Quantifying photoinduced charge transfer in atomically thin transition metal dichalcogenide/graphene van der Waals heterostructures

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Van der Waals heterostructures (vdWH) made of two-dimensional materials, such as graphene and transition metal dichalcogenides, exhibit interesting properties both from a fundamental standpoint and for optoelectronic applications [1-4]. The behavior of photoexcited carriers in vdWH is strongly affected by near-field interlayer coupling through charge and/or energy transfer. In particular, unraveling the efficiency of interlayer charge transfer and its dependence upon the incoming photon flux or an externally applied electric field is of utmost importance for optoelectronics [3,4].

Here, we report a study of monolayer molybdenum diselenide ($MoSe_2$)/monolayer graphene vdWH by means of micro-Raman spectroscopy. From an analysis of the graphene Raman modes in the vdWH, we are able to quantify the photoinduced charge carrier concentration in graphene and to identify the nature of the charge transfer process. Raman measurements are compared to micro-photoluminescence (PL) studies, which reveal a strong quenching of the $MoSe_2$ PL in the vdWH. Our work opens avenues for spatially-resolved photogating and raises the question of the relative efficiencies of charge and energy transfer in vdWH.

References

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Figure

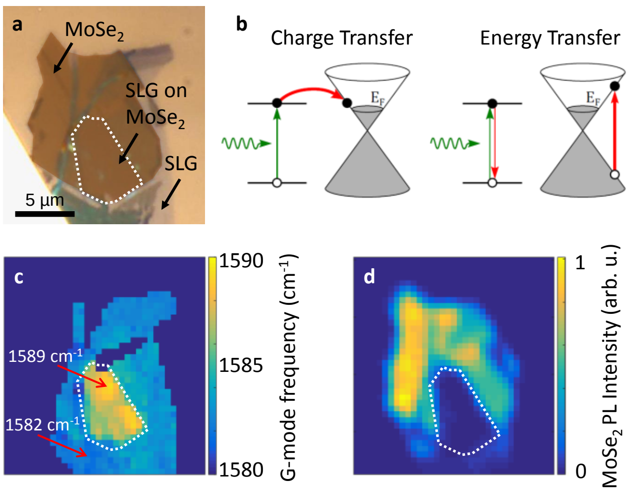

Figure 1: (a) Optical image of a $MoSe_2$/graphene (SLG) van der Waals heterostructure fabricated at IPCMS. Photoinduced charge and energy transfer from a two-level system to graphene are illustrated in (b). The map of the graphene Raman G-mode frequency (c) and of the $MoSe_2$ photoluminescence intensity (d) of this sample reveals clear signatures of interlayer coupling on the heterostructure (dashed contour in a, c, d). In particular, the significant stiffening of the Raman G-mode observed on the heterostructure (c) is assigned to photoinduced electron transfer from $MoSe_2$ to graphene. (G. Froehlicher *et al.*, in preparation)