Investigation of the influence of inter-layer coupling strength on exciton binding energies in bulk ReX2 compounds

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Re-based TMD compounds show much weaker interlayer coupling,compared to other transition metal dichalcogenide (TMD) compounds, due to the stacking layers with low symmetry, and are thus expected to display thickness-independent physical properties. Despite its potential in device applications, bulk Re-TMD compound still lacks the fundamental information on the material, including the nature of quasi particle electronic bandgap.

In this works, we studied the bulk crystalline ReS2 and ReSe2 with 1T' phase using scanning tunneling microscopy and spectroscopy, and angle-resolved photoemission spectroscopy. Our atom-resolved topography images show well-ordered, diamond chain structures in agreement with the previous works. When compared with the photoluminescence and ellipsometry data, our measurements of the electronic bandgap at low temperature by using scanning tunneling spectroscopy display the significantly large exciton binding energy in bulk ReSe2, in contrast to the bulk ReS2.

In addition, we find strong evidence that the interlayer-coupling strength in ReSe2 is much weaker compared to that of ReS2, indicating that the large exciton binding energy originates from the more two-dimensional nature of the layers in bulk ReSe2. This analysis is also supported by our photoemission data.

Our investigation of 2D- and 3D-like Re-TMD compounds sheds light on the importance of interlayer coupling strength in the determination of the exciton binding energy, and may provide valuable information in designing materials tailored to the future optical devices.

References:
[1] Miguel M. Ugeda, Steven G. Louie & Michael F. Crommie, Nature Materials **13**, 1091–1095 (2014)