Wide bandgap nanowire ultraviolet photodetectors with a graphene transparent contact

H. Zhang[1], A. V. Babichev[1-3], P. Lavenus[1], G. Jacopin[4], F. H. Julien[1], A. Yu. Egorov[2], J. Zhang[5], T. Pauporté[5], Y. T. Lin[6], L. W. Tu[6], and M. Tchernycheva[1]

[1] *Institut d'Electronique Fondamentale, UMR 8622 CNRS, University Paris Sud XI, 91405 Orsay cedex, France*
[2] *St. Petersburg Academic University, Nanotechnology Research and Education Centre, Russian Academy of Science, Khlopina 8/3, 194021 St. Petersburg, Russia*
[3] *Ioffe Physical-Technical Institute of the Russian Academy of Science, Polytechnicheskaya 26, 194021 St. Petersburg, Russia*
[4] *ICMP LOEQ Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland*
[5] *Laboratoire d'Electrochimie, Chimie des Interfaces et Modélisation pour l'Energie, UMR-CNRS 7575, Ecole Nationale Supérieure de Chimie de Paris, 11 rue P. et M. Curie, 75231 Paris cedex 05, France*
[6] *Department of Physics and Center for Nanoscience and Nanotechnology, National Sun Yat-Sen University, Kaohsiung 80424, Taiwan*

Email of presenting author: hezhi.zhang@u-psud.fr

Thanks to its enhanced transparency and high conductivity, graphene is an excellent candidate for low-resistance transparent contacts to optoelectronic devices. The graphene / nanowires (NWs) hybrid materials attract today a great attention for different optoelectronic applications, in particular for light detection [1, 2, 3]. GaN and ZnO NWs have demonstrated their capacity to produce highly sensitive UV photodetectors using Indium Tin Oxide (ITO) top contact [4]. However, the significant absorption of the ITO top electrode limits their responsivity in the deep UV range. In this context, it is desirable to replace the ITO with a graphene contact having a better UV transparency. In the present work, we report the fabrication and characterization of ZnO [5] and GaN [6] UV photodetectors based on NW arrays with a transparent graphene top electrode.

The ZnO NW arrays were synthesized by the electrodeposition method on F-doped SnO_2 (FTO), and GaN NWs were grown by plasma-assisted molecular beam epitaxy (PAMBE). The chemical vapor deposition (CVD)-grown graphene was transferred to the nanowires by a wet transfer method resulting in a continuous coverage over a large area. Then, the graphene / nanowire sample was processed into micro-photodetectors by depositing Ti/Al/Ti/Au open contacts and structuring graphene using reactive ion etching (RIE). Figure 1 shows an SEM image of the processed photodetector.

The optical and electrical properties were characterized by current-voltage (I-V) measurements and by photocurrent (PC) spectroscopy. The graphene / ZnO detectors exhibit linear I-V behavior (figure 2(a)) in the dark, which shows that the graphene/ZnO contact has ohmic properties. This is indeed expected due to the similar work function of ZnO (4.25 eV, 4.64 eV and 4.95 eV depending on the face [5]) and of graphene (4.32-5.08 eV depending on the layer number and doping [6]). Under illumination, the conductivity increases. The PC spectra (figure 2(b)) show a photocurrent signal starting from approx. 3 eV. The response is maximal at 3.365eV and slowly decreases for higher energies, which may be attributed to the reduction of the penetration depth of the light at shorter wavelength. The responsivity is larger than 10^4 A/W in the near UV range thanks to a high photoconductive gain in ZnO NWs [5].

The I-V curve of graphene / GaN NW photodetector (figure 3(a)) presents a non-linear behavior, which can be explained by intermediate doping level of GaN nanowires forming Schottky contact with the graphene film. The PC signal (figure 3(b)) rapidly increases from 3.2 eV and exhibits a peak at 3.42 eV close to the GaN bandgap. The detector presents a responsivity of 25 A/W at 1 V bias at 357 nm at low excitation power. The results attest the good transparency of the graphene electrode and the response originating from GaN NW photoconductivity [6].

References

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Figures :

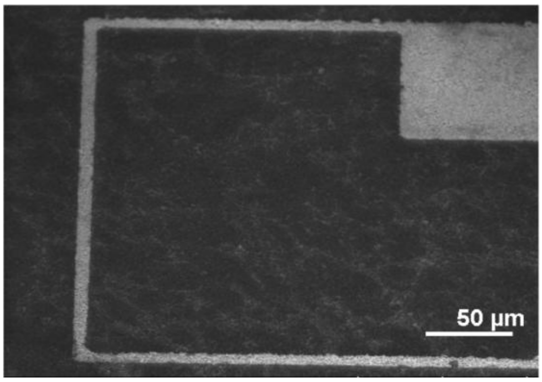

Figure 1: processed graphene / ZnO NW photodetector.

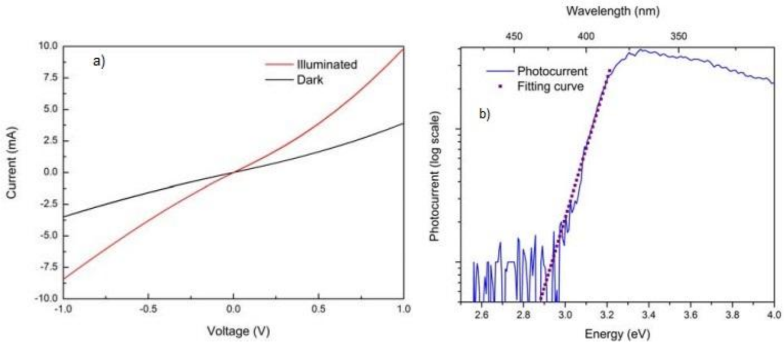

Figure 2: a) I-V curve and b) PC spectrum of graphene / ZnO photodector.

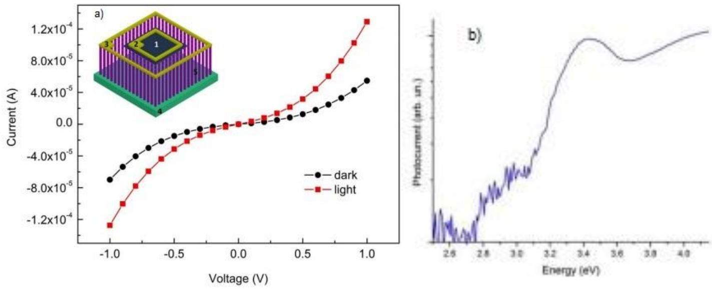

Figure 3: a) I-V curve and b) PC spectrum of graphene / GaN photodector. The inset of Fig a) shows the photodetector schematic.