Monolayer indium selenide: an indirect bandgap material exhibits efficient brightening of dark excitons

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Atomically thin indium selenide (InSe) exhibits distinctive excitonic behaviors because of its atypical sombrero-like valence band. [1] Previous studies have highlighted that the indirect band gap of thin InSe layers leads to faint emission from the lowest-energy excitonic state, known as the A exciton, which is often weak or undetected in monolayer (ML) InSe. [2,3] This has left the characteristics of its excitonic states largely unexplored. In this work, we successfully fabricate high-quality ML InSe samples and observe pronounced PL emission from them, suggesting an efficient brightening of the momentum-indirect dark excitons. [4] The mechanism is attributed to acoustic phonon-assisted radiative recombination facilitated by strong exciton-acoustic phonon coupling and extended wavefunction in momentum space. Systematic analysis of layer-, power-, and temperature-dependent PL demonstrates that a carrier localization model can account for the asymmetric line shape of the lowest-energy excitonic emission for atomically thin InSe. [5] Our work reveals that atomically thin InSe is a promising platform for manipulating the tightly bound dark excitons in two-dimensional semiconductor-based optoelectronic devices.

References

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Figures

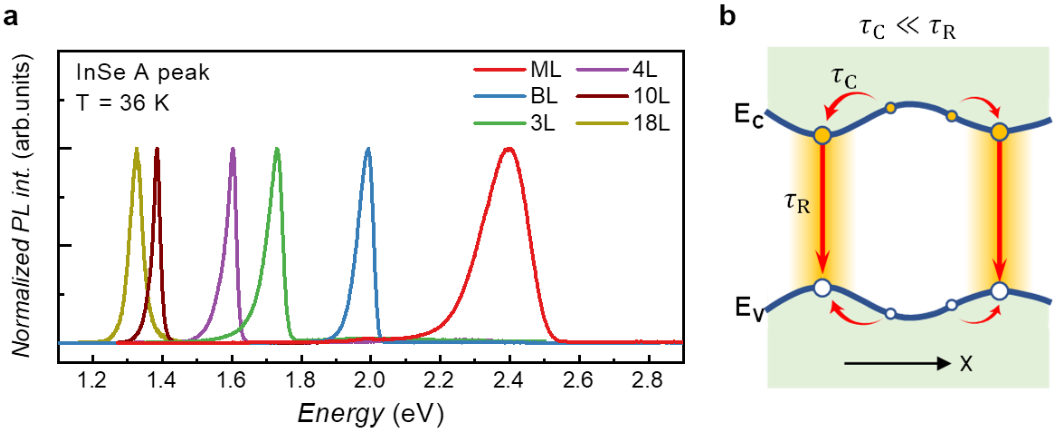

Figure 1: (a) Normalized PL spectra of the A peaks of InSe from ML to 18 L. (b) Schematic of the carrier localization model when the carrier localization time (τ_C) is smaller than the recombination time(τ_R).