Tunable photonic molecules for spectral engineering in dense photonic integration

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Large optical communication and interconnection bandwidth, wireless access, and fast data processing are demanded for future ubiquitous computing. Photonic integration is poised to become the high-performance ultra-fast technology that will overcome the limitations imposed by electronics in future computing systems. Optical interconnections, chip-to-chip as well as within the same chip, are expected to provide complex optical signal processing capacity while complying with a tight power budget and drastic footprint constraints, in a fully CMOS-compatible platform. Light sources, modulators and detectors have been demonstrated with great performance, along with a variety of optical signal processing functionalities in silicon waveguides. Numerous proof-of-concept devices showing promising capabilities are still to be enhanced.

In this context, the ability to tailor the spectral and spatial features of photonic devices so as to match them to selected applications is critical. We will present our recent advances in demonstrating enhanced signal processing capabilities using CMOS-compatible photonic molecules. Arrangements of multiple coupled optical resonators overcome the intrinsic interdependence between photonic lifetime, resonance spacing and footprint for single micro-resonators, introducing a new degree of freedom to perform spectral engineering. Carrier recycling, potential for modulation beyond resonance line-width limit, and multi-wavelength broadcasting are demonstrated for devices with reduced power and footprint. In addition, we will show the active control of these devices that allows flexible tuning of the spectral response.

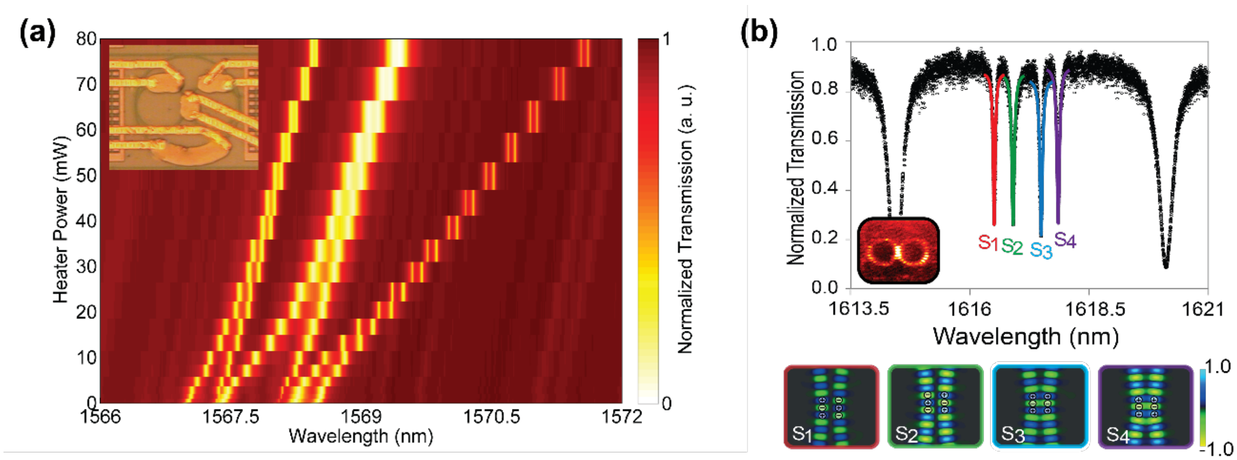

Fig. 1. (a) Photonic molecules with active control enable interesting spectral features, as exemplified by this transmission spectrum, as one of the resonators is detuned with respect to the others using electrical heaters. (b) Transmission spectrum highlighting increased loaded quality-factor resonances and the consequent high field enhancement (infrared image) achieved in these compact cavities. The electric field profile (bottom), showing bonding and anti-bonding couplings between resonators in each resonance, justifies the analogy with molecules.