

Optimum absorption of MoS₂ monolayer using Cavity Resonator Integrated Filtering

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Transition Metal Dichalcogenides (TMD) are two-dimensional (2D) semiconductor materials with astonishing physical and especially optical properties [1] thanks to their stunning excitonic binding energy [2]. In order to exploit these promising optical properties for applications, this work explores the conception and fabrication of hybrid photonic devices based on the integration of a MoS₂ monolayer in photonic structures. To enhance the photocurrent (PC) and photoluminescence (PL) of MoS₂ monolayer, the latter is incorporated into photonic cavities designed to achieve a maximum optical absorption by the TMD layer at a target excitation wavelength. Numerical simulations based on the scattering matrix method [3, 4] are used to explore the optical properties of these hybrid structures combining micro and nanoscale engineering. **Figure 1.a** shows the typical studied stack consisting of a Grating-Mode Resonant Filter (GMRF) structure with a planar guiding layer fabricated on a monolayer of MoS₂ deposited or transferred onto silicon oxide film with a back side metallic mirror forming a vertical cavity. The optimisation of the layer thicknesses and parameters of the GMRF led to the selection of a particular structure which allows to achieve more than 97% of absorption of the incident light at 532 nm in the MoS₂ monolayer as shown in **Figure 1.b**. To reduce the lateral extension of the optical structure while maintaining high absorption in the TMD, the simple GMRF can be replaced by a Cavity Resonator Integrated Filter (CRIGF) [5] to combine vertical and horizontal optical confinements. With this hybrid TMD/photonic structure, 90% of the incident light at 532 nm is absorbed by the MoS₂ monolayer.

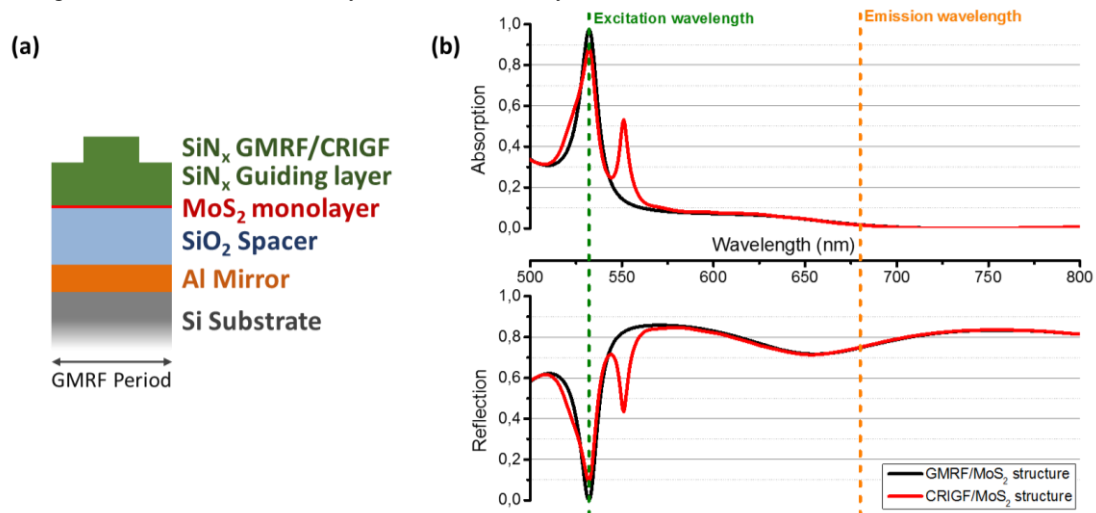


Fig. 1 Schematic of hybrid MoS₂/photonic vertical stack (a) and calculated optical response spectra of these structures (b).

In addition, the reflectivity of the proposed hybrid optical structures is close to 75% at the PL wavelength of the MoS₂ monolayer (~680 nm). The combination of high absorption at the excitation wavelength and high reflectivity at the emission wavelength of MoS₂ monolayer in this stack provides an optimal system for exploring the PL properties of the integrated MoS₂ monolayer. The development of these hybrid structures contributes to study the impact of integration processes on TMD materials, identified as the main present challenge concerning TMD materials [1, 6]. Efforts are currently focused on the fabrication of the designed CRIGF/TMD hybrid optical structures to pave the way towards the integration of TMD into a wider variety of photonic devices.

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