Realization and Operation of Modular 3-D Optical Nanocircuits

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In this talk, we review our recent work on the realization and operation of optical nanocircuits, and on their application for signal manipulation, filtering, and antenna loading. We discuss theoretical advances and experimental realizations of 3-D optical nanocircuits to realize relatively complex filtering functionalities at the nanoscale. In the first configuration [N. Liu*, F. Wen*, Y. Zhao*, et al., Nano Letters 13, 142 (2013)], together with our colleagues at Rice University, we realized basic parallel and series combinations of lumped optical nanocircuit elements, and we used them as loads of optical antennas sitting on a dielectric substrate, in order to efficiently tailor their radiation properties. In a second setup [J. Shi*, S. Elias*, F. Monticone*, et al., Nature Communications 5, 3896 (2014)], together with our colleagues at UT Austin, we demonstrated the modular assembly of nano-clusters of optical nanocircuit elements using atomic-force-microscope tips, realizing nanofilters of different order. We were able to observe suitable filtering of the scattered light, in line with basic circuit rules governing filters of up to fourth order. Finally, following a similar approach, we tailored a subwavelength cluster of nanoparticles supporting strong circulating displacement current [F. Shafiei*, F. Monticone*, et al., Nature Nanotechnology 8, 95 (2013)], capable of enhancing the local magnetic response to impinging light. During our talk, we will discuss physical insights and new directions in the area of metatronics and optical nanocircuits, aiming to contribute to the possibility of tailoring signals at the nanoscale in much the same way we do today with radio-frequency circuits, but with significantly enhanced bandwidths and much reduced time delays.