Room-temperature, high-gain, broad-spectrum InAs nanowire infrared photodetectors

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***Abstract*—In this paper, we review our recent progress on low dimensional room-temperature, high-gain, and broad-spectrum photodetectors based on InAs nanowires. Several novel infrared photodetectors based on InAs nanowire are fabricated showing a high photo-gain at room temperature.**

I. Introduction and Background

In recent decades, high-performance infrared photodetectors, which is generally based on HgCdTe, InAs, InGaAs, AlGaAs/GaAs quantum well, and type-II superlattice materials, have achieved rapid development [1-3]. The ability of high-sensitive broad-spectrum detection for photodetectors is critical for many applications in imaging techniques, sensing and optical communications [3]. InAs nanowire (NW) is a promising candidate for broadband photodetector because of its narrow band gap and high carrier mobility at room temperature. However, it is difficult to achieve high performance due to its short minority carrier lifetime and low I_{light}/I_{dark} ratio. In this paper, we review our recent progress on low-dimensional InAs NW infrared photodetectors. Several novel InAs NW infrared photodetectors are fabricated showing a record-high photo-gain at room temperature. The hybrid hetero-junctions photodetector show good temporal photoresponse.

II. Results

We fabricated a core-shell-like InAs NW photodetector. Under illumination, electrons generated from the core are excited into the self-assembled near-surface photo-gating layer (shell), forming a built-in electric field to significantly regulate the core conductance resulting in a majority carrier dominated photodetection. Such majority carrier dominated photodetector could open up the possibility for broad-spectrum photodetection using NW-based transistors [4].

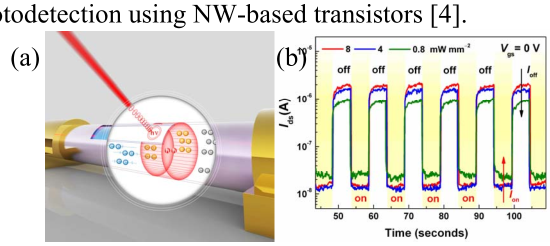

Figure 1. (a) Schematic of novel InAs nanowire room-temperature visible/near-infrared photodetectors based on majority-carrier photodetection mechanism duo to the photo-gating effect. (b) Temporal photoresponse of the InAs NW photodetectors.

Single InAs NW infrared photodetectors have been fabricated with a detection wavelength up to 1.5 μm [5]. The photodetectors displayed minimum hysteresis with a high I_{light}/I_{dark} ratio of 10^5 and photoresponsivity of 10^3 A/W. A large enhancement in photoresponsivity had been achieved in metal Au-cluster-decorated InAs NW photodetectors due to the InAs/Au cluster contacts. An InAs NW photodetector with a half-wrapped top-gate had been fabricated by using 10 nm HfO_2 as the top-gate dielectric. Figure 2(a) shows the schematic of half-wrapped-top-gated InAs NW photodetectors. It shows strong gate control and high-efficient energy harvest abilities.

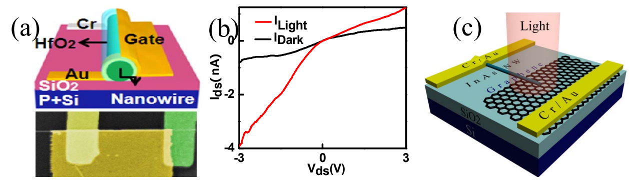

Figure 2 (a) Schematic of half-wrapped-top-gated InAs NW photodetectors. (b) Photo-induced I_{ds}-V_{ds} curves of the photodetectors. (c) Schematic of graphene/InAs NW infrared photodetectors. Reprinted with permission from Ref. [5] and [6] © 2015, Wiley-VCH.

To further suppress the dark current of the InAs NW photodetectors, the graphene/InAs NW vertically stacked infrared photodetectors have been fabricated [6]. Figure 2(c) shows the schematic of graphene/InAs NW photodetectors. The distinct I_{light}/I_{dark} ratio of 5×10^2, larger than that of single InAs NW devices (<5) and graphene devices (~1), was obtained.

III. Conclusion

In this paper, the novel infrared photodetectors based on InAs NW are fabricated showing a record high photo-gain of 10^5 at room temperature. The hybrid hetero-junctions photodetector show good temporal photoresponse with I_{light}/I_{dark} ratio up to 500. Such low-dimensional photodetectors could open up the possibility for room-temperature, high-gain, and broad-spectrum photodetection using NW-based transistors.

Acknowledgements

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