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Recent progress on localized field enhanced two-dimensional material photodetectors from ultraviolet-visible to infrared

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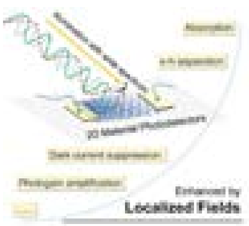
Bonded tightly in the plane and stacked with weak van der Waals force, two-dimensional (2D) materials have attracted increasing attention over the past decade owing to their unique structures and physical properties. To date, 2D materials comprise graphene, black phosphorus (BP), transition metal dichalcogenides (TMDs), boron nitride (BN) and so forth. Among them, graphene was first discovered and studied as early as 2004. Because of the reduced feature dimensions, quantum confinement effects in 2D systems are particularly significant. With weaker dielectric screening in a several-nanometer or even atomic thickness, stronger Coulomb interactions occur. 2D systems provide an open platform for exploring novel physical phenomena and mechanisms. For instance, the breaking of inversion symmetry and strong valley-spin coupling in TMDs cause them to exhibit valley-dependent circular dichroism and scaling the material from multilayer to monolayer can realize an indirect-to-direct bandgap transition. Therefore much effort has been devoted to seeking various applications based on 2D materials and the study of photodetectors based on 2D materials is a hot research field. In this report, we introduce localized field enhanced 2D material photodetectors (2DPDs) from ultraviolet, visible to infrared in the sight of the influence of device structure on photodetector performance instead of directly illustrating the detection mechanisms. Six kinds of the localized field are summarized. They are a ferroelectric field, photogating electric field, floating gate induced electrostatic field, interlayer built-in field, localized optical field and photo-induced temperature gradient field, respectively. By suppressing the background noise, enhancing the optical absorption, improving the electron-hole separation efficiency, amplifying the photogain or extending the detection range, these localized fields are demonstrated to effectively promote the detection ability of 2DPDs. Particularly, among them, the photogating has been demonstrated to play a very important role especially in photodetectors based on hybrid structures. We consider photogating as a way of conductance modulation through photo-induced gate voltage instead of simply and totally attributing it to trap states. A high gain-bandwidth product as high as 109Hz has been achieved for photodetectors enhanced by the trap- and hybrid-induced photogating, though a trade-off has to be made between gain and bandwidth. We also put forward the general photogating according to another three reported studies very recently. General photogating may enable simultaneous high gain and high bandwidth, paving the way to explore novel high-performance photodetectors.



Biography

Weida Hu received his BS and MS degree in Material of Science from Wuhan University of Technology, Wuhan, China, in 2001 and 2004, respectively and PhD degree (with honors) in Microelectronics and Solid-State electronics from the Shanghai Institute of Technical Physics (SITP), Chinese Academy of Sciences (CAS), in 2007. He is currently a full professor on fabrication and characterization of infrared photodetectors in SITP. He has authored or coauthored more than 110 technical journal papers and conference presentations with the total citations of 3100 and h-index of 33. He received the National Science Fund for Distinguished Young Scholars in 2017, National Science Fund for Excellent Young Scholars in 2013 and National Program for Support of Top-notch Young Professionals (Ten Thousand Talents Program for Young Talents) in 2015. He is selected as the Royal Society-Newton Advanced Fellowship in 2017. He is also serving as the Associate Editor of Infrared Physics & Technology, the Executive Editor of Optical and Quantum Electronics, the Program Committee of SPIE DCS Defense and Security-Infrared Technology and Applications (USA) and the Program Committee of the International Conference on Numerical Simulation of Optoelectronic Devices (NUSOD).

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