Contribution ID: **459**   Type: **Oral Presentation**

Tuning interlayer exciton emission in binary-ternary heterobilayers based on $Mo_{0.5}W_{0.5}Se_2$

Thursday 10 July 2025 09:20 (20 minutes)

Semiconductor heterostructures have been pivotal in the progress of electronic and optoelectronic devices. A notable category within this realm is the type II band alignment, where optically excited electrons and holes localise in separate material layers. The distinctive properties exhibited by two-dimensional transition metal dichalcogenides, coupled with the potential for engineering van der Waals heterostructures, position them as strong contenders for future high-tech applications. In these structures, electronic, optical, and magnetic properties can be tuned through the interlayer coupling, thereby opening avenues for developing new functional materials. The possibility of explicitly tuning the emission of interlayer exciton energies in the binary–ternary heterobilayer of $Mo_{0.5}W_{0.5}Se_2$ with $MoSe_2$ and WSe_2 is reported. The respective interlayer energies of 1.516 eV and 1.490 eV were observed from low-temperature photoluminescence measurements for the $MoSe_2$- and WSe_2- based heterostructures, respectively. These interlayer emission energies exceed those reported for $MoSe_2/WSe_2$ (⊠1.30 −1.45 eV). Consequently, binary–ternary heterostructure systems provide a broader energy range and tailored emission energies not available with binary counterparts. Moreover, although $Mo_{0.5}W_{0.5}Se_2$ and $MoSe_2$ have nearly identical optical gaps, their band offsets differ, which results in charge transfer between the monolayers after optical excitation. This confirms that TMD alloys allow for tuning the band offsets, adding another design parameter for application-specific optoelectronic devices.

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Session Classification: Physics of Condensed Matter and Materials

Track Classification: Track A - Physics of Condensed Matter and Materials