Ultra high photoresponsivity with field effect control in a graphene nanoribbon device

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We report on the realization and characterization of a novel concept of highly-performing nano-optoelectronic device, fully based on graphene. The active channel consists in a film of structurally well-defined graphene nanoribbons (GNRs) contacted by multilayer graphene electrodes. GNRs are grown by a large throughput chemical vapor deposition (CVD) method and are transferred on on pre-fabricated graphene electrodes.

The resulting device (see Figure 1) shows n-type field effect transistor (FET) behavior, with a large tunability of the device current with the applied gate voltage, likely as a consequence of the good affinity between the GNRs and the graphene-based electrodes, limiting the contact resistance. We demonstrate a current on/off ratio as high as 10^4 at room temperature, which is the best value reported so far for devices based on bottom-up fabricated GNRs.

Our fully graphene-based devices show an ultra-high photo-responsivity at the visible-UV frequencies, as high as 10^6 A/W for low illumination powers, which is almost nine orders of magnitude higher than standard graphene. The improved sensitivity is ascribed to the semiconducting nature of the GNRs (with a direct bandgap of around 1.8 eV) and to the peculiar geometry of our device, where the contacts regions (i.e. the interface between the GNRs and graphene) is directly exposed to the light.

With the possibility to precisely tailor the chemical and physical properties of the GNRs directly at the synthetic level, and the demonstrated use of large scale production techniques, our results show the great potentialities of hetero-structured graphene devices for applications in nano-optoelectronics and sensing.

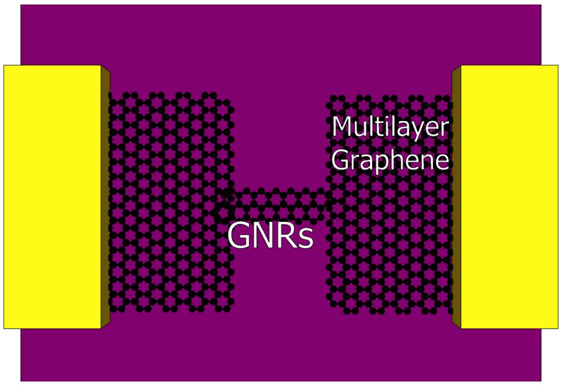

Figure 1: schematic view of the device: graphene nanoribbon (GNRs) are contacted using multilayer graphene as the electrode material