Large-Area α-MoO_3 Thin Films via Pulsed Laser Deposition for Polariton-Enhanced Infrared Molecular Sensing

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Phonon polaritons supported by natural hyperbolic materials have recently attracted significant attention as low-loss frameworks for mid-infrared (IR) light-matter interaction, where molecules exhibit characteristic vibrational signatures. In this work, we show that large-area α-phase molybdenum trioxide (α-MoO_3) thin films prepared via pulsed laser deposition (PLD) can act as intrinsic phononic platforms for IR molecular detection. We investigate the optical behavior of these films using micro-FTIR reflection spectroscopy, which reveals distinct Reststrahlen bands arising from the highly anisotropic lattice vibrations of α-MoO_3. To explore the coupling between molecular vibrational modes and the polaritonic resonances of the oxide platform, a thin poly(methyl methacrylate) (PMMA) top layer was utilized as a model analyte. The introduction of PMMA leads to reproducible alterations in the reflection spectra within the frequencies where its specific vibrational signatures overlap with the α-MoO_3 phonon modes, pointing to a phonon-assisted enhancement of molecular absorption. Comparative assessments against standard Au, SiO_2, and α-MoO_3/SiO_2 configurations reveal that the standalone α-MoO_3 substrate yields the highest spectral contrast, emphasizing how its multiple Reststrahlen bands significantly improve detection sensitivity. Ultimately, these findings validate PLD-grown α-MoO_3 thin films as a scalable, fabrication-free architecture for polariton-enhanced IR spectroscopy, offering a practical strategy for designing compact dielectric surface-enhanced infrared absorption (SEIRA) devices leveraging natural hyperbolic materials.

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