Ferroelectric control of second-harmonic generation in monolayer MoS_2 on periodically poled $LiNbO_3$

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Monolayer (1L) transition metal dichalcogenides (TMDs) have attracted significant interest for nanophotonic and nanoelectronic applications due to their unique electronic and optical properties. The intrinsic broken inversion symmetry of these monolayers gives rise to strong second-order nonlinearities, making them particularly interesting for nonlinear frequency conversion processes. In addition, their atomic-scale thickness makes them highly sensitive to the local environment, enabling efficient control of light–matter interactions through integration with ferroelectric platforms [1,2].

In this work, we investigate the influence of ferroelectricity on the second-harmonic generation (SHG) response of monolayer molybdenum disulfide (1L-MoS_2) transferred onto a periodically poled $LiNbO_3$ (PPLN) substrate. Spatially resolved micro-SHG experiments reveal that the alternating ferroelectric domain structure of the substrate induces a pronounced spatial modulation of the 1L-MoS_2 SHG signal. Furthermore, this modulation exhibits a clear dependence on the intensity, wavelength, and polarization state of the fundamental beam light. The results are explained by a domain-dependent photoinduced charge transfer processes at the 1L-MoS_2/PPLN interface, which induce a selective enhancement of the second-order susceptibility, $\chi^{(2)}$ of the monolayer. These results establish a new route to manipulate and enhance the nonlinear optical response of two-dimensional materials in integrated photonic systems, paving the way for advanced photonic functionalities.

[1] Ramírez M. O. et al. (2024) Advanced Optical Materials 12, 2400624.
[2] Hernández-Pinilla D. et al. (2025) Materials Horizons, 12, 6992.

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