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Circular Photogalvanic Photocurrents in 2D Materials

Helicity dependent photocurrent (PC) is the electric current generated by elliptically polarized light incident on to sample plane. For the circular polarized light absorption, based on particular directions of optical field and the point group symmetries of the material, this PC can be mainly due to the circular photogalvanic effect (CPGE). The PC due to the CPGE has been studied in detail for III-V and II-VI semiconductor quantum wells as one kind of spin PCs in those materials. Recently, the CPGE current in 2D materials has attracted attention and been observed for oblique incidence and excitation perpendicular to the direction of current. Here first we provide a review about the CPGE current in 2D materials, starting with observation in graphene which has weak spin orbit coupling. The microscopic origin of the CPGE current in graphene is due to the quantum interference between Drude transitions and indirect intraband transition with intermediate states [1]. Then we demonstrate that in single layer graphene (1LG), bilayer graphene (2LG) [2], the carrier density dependence of the CPGE current follows the Fermi-Dirac distribution, as expected. Unlike 1LG, 2LG, and ABA stacked 3LG cases, the large enhancement of the CPGE current in ABC stacked 3LG is attributed to the coexistence of band gap opening and restored inversion symmetry [3]. On the other hand, monolayer transition metal dichalcogenide semiconductors, such as MoS2, have a large direct band gap in their K valley, broken inversion symmetry and strong spin orbit coupling. They also exhibit CPGE current as a result of giant spin-valley coupling which can be controlled by circularly polarized light and global back-gating. A large CPGE current polarization was observed for excitation on –resonance with exciton, which is negligible for off-resonance excitation [4]. Also a large on-off ratio of CPGE current as a function of carrier density was reported [5]. We also discuss the modulation of the CPGE current in monolayer MoS2 upon doping with magnetic elements.

References

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