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Mid-infrared single InAs nanowire metal-semiconductor-metal photodiodes

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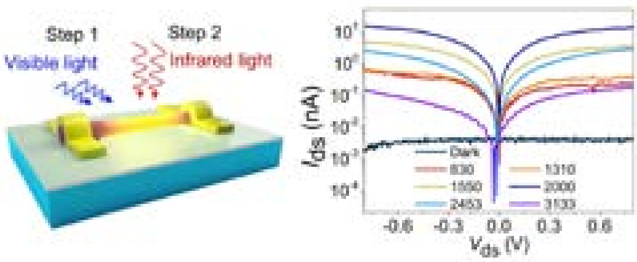
Indium arsenide nanowires (InAs NWs), have been widely researched in recent years together with other III-V semiconductor NWs like InP, GaN, InSb etc. With a high mobility and a direct narrow bandgap (approximately 0.35eV), InAs NWs seem to be more appropriate for applications of high-speed electronic components and broad-spectrum detection media. Photodetectors based on single InAs NW and NW arrays have been successfully fabricated and exhibit a good photoresponse. Research has identified two different photodetection mechanisms for single InAs NW photodetector, which are positive photoresponse (PPR) and negative photoresponse (NPR) respectively. The difference between these two mechanisms is that the latter is a phenomenon induced by surface states similar to a photo-gating layer (PGL) trapping hot electrons and seems to work only when the energy of an incident photon is much higher than the bandgap of InAs. For NPR, an ultrahigh photoconductive gain of -10^5 and a response time of less than 5ms have been achieved. While for PPR, the responsivity and detectivity reach 5.3×10^3A/W and 2.6×10^{11} Jones, which is also a high performance. However, most reported work about InAs NW-based photodetectors is limited to the visible waveband. Although some work shows the certain response for near-infrared light, the problems of large dark current and a small light on/off ratio are unsolved, thus significantly restricting the detectivity. Here in this work, a novel "visible light-assisted dark-current suppressing method" is proposed for the first time to reduce the dark current and enhance the infrared photodetection of single InAs nanowire photodetectors. This method effectively increases the barrier height of the metal-semiconductor contact, thus significantly make the device a Metal-Semiconductor-Metal (MSM) photodiode. These MSM photodiodes demonstrate broadband detection from less than 1 μm to more than 3μm and a fast response of tens of microseconds. A high detectivity of $\sim10^{12}$ Jones has been achieved for the wavelength of 2000nm at a low bias voltage of 0.1V with the corresponding responsivity of as much as 40A/W. Even for the incident wavelength of 3113nm, a detectivity of $\sim10^{10}$ Jones and a responsivity of 0.6A/W have been obtained. Our work has achieved an extended detection waveband for single InAs NW photodetector from visible and near-infrared to mid-infrared. The excellent performance for infrared detection demonstrated the great potential of narrow bandgap NWs for future infrared optoelectronic applications.



Biography

Hehai Fang received his Bachelor degree with honors in condensed matter physics from Nankai University, China, in 2014. He is now pursuing a PhD degree in Microelectronics and Solid-State electronics at the Shanghai Institute of Technical Physics (SITP), Chinese Academy of Sciences (CAS). He got the National Scholarship for outstanding PhD students in 2017. His research interests are in fabrication and characterization of infrared photodetectors based on low dimensional materials, including nanowires, 2D materials and nanostructured semiconductors with narrow bandgaps.

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