Intersubband optics in atomically thin InSe films

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Among 2D materials, a special place is taken by two post-transition metal chalcogenides (PTMCs): InSe and GaSe. These optically active 2D compounds were found, both theoretically[1] and experimentally[2], to have a band gap that varies widely from the monolayer to multilayer films, densely covering the range of energies Eg ~ 1.3eV – 3eV. Also, these 2DMs have relatively light (m*~0.2me) conduction band electrons with very high mobility, even in the case of atomically thin films. While the recent optical studies of 2D InSe and GaSe crystals have been performed using mechanically exfoliated films, manufacturability of 2D crystals of PTMCs using molecular beam epitaxy[3] and chemical vapour deposition[4] has already been demonstrated, and the potential of various PTMCs for optoelectronics applications identified in terms of their implementation in high-sensitivity[5] and fast[6] broad-band photodiodes. Here, we propose atomic films of n-doped γ-InSe as a platform for intersubband optics in the infrared (IR) and far infrared (FIR) range, coupled to out-of-plane polarised light. Depending on the film thickness (number of layers) of the InSe film these transitions span from ~0.7 eV for bilayer to ~0.05 eV for 15-layer InSe (see Figure 1). We use a hybrid k·p theory and tight-binding model, fully parametrised using density functional theory, to predict their oscillator strengths and thermal line-widths at room temperature[7].

References

[1] S. J. Magorrian, V. Zólyomi, and V. I. Fal'ko, Phys. Rev. B 94 (2016), 245431
[2] D. A. Bandurin et al., Nature Nanotech. 12 (2016), 223
[3] Z. Ben Aziza et al., Phys. Rev. B 96 (2017), 035407
[4] R. Browning, N. Kuperman, B. Moon, and R. Solanki, Electronics 6 (2017), 27
[5] S. R. Tamalampudi et al., Nano Lett. 14 (2014), 2800
[6] N. Balakrishnan et al., Adv. Opt. Mat. 2 (2014), 1064
[7] S. J. Magorrian, V. Zólyomi, and V. I. Fal'ko, arXiv:1801.07052

Figures

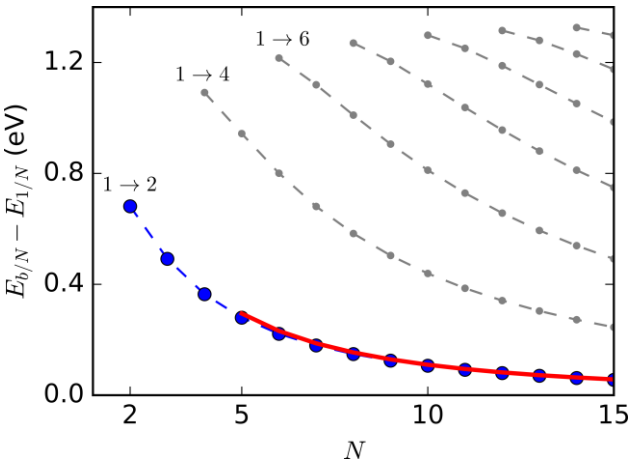

Figure 1: . Intersubband energies for allowed electric dipole transition for excitation from the lowest sub-band in N=2-15-layer InSe. Transitions to the second lowest sub-band (marked in blue) are expected to be significantly stronger than transitions to higher sub-bands.