All-optical polarization and amplitude modulation of second harmonic generation in atomically thin semiconductors

Sebastian Klimmer
Omid Ghaebi, Ziyang Gan, Antony George, Andrey Turchanin, Giulio Cerullo and Giancarlo Soavi
Institute of Solid State Physics, Friedrich Schiller University Jena, 07743 Jena, Germany
Sebastian.Klimmer@uni-jena.de

Nonlinear optics is of paramount importance in several fields of science and technology. This is particularly true in the case of second harmonic generation (SHG), which is commonly used for frequency conversion, self-referencing of frequency combs, crystal characterization, sensing, and ultra-short pulse characterization. Large efforts have been devoted in the last years to realizing electrical and all-optical modulation of SHG in atomically thin materials, which are easy to integrate on photonic platforms and thus ideal for novel nano-photonic devices. Here, we propose a new approach to broadband all-optical modulation of SHG in 2D materials. Our concept is based only on symmetry considerations and thus is applicable to any material of the D_{3h} symmetry group and with deep sub-wavelength thickness, such as all monolayer transition metal dichalcogenides (Fig. 1(a)). With this approach we demonstrate a 90° rotation of the polarization of the emitted SH on a time-scale limited only by the fundamental pulse duration. In addition, this ultrafast polarization switch can be immediately applied to realize all-optical SH amplitude modulation with depth of 100% (Fig. 1(b)). Our results outperform any previous work on all-optical SHG modulation [1,2] in terms of modulation speed, modulation depth and SHG bandwidth.

References

[1] Taghinejad M. et al., Small 16, 1906347 (2020)
[2] Cheng Y. et al., Nano Lett. 20, 11 (2020) 8053-8058

Figures

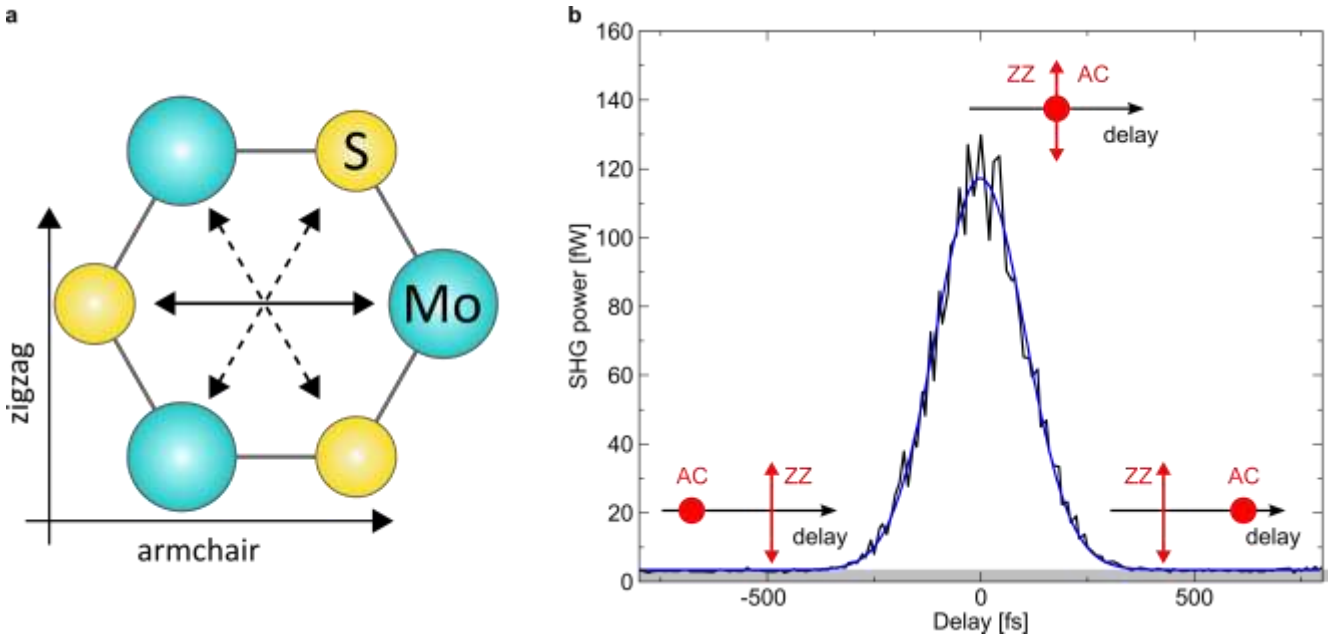

Figure 1: (a) Schematic top view of a MoS_2 crystal. The arrows inside the hexagon highlight the D_{3h} three-fold rotational symmetry. (b) All-optical SH modulation along the zigzag direction as a function of the delay between two perpendicular pulses polarized along the armchair and zigzag directions.