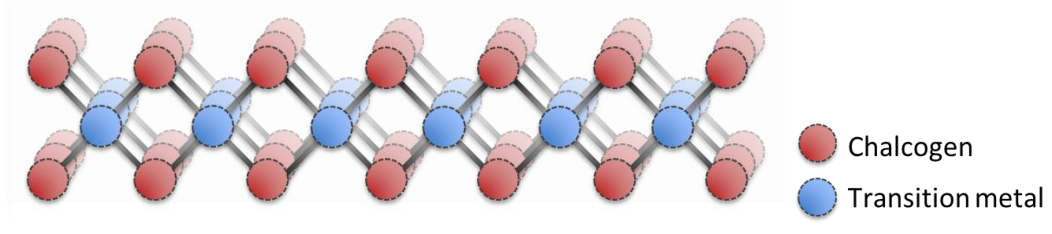
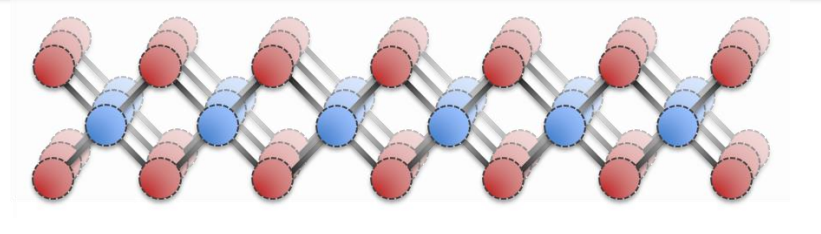


Optimum absorption of MoS₂ monolayer using Cavity Resonator Integrated Filtering

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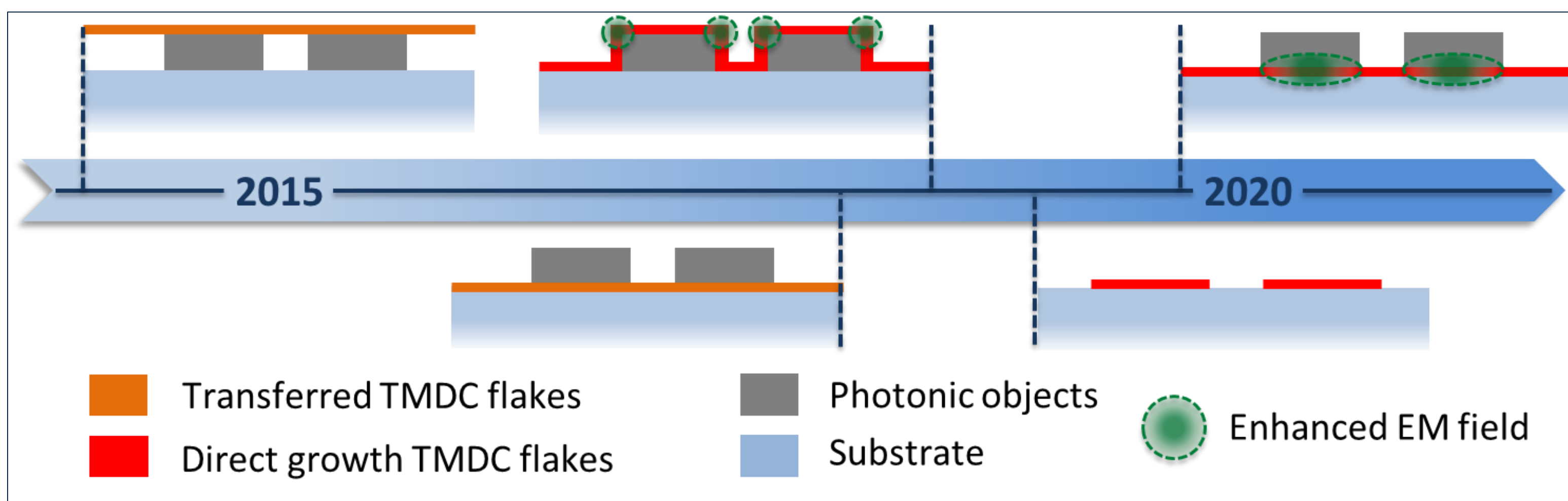


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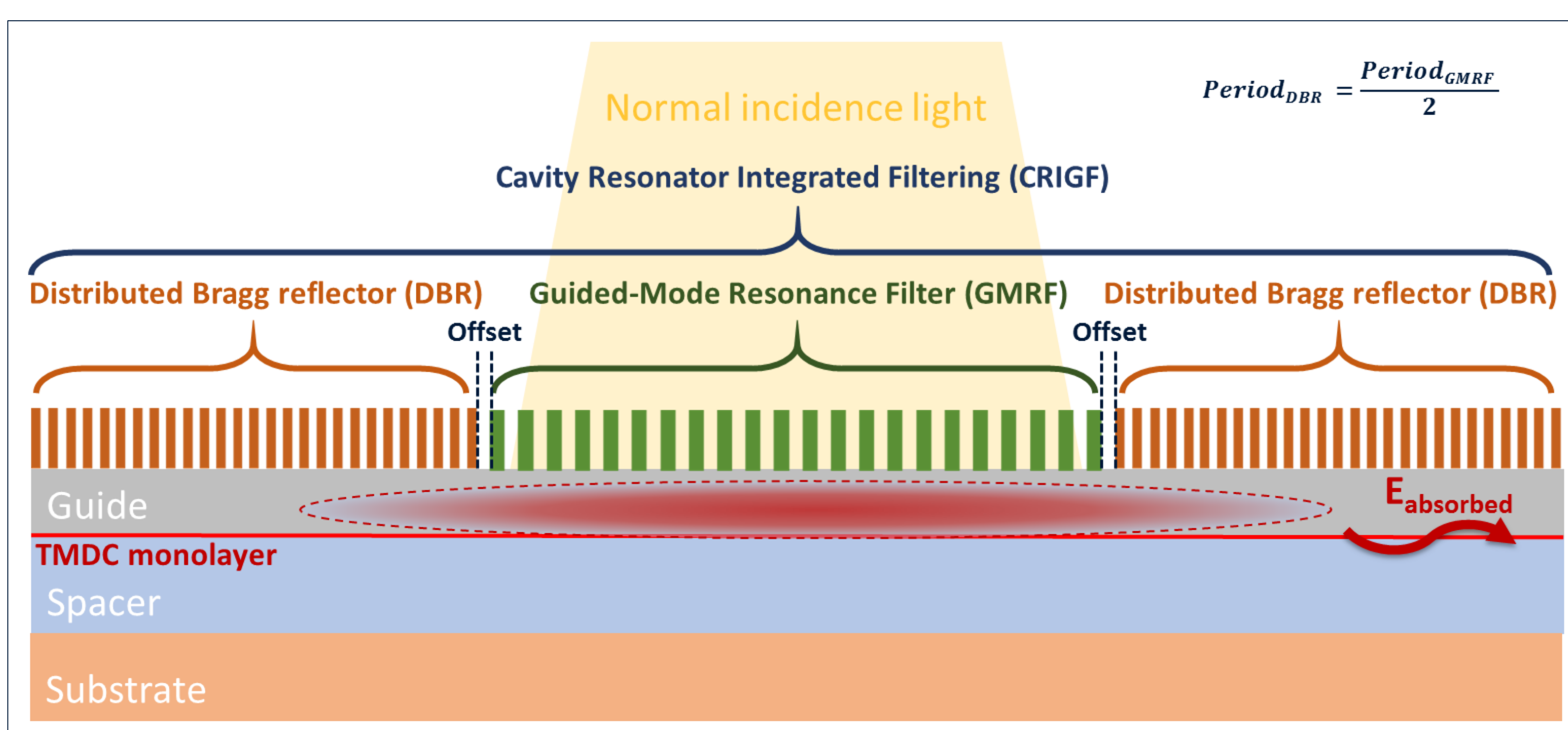


Elaboration of hybrid photonic devices with Transition Metal DiChalcogenide (TMDC) monolayers

TMDCs are lamellar semiconductor materials exhibiting astonishing physical and especially optical properties^[1] thanks to their stunning excitonic binding energy^[2]. These remarkable excitonic effects at room temperature can be used for photovoltaic and photodetection applications due to their exceptional absorption given their sub-nanometer thickness^[3].



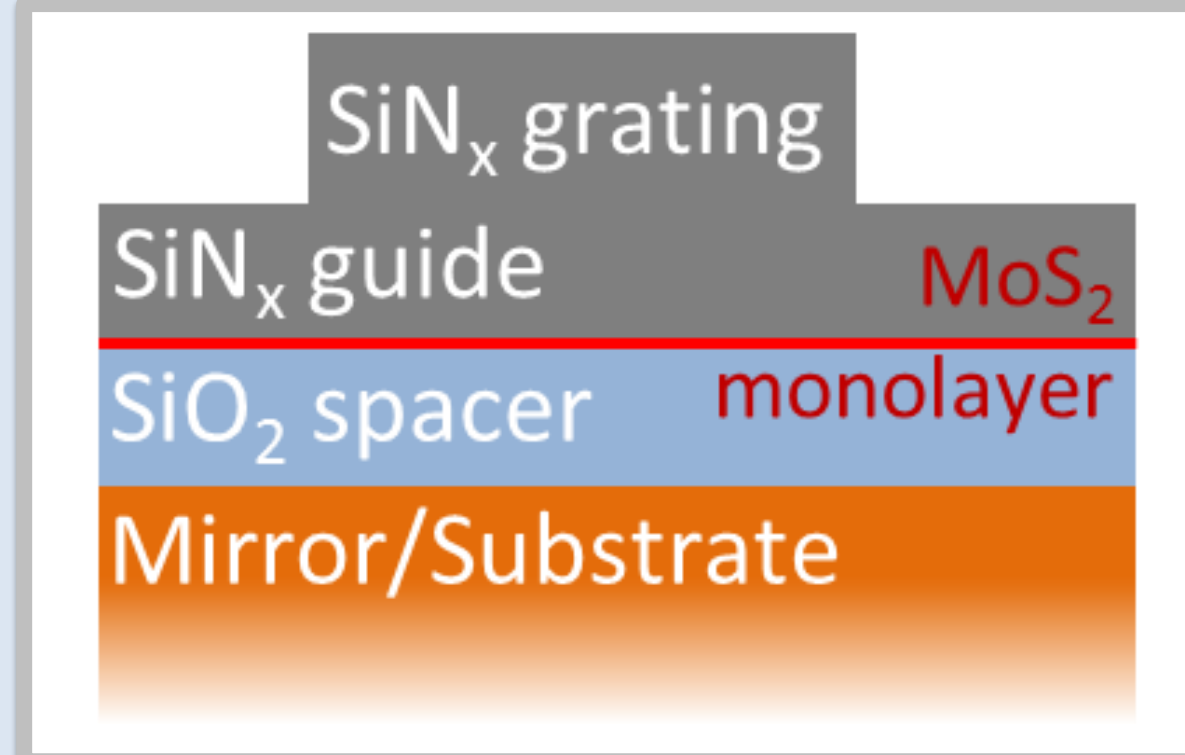
The first examples of TMDC - photonic structure coupling were achieved by transferring TMDC monolayers on top of plasmonic antennas^[4]. Subsequently, hydride polaritonic structures have also been obtained by texturing metal films deposited on top of DMT sheets previously transferred onto a suitable substrate^[5-7]. On the other hand, experimental demonstrations of hybrid structures fabricated without DMT transfer are very recent and rare^{[8][9]}.



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 TMDC layer at a target excitation wavelength.

Enhancement of hybrid GMRF-TMDC device performances

TMDC deposition is a high temperature process (600-1000°C) that is not compatible with all materials. Thus, growth substrate must be designed considering both optical properties and thermal stability. Finally, conception of hybrid photonic devices is performed using rigorous coupled-wave analysis (RCWA).

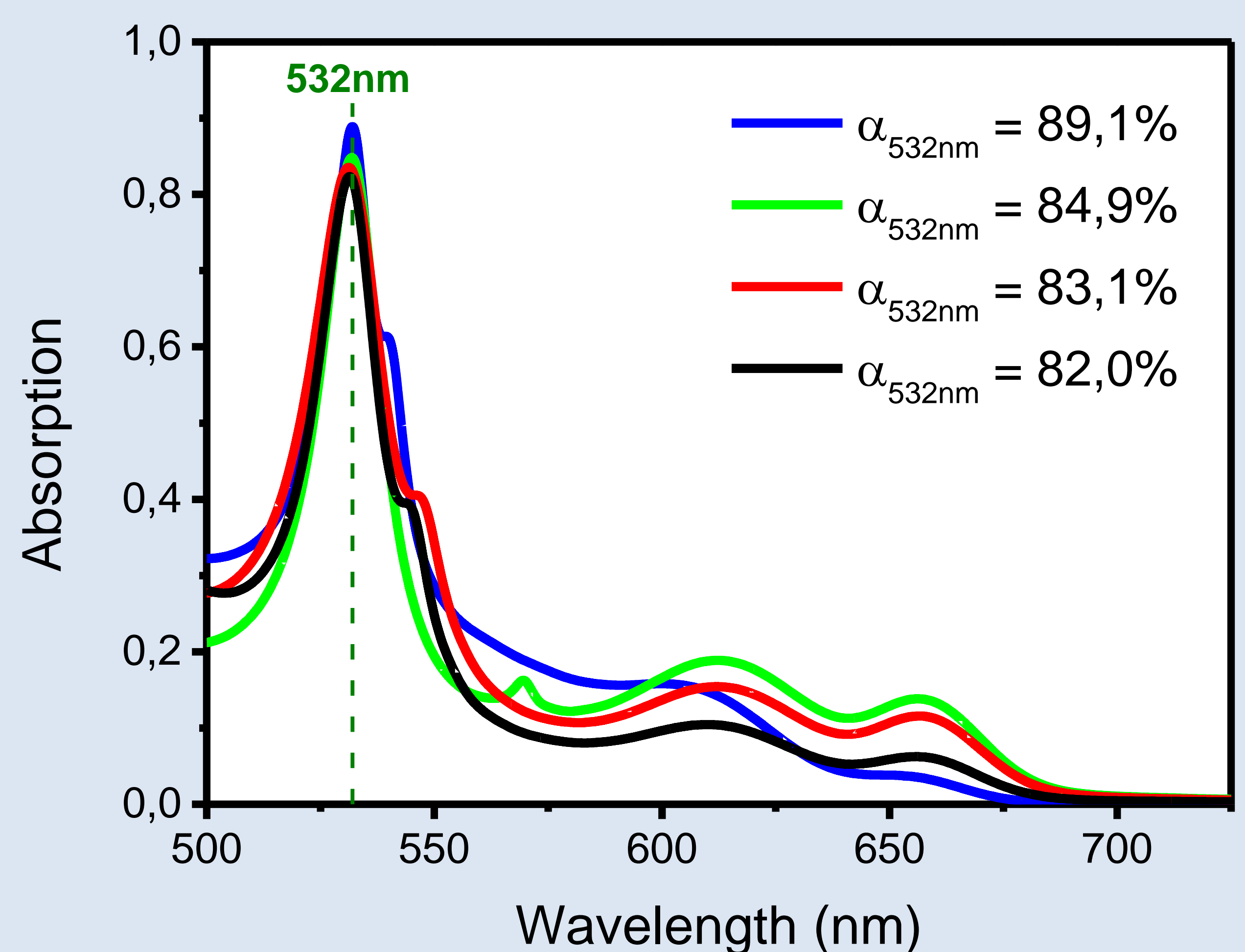
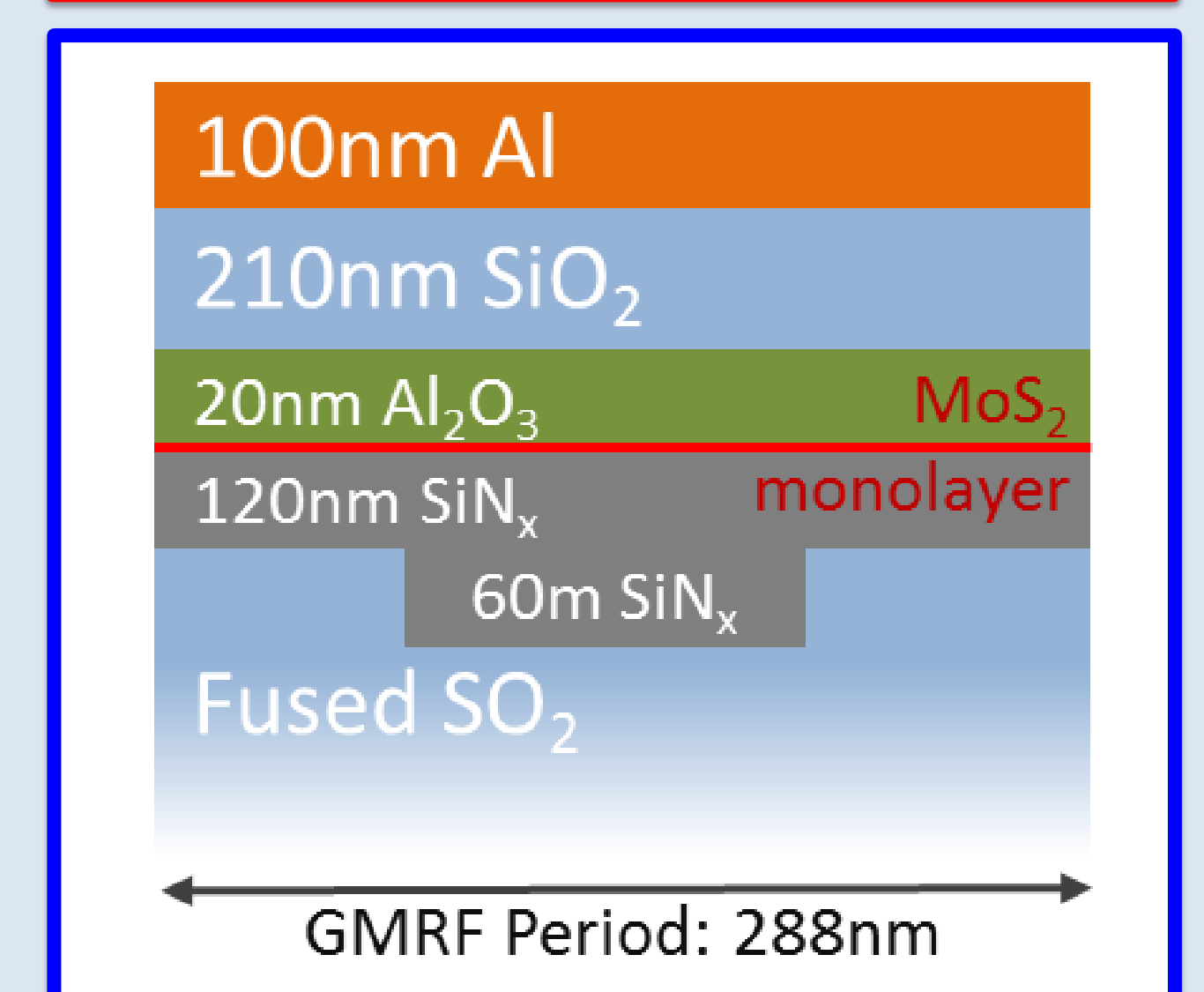
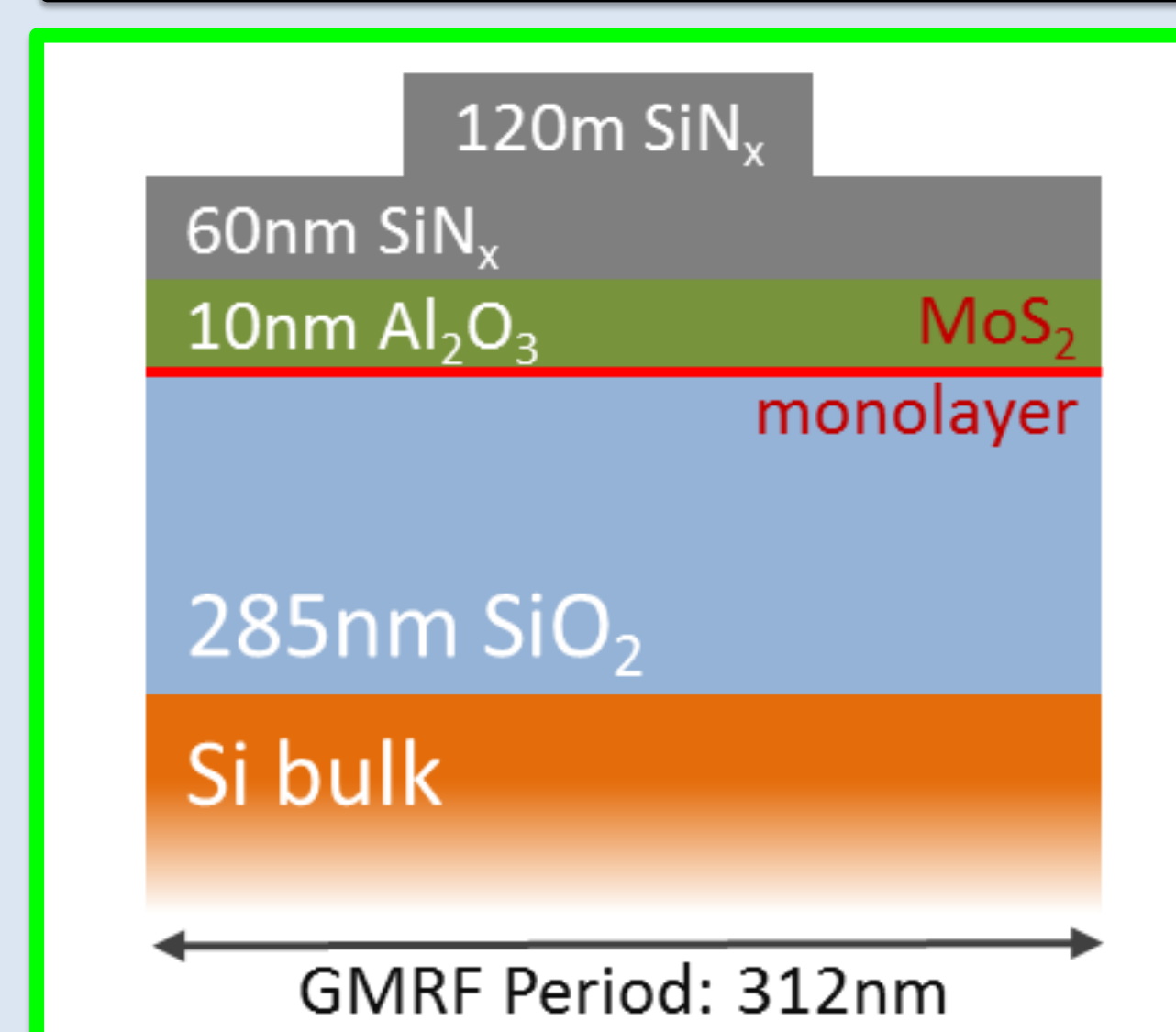
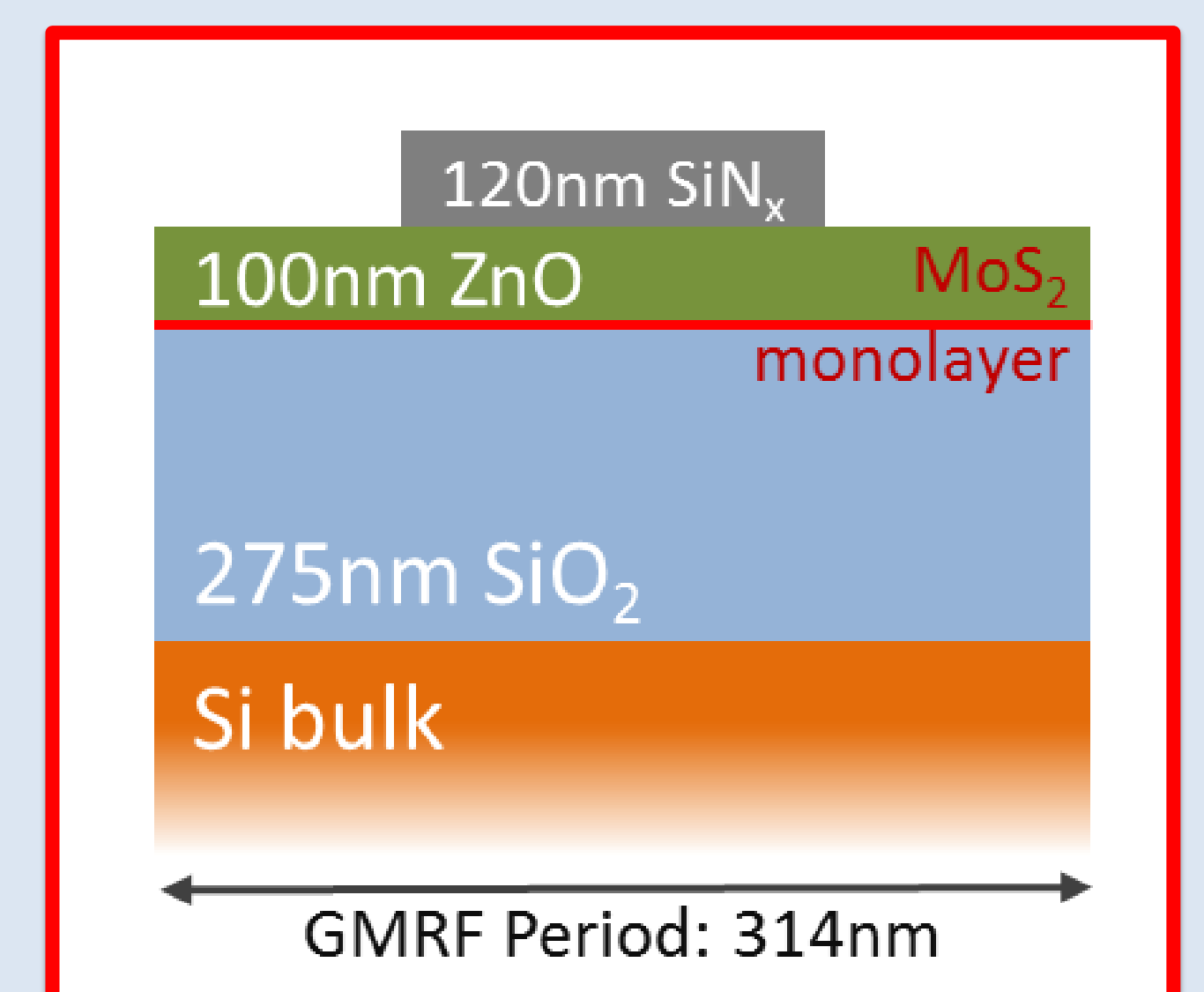
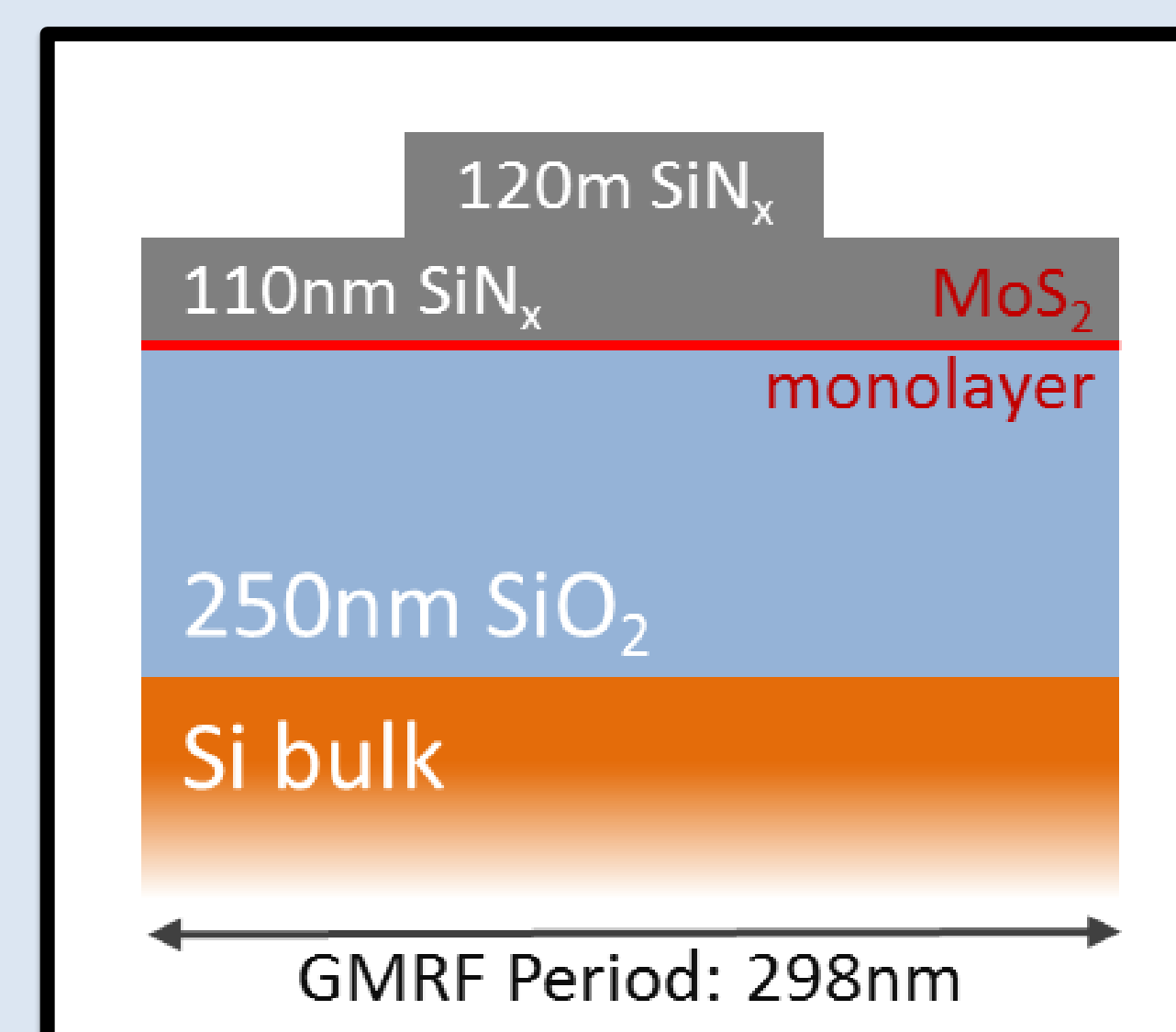


Materials	T _f (°C)	Absorption at 532nm (%)	SiN _x grating		SiN _x guide	SiO ₂ spacer
			Thickness (nm)	Period (nm)	Thickness (nm)	Thickness (nm)
Chrome	1860	92	110	299	110	260
Platine	1770	91.3	110	295	120	230
Cobalt	1495	91.8	110	295	120	230
Nickel	1453	92	110	303	100	260
Si bulk	1414	85.8	120	298	110	250
Or	1064	92.4	120	298	110	210
Argent	961	99.1	135	294	125	250
Aluminium	660	97.1	110	294	130	240

Addition of metallic film as back reflector increase devices performances compare to optical structures on Si bulk substrate. Hybrid devices with Ag and Al thin films achieve near total absorption by the TMDC layer however the low thermal stability of these materials requires reconsideration of the design.

Performances of hybrid CRIGF-TMDC device

TMDC monolayers are sensitive to integration processes including deposition steps. Therefore, various optical stacking have been simulated to consider several encapsulating thin films: SiN_x layer by plasma enhanced chemical vapour deposition or ZnO and Al₂O₃ films by atomic layer deposition. Finally, fused silica substrate offers an alternative to achieve co-integration of Al reflector and TMDC monolayer without transfer.



Hybrid photonic devices based on SiN_x gratings and guides achieve absorption by the MoS₂ monolayer of 85.8% and 82.0% respectively considering infinite lateral GMRF or finite CRIGF layer. The performances of these devices are increased by the addition of encapsulation films and metallic reflector.

Perspectives

These numerical results show that coupling a photonic grating with TMDC monolayer is a promising method to enhance the absorption by these two dimensional materials. Given the recent demonstration of the synthesis of high-quality large area of TMDC monolayer, new challenge to enable fabrication of these hybrid devices is to develop integration way compatible with TMDC materials^[10].

The continuation of this work is to study the impact of deposition processes on properties of TMDC materials. The objective of this experimental part is to reveal suitable encapsulation processes for TMDC materials without disturbing the exceptional charge confinement in these two dimensional materials.

