MODULATING TRIONS AND EXCITONS IN TWO-DIMENSIONAL MOS2 BY ACOUSTIC MEANS

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Two-dimensional molybdenum disulfide (2D MoS2) has attracted increasing attention in recent years due to its fascinating physical and chemical properties.1-8

A very recent discovery is the observation that 2D MoS2 is by nature piezoelectric, if it contains an odd number of layers but not so in even layered configurations.8 This appears to originate from the opposite orientation of alternating layers in 2H-MoS2, resulting in an inversion symmetry breaking only in oddnumbered layers, whereas systems with an even number of layers remain centrosymmetric, losing its piezoelectric response. Wu et al.8 subsequently investigated the piezoelectric properties of one to six layered MoS2 through continuous stretching and releasing of the flakes with a strain frequency of 0.5 Hz, in which the piezoelectric coupling coefficient was estimated to be ~5.08% for a single layer and observed to reduce significantly for 3 and 5 layers.

In this work, by exploiting the very recent discovery of the piezoelectricity in odd-numbered layers of 2D MoS2, we show the possibility of reversibly tuning the photoluminescence of single and odd-numbered multilayered MoS2 using high frequency sound wave coupling.5 We observe a strong quenching in the photoluminescence associated with the dissociation and spatial separation of electrons–holes quasiparticles at low applied acoustic powers. At the same applied powers, we note a relative preference for ionization of trions into excitons. This work also constitutes the first visual presentation of the surface displacement in one-layered MoS2 using laser Doppler vibrometry. Such observations are associated with the acoustically generated electric field arising from the piezoelectric nature of MoS2 for odd-numbered layers. At larger applied powers, the thermal effect dominates the behaviour of the two-dimensional flakes. Altogether, the work reveals several key fundamentals governing acousto-optic properties of odd-layered MoS2 that can be implemented in future optical and electronic systems.

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