Graphene-nanopillars photodetector

Antonio Lombardo[1], Alan Colli[2], Tim J. Echtermeyer[1], Shakil A. Awan[1], Ravi S. Sundaram[1], Silvia Milana, Andrea C. Ferrari[1]

[1]Cambridge Graphene Centre, 9 JJ Thomson Avenue, Cambridge CB3 0FA, UK
[2] Nokia Research Centre, Cambridge, UK, 21 JJ Thomson Avenue, Cambridge CB3 0FA, UK

al515@cam.ac.uk

Abstract

Graphene-based photodetectors exhibit good quantum efficiency [1], fast response[2] and broadband operation [2,3]. In order to convert the incident light into a detectable electric signal, photo-generated carriers must be separated by an electric field. This is usually achieved by exploiting the built-in potential created at the graphene-contact interface by the difference in work function of metal and graphene [1,2,4]. However, the active area of these devices (i.e. where carrier separation occurs) is limited to the region in close proximity to the metal contacts (~0.2μm[4]), while carriers generated elsewhere recombine without contributing to the external photocurrent [4]. Here we fabricate graphene-nanopillars photodetectors, where graphene is suspend onto vertically-aligned metallic nano-pillars (Fig. 1a). We fabricate high aspect-ratio silicon nanostructures via deep reactive ion etching by alternating etching and passivation steps [5]. By tuning the etching/passivation parameters we produce vertically aligned silicon pillars, usually referred as black Si or Si grass [6]. Pillars are subsequently coated with Ni by magnetron sputtering. This configuration allows us to extend the active area of the photodetector. Each nano-pillar constitutes a point-like contact (Fig. 1b) and locally induces a built-in field. Such field is exploited to separate the photo-generated charges, then collected by the nearby metallic pillar and the external electrode (yellow contact in Fig 1a). Therefore, a net voltage (up to 1.5V/W) develops between the substrate (to which pillars are connected) and the external electrode. In this geometry, the whole graphene area suspended over the pillars is active both for light absorption and for the collection of photogenerated charge. This allows us to reach responsivities up to 2 orders of magnitude higher than standard graphene photodetectors.

References

[1] E.J.H. Lee, K. Balasubramanian, R.T. Weitz, M. Burghards, K. Kern, Nature Nanotech, **3** (2008), 486
[2] F. Xia, T, Mueller, Y.M. Lin, A. Valdes-Garcia, P. Avouris, Nature Nanotech. **4** (2009), 839
[3] F. Bonaccorso, Z. Sun, T. Hasan, A.C. Ferrari, Nature Photon. **4** (2010), 611
[4] T. Mueller, F. Xia, P. Avouris, Nature Photon. **4** (2010), 297
[5] Y.Q. Fu, A. Colli, A. Fasoli, J.K. Luo, A.J. Flewitt, A.C. Ferrari, W.I. Milne, J. Vac. Sci. Technol. B **27** (2009), 1520
[6] M. Stubenrauch, M. Fischer, C. Kremin, S. Stoebenau, A. Albrecht, O. Nagel, J. Micromech. Microeng. **16** (2006), S82-S87

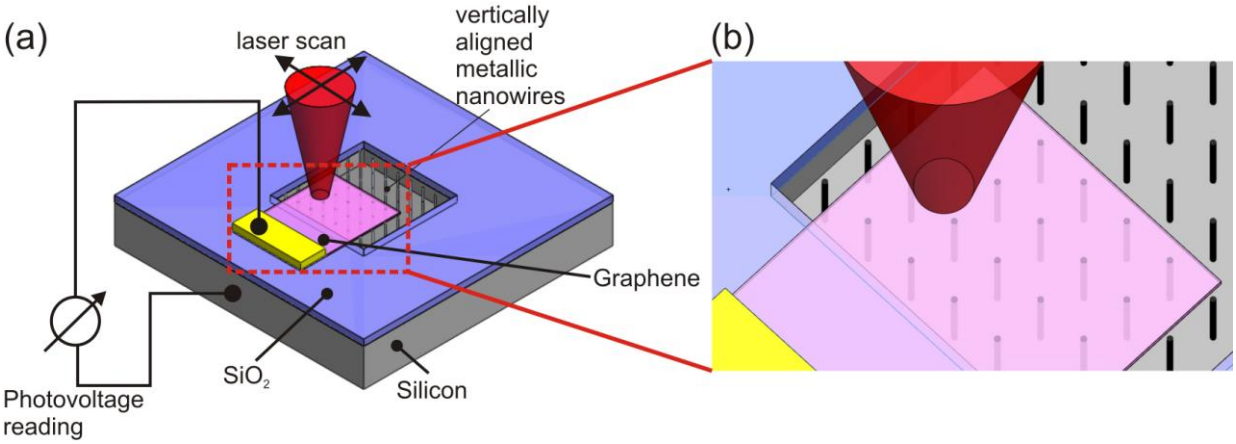

Figure 1: schematic of photodetector and measuring set-up: graphene is partially suspended on vertically aligned pillars. A laser is scanned across the graphene surface and photovoltage is recorded between the substrate (in ohmic contact with pillars) and the electrode on graphene on SiO_2.