Resonant amplification via Er-doped clad silicon photonic molecules

Paulo F. Jarschel, Mário C. M. M. Souza, Rafael B. Merlo and Newton C. Frateschi
"Gleb Wataghin" Physics Institute, Univ. of Campinas, 13083-859 Campinas, SP, Brazil

As silicon photonics applications evolve, the number of components and the routing complexity within the chip increase significantly. This leads to the challenge of maintaining the optical power level along the entire circuit. One possibility of overcoming this obstacle is the addition of erbium-doped waveguide amplifiers (EDWAs) within the chip, in an attempt to replicate erbium-doped fiber amplifiers (EDFAs) functionality on the chip level. The conventional approach for EDWAs demands the substitution of the waveguide core and the use of materials usually not compatible with standard CMOS. Also, large areas on the chip are required for the amplifier and yield reductions are expected due to the required post-processing steps. Considering the considerable fraction of the propagating energy residing outside the Si core, another approach to achieve loss reduction is the use of the top cladding layers of the waveguides/resonators as gain media in a resonant pumping scheme.

In this work, we present our recent results of using Er-doped Al_2O_3 (aluminum oxide, or alumina) top cladding layers on Si ring resonators, demonstrating the possibility of resonant optical amplification with minimal post-processing steps. Also, we show that when multiple rings are coupled, forming photonic molecules, the amplification potential can be dramatically enhanced, since it is possible to obtain resonances with very high Q-factors for some super modes. Experimental results of signal enhancement using this technique will be presented, showing very high net gain/area values, which can be used for compensating the losses in complex photonic routers. Finally, a comparison between the amplification potential of standard rings and photonic molecules will be discussed, along with the optimization of the design for very high net gain.

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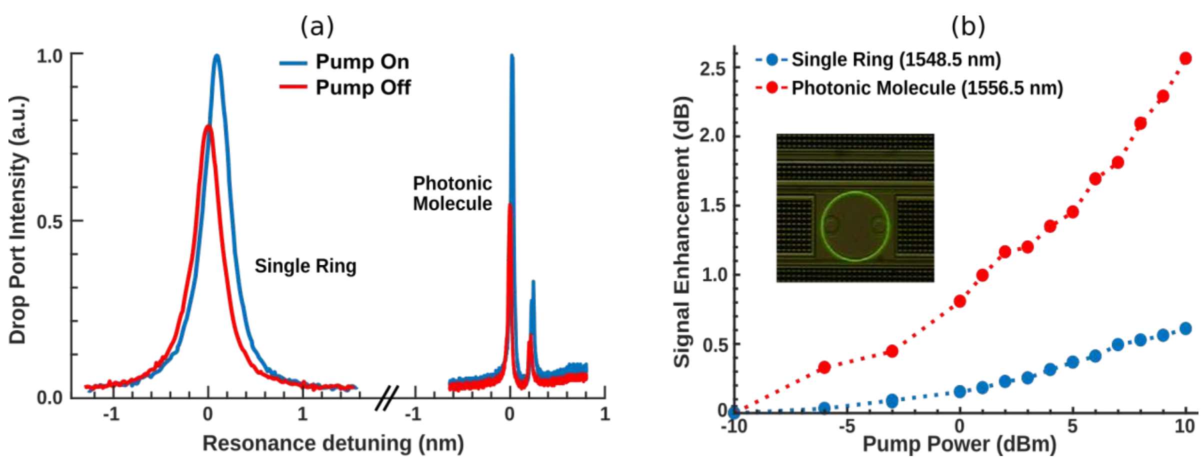

FIG. 1: (a) Measured normalized output intensities at the drop port of a single ring resonator and a photonic molecule, for the pump off and on conditions. The photonic molecule produces a higher increase in output power. (b) Measured signal enhancement for a single ring and for a photonic molecule *vs.* pump power, with a photonic molecule resonantly pumped at ~1480 nm shown in the inset. The higher signal enhancement for the photonic molecule is evident.