High Harmonic Generation in Monolayer MoS2 with Electrostatic Modulation

Taeho Kim[1], Minjeong Kim[1] and Jonghwan Kim[1]

[1]*Department of materials science and engineering, Pohang University of Science and Technology, Pohang, 37637, South Korea*

kth9968@postech.ac.kr

Abstract: High harmonic generation (HHG) from solids is a promising route to probe electronic states in sub-laser-cycle timescale and to realize compact, coherent light sources with high photon energy. In this study, we investigate the generation of high harmonics in monolayer transition metal dichalcogenides (MoS2) under strong laser fields and electrostatic gating. These findings provide insights into engineering coherent light sources with a gate control.

High harmonic generation (HHG) from solids has emerged as a fascinating new route to probe electronic states in sublaser-cycle timescale and to realize compact, coherent light sources with high photon energy (up to ~40 eV).

Hiroyuki et al. controlled HHG in single-walled carbon nanotubes through electronic structure tuning and carrier injection. They demonstrated that high harmonic intensity can be enhabce or reduce with carrier injection, depend-ing on the harmonic order. [1]

In this study, we investigate the HHG from monolayer MoS2, promising materials with novel properties like strong spin-orbit coupling and valley degree of freedom, under strong laser fields with electrostatic gating. We deomostrate that high harmonic intensity modulate differently depending on the harmonic order, while injecting carriers on conduction band electrostatically. In figure 1, the harmonic spectrum of two repre-sentative cases are shown: high harmonic from a charge neutral(VG = 0 V) and highly doped(VG = 2 V) MoS2. When carriers are injected, harmonic intensiy shows different behavior depending on harmonic order, as demonstrated in the strudy on carbon nanotubes. [1] The 5th harmonic with en-ergy of 1.375 eV, which is below the bandgap (1.88eV) are enhanced through carrier injection while 7,9,11th (1.925, 2.475, 3.025 eV) above the bandgap are reduced.

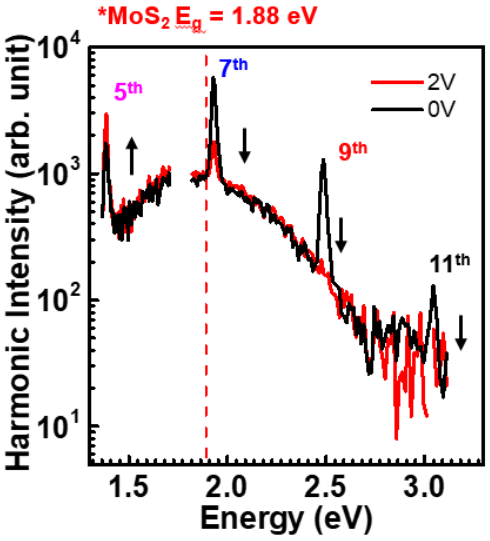

Fig.1. High Harmonic Generation spectrum in charge neutral state, 0V (black line) and highly doped state, 2V (red

Considering the HHG from MoS2 with elec-trostatic gating could provide an insight into how relative contribution of interaband and intraband transitions is related to band gap of solids. Moreover, our findings pave the way for engi-neering coherent light sources based on high en-ergy radiation with gate control.

References

[1] G. Vampa, Phys. Rev. Lett. **113**, 073901 (2014).