Fernandez, H. Andersen, C.-T. Toh, and B. Özyilmaz, (2015), *Adv. Opt. Mater.*, **3** (2015) 34-38

Figures

