Hybrid chip-based nonlinear optical devices using graphene

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The recent development of silicon photonics, namely based on Si and Si derivative materials (e.g. Si_3N_4), has enabled the integration of a wide range of optical devices onto the same chip. However, due the intrinsic limitations of silicon, some devices cannot be efficiently integrated in silicon monolithic architectures. III-V/ Si wafer bonding and $LiNBO_3$ thin film technologies have already provided a path to increase the functionalities that can be heterogeneously integrated onto silicon chips, now turned hybrid [1]. Two-dimensional materials represent another promising route to complement the properties of silicon and create compact hybrid architectures with novel functionalities. The most mature of these 2D materials, graphene, has attracted lots of attention as it exhibits attractive nonlinear optical properties, such as a large photo-refractive Kerr index, and saturable absorption, which might be interesting for nonlinear photonic chips and all-optical information processing. While its intrinsic properties are relatively high for a monolayer-thick material, the use of integrated optics provides a way to enhance the otherwise low absolute response of this 2D material. Besides, the capability of tuning graphene optical properties provides an additional advantage to realize on-demand and reconfigurable nonlinear photonic devices.

I will here discuss some of these developments, including our recent demonstration of hybrid graphene/ Si_3N_4 waveguides for chip-based saturable absorbers [2]. Our work also shows that hybrid graphene coated waveguides provide a relevant platform to unravel the dynamics of graphene nonlinear optical properties. Finally, some limitations of graphene nonlinear properties lead us to explore, with our Australian collaborators, alternative 2D materials such as graphene oxide [3], which might represents an interesting trade-off in terms of linear absorption and nonlinearity.

References

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