NANOPHOTONICS TECHNOLOGY CENTER

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Design and Optimization of Graphene-On-Silicon Nitride Integrated Waveguide Mode Filters

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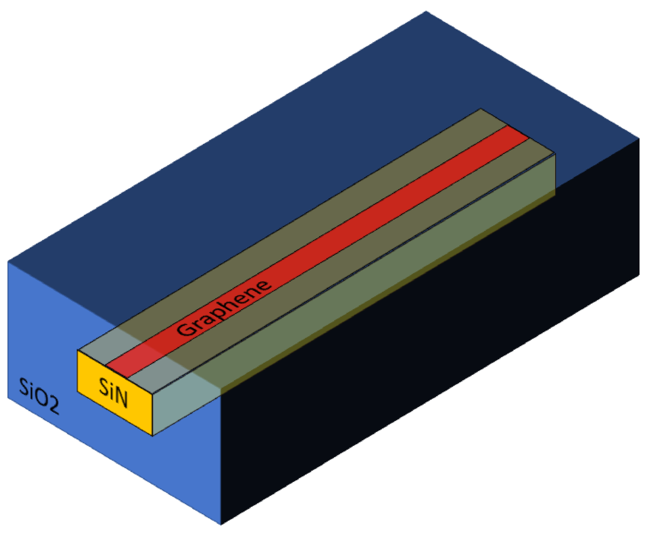
Abstract

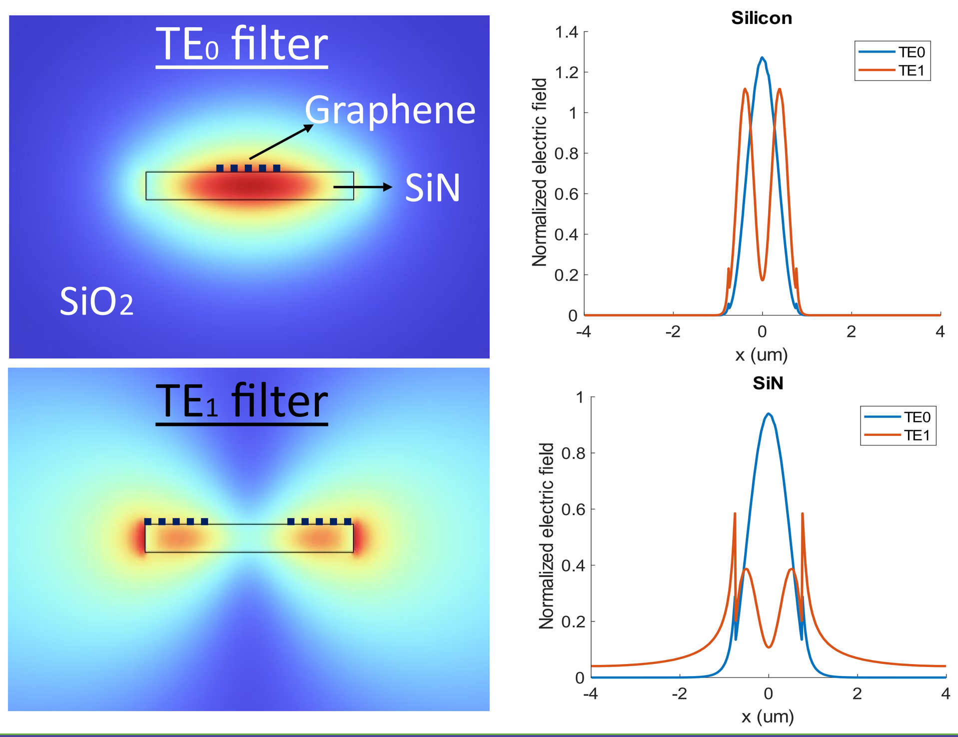
We report on the design and optimization of graphene-on-silicon nitride (GOSiN) integrated waveguide mode filters for suppressing the spurious propagation of either TE_0 or TE_1 modes. The integrated waveguide consists of a silicon nitride core partially covered by single layer graphene films. We then compare the efficiency, fabrication tolerance and bandwidth of the devices to those of similar graphene-on-silicon (GOS) integrated waveguide mode filters.

Mode Division Multiplexing (MDM):

- **Mode Division Multiplexing** increases channel capacity by transmitting **higher order waveguide modes.**
- Traditional MDM systems suffer from **high insertion losses, large device footprints and high costs.**
- Promising approach: **graphene-on-SiN integrated waveguide mode filters** [1]-[3].

Motivation and design





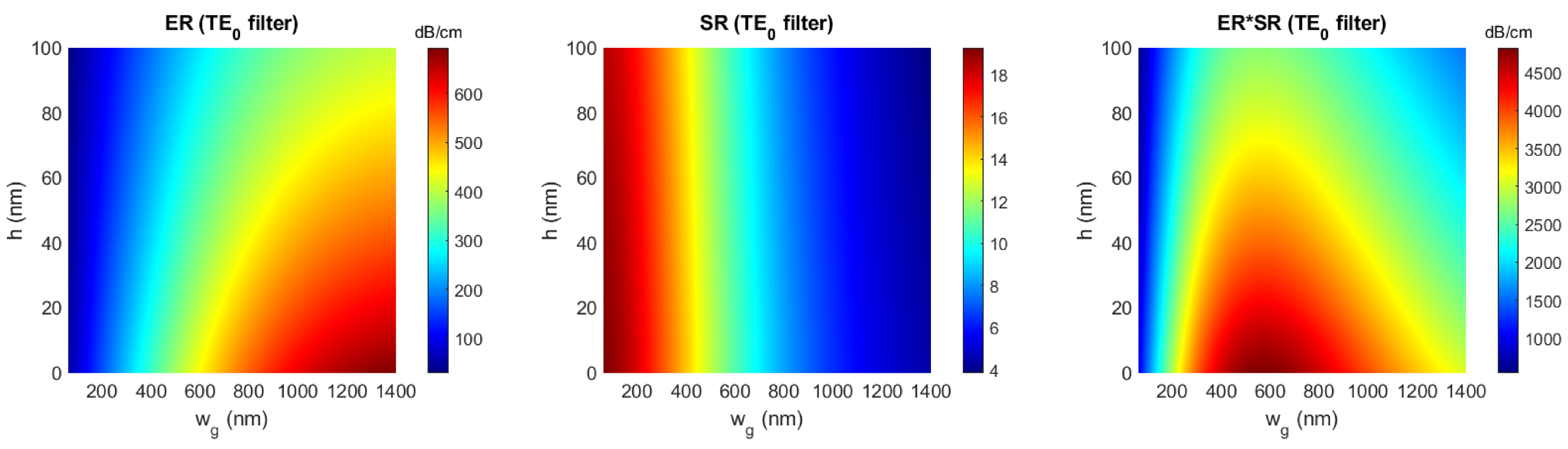
$$ER = \alpha_{stop} - \alpha_{pass} \qquad SR = ER/\alpha_{pass}$$
$$L = C/ER \qquad IL = C/SR$$

α_{stop}: Absorption coefficient of the stop mode
α_{pass}: Absorption coefficient of the pass mode
ER: Extinction Ratio
SR: Selection Ratio
C: Contrast
L: Device length
IL: Insertion Losses

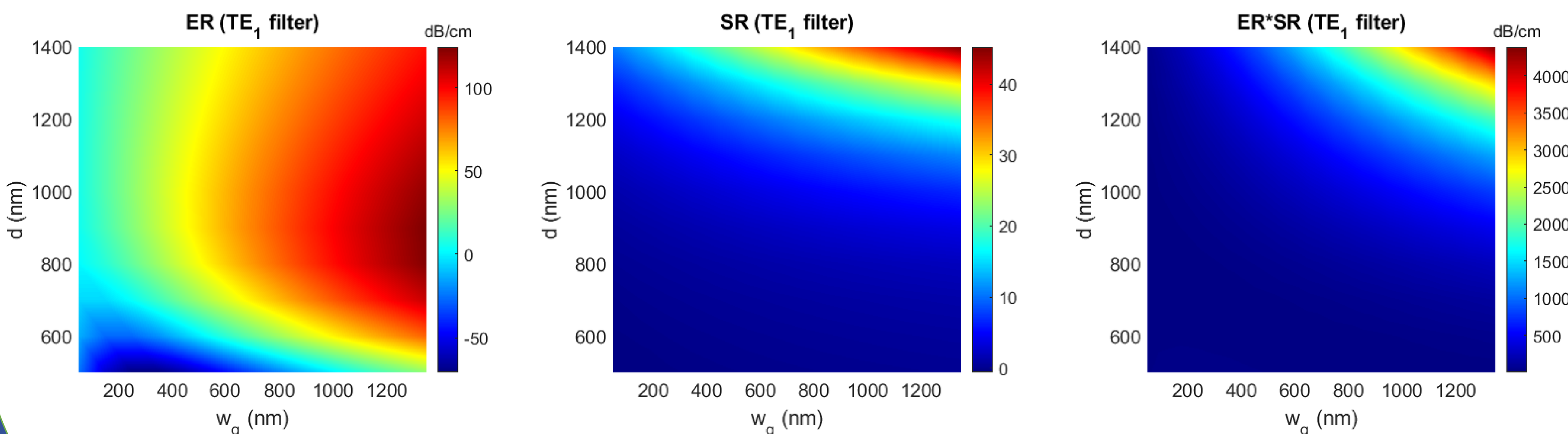
Minimize $L \times IL$
↓
Maximize ER × SR

Optimization of the design

Performance of a TE_0 and a TE_1 filter with a SiN waveguide core of W = 1500 nm and H = 200 nm, at $\lambda = 1550$ nm, as a function of the graphene strips width (w_g) and separation (h – vertical, d – horizontal).



TE_0 filter: Better performance than GOS [2]. Less overlapping between modes.

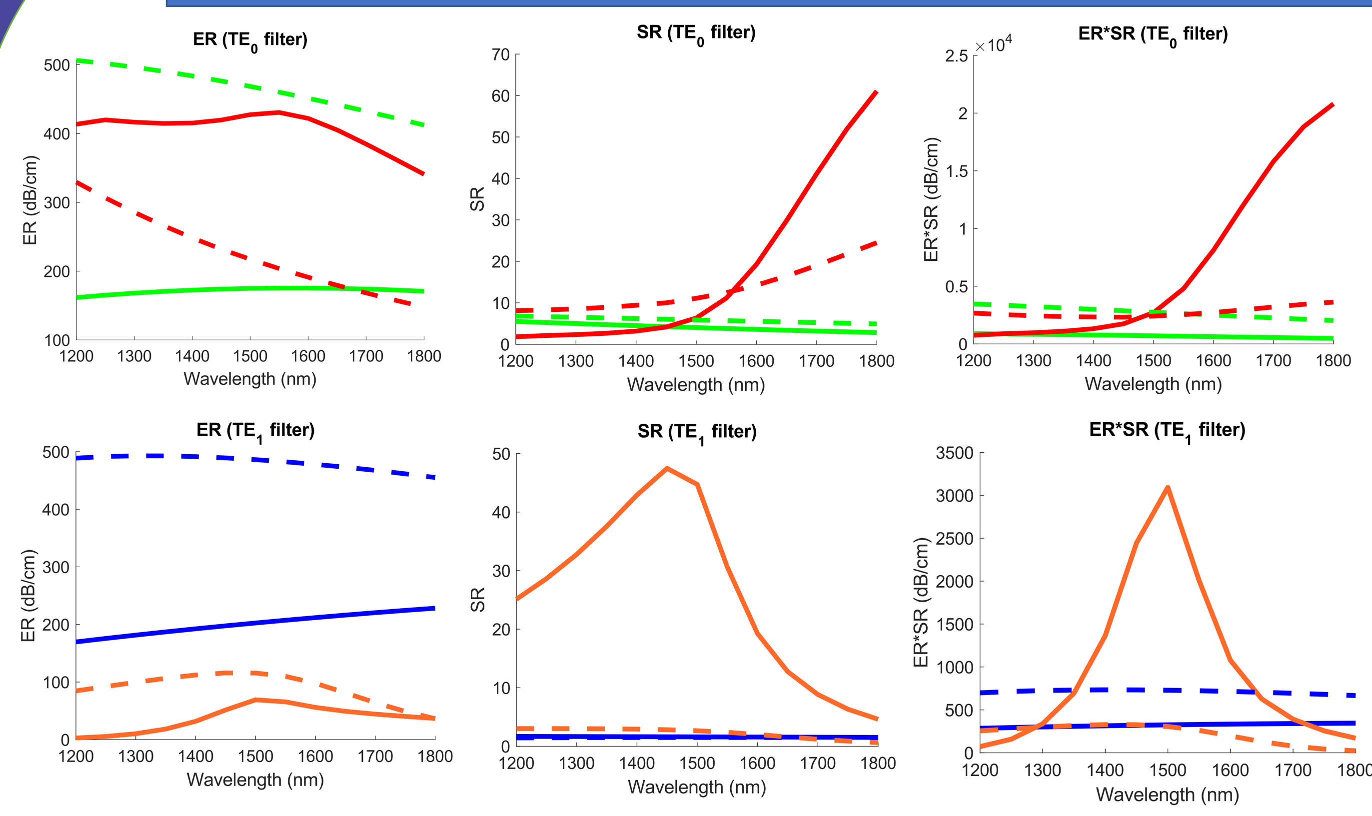


TE_1 filter: Worse ER than GOS [2], but better $ER \times SR$. Large optimal distance between graphene strips.

Fabrication tolerance of the TE₀ filter

If we define the fabrication tolerance of the TE_0 filter as the range of graphene width values in which the $ER \times SR$ product is above 90% of its maximum value, it can be observed that the tolerance for GOS filters is ±80 nm, while for GOSiN filters it is +180 nm -200 nm.

Optical bandwidth



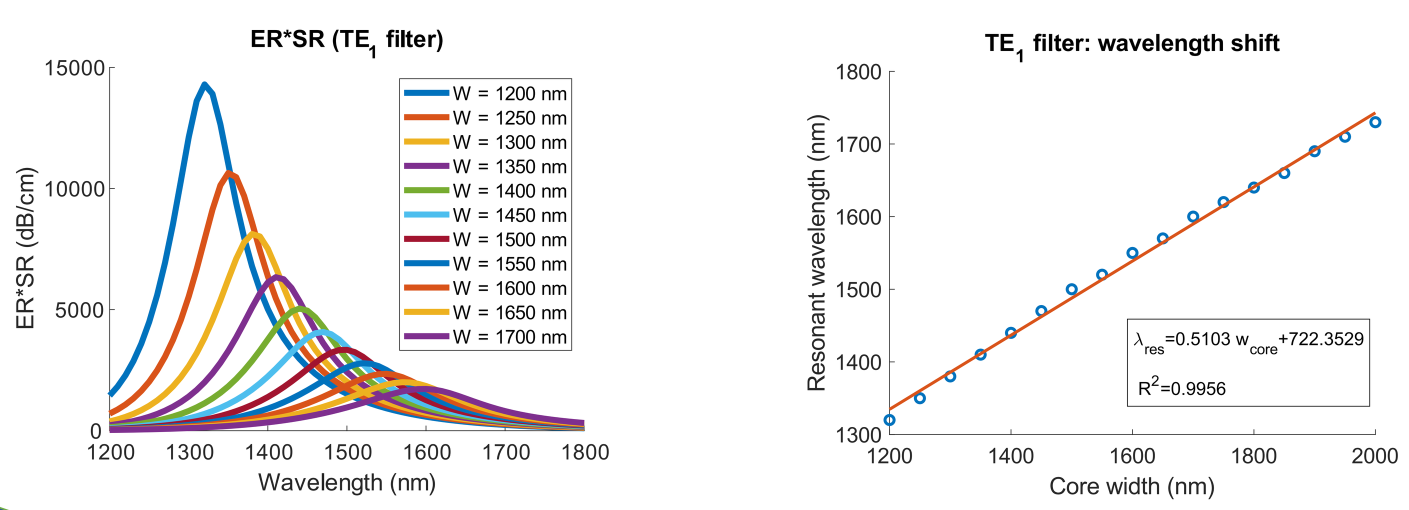
Core	Si	SiN	Si	SiN
W (nm)	1500	1500	3000	3000
H (nm)	200	200	100	100
w_g (nm)	260	580	560	550

Core	Si	SiN	Si	SiN
W (nm)	1500	1500	3000	3000
H (nm)	200	200	100	100
w_g (nm)	1200	1300	1300	1400
d (nm)	400	1400	750	1400

GOS	GOSiN
Generally larger ER (shorter device), depending on the geometry.	Much larger SR (lower insertion losses), and much **larger figure of merit** $ER \times SR$ (smaller product of length and insertion losses).
Homogeneous response.	**Tunable resonance** peak.

Wavelength tuning of GOSiN TE₁ filter

If we fix the width and position of graphene in the GOSiN TE_1 filter at w_g=1400 nm and d=1400 nm, we observe that the **resonant wavelength grows linearly when the core width (W) is increased**.



Acknowledgements and References

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Conclusions

The proposed graphene-on-SiN integrated devices would allow to selectively filter the TE_0 or the TE_1 mode of a SiN waveguide. They show a wavelength region where the figure of merit is much larger than that of graphene-on-silicon devices, and which in the case of the TE_1 filter consists of a tunable resonant peak.