Frequency translating add/drop filters designed for on-chip light manipulation

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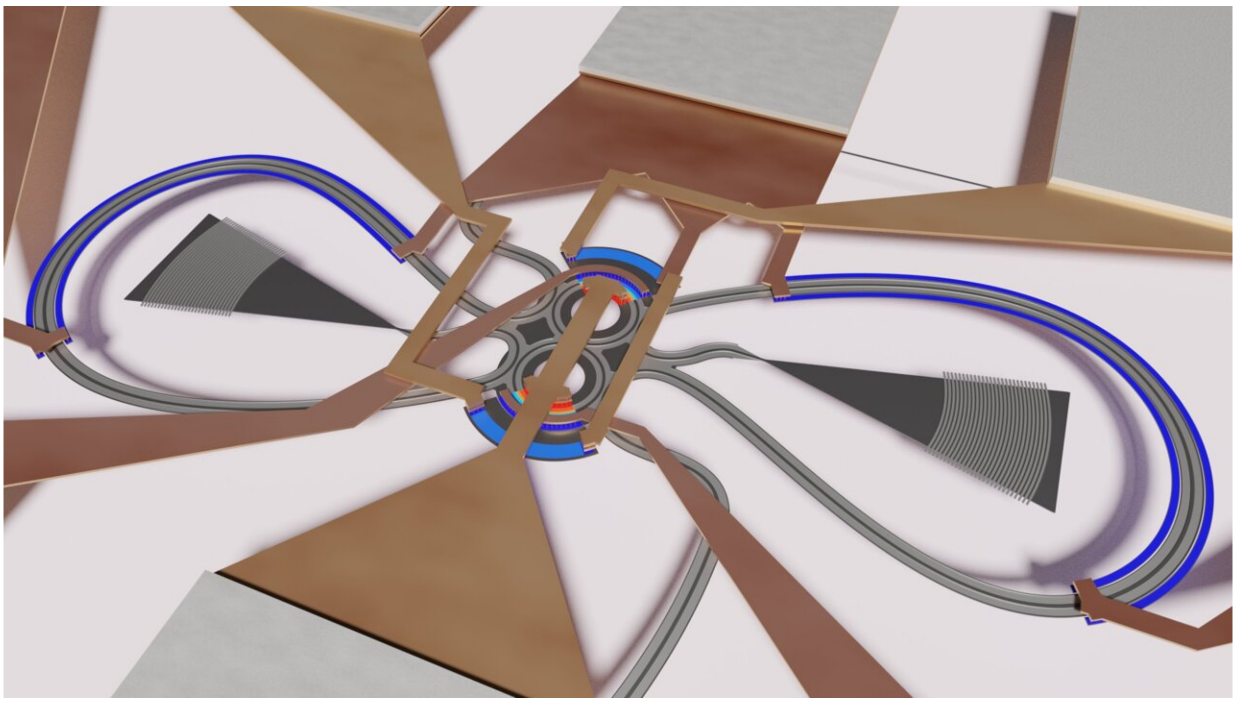


Three-dimensional rendering of the frequency translating add/drop filter showing two coupled active microring resonators, interferometric input/output waveguides, metal wires connected to electro-optic and thermo-optic phase shifters, and vertical grating couplers. Credit: Hayk Gevorgyan, Boston University

Researchers report the development of frequency translating add/drop filters based on electro-optically modulated photonic molecules. The new class of filters could open important new avenues for on-chip light manipulation.

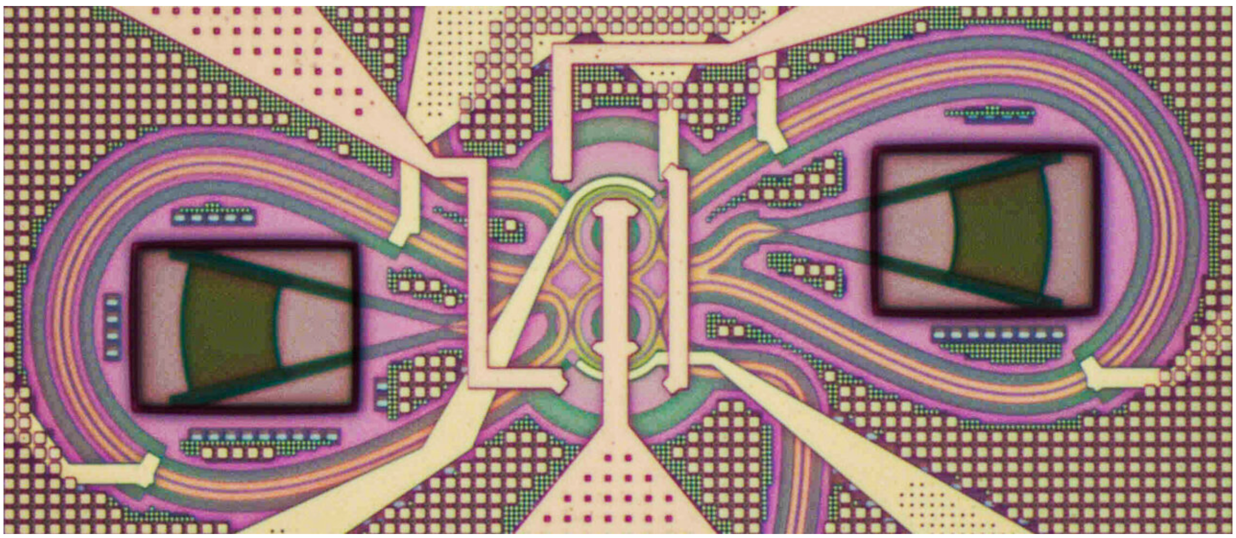
Hayk Gevorgyan from Boston University, U.S. will present the research at the Frontiers in Optics + Laser Science Conference (FiO LS) all-virtual meeting, 01-04 November 2021.

Add/drop filters are used to add and/or drop an individual light channel without disturbing other channels. These filters are commonly used in optical data communication, but are also important for quantum information processing, optical neural networks and other applications. Being an example of linear time-invariant systems, they drop or add a light channel but never change its wavelength. A key attribute of the new filters is their added ability to shift the frequency of the light signals that are dropped or added.

"This is a fundamentally new building block in the toolbox of optical chip designers," said Gevorgyan. "Because we have implemented it in a silicon chip foundry process, it can be used by others to build new more complex systems on chip. This new frequency shifting filter concept may allow easier manipulation of wavelength channels on chip to manage congestion of wavelengths in data communication. But it could also enable a new type of beam splitter for quantum computing using photons."

The new filters build on previous work in which the researchers created frequency translating filters that combined microring modulators and linear filters in a device that produces a shifted drop-port response passband. This design included two actively coupled microring resonators and one bus waveguide. Although the through and drop ports were frequency shifted from each other, they shared the same physical waveguide port, which, for some applications, would require linear filtering to separate the signals spatially.

In the new work, the researchers created a second-order frequency translating add/drop filter with frequency ports that map to distinct waveguide ports. The device uses two coupled microring resonators with built-in electro-optic phase shifters and two waveguides that are coupled to both rings. All four connections feature equal coupling strengths.



Optical microscope image of the second order frequency translating add/drop filter designed by the researchers in Boston University and implemented using IMEC's ISIPP50G active silicon photonics process. Credit: Hayk Gevorgyan

To test the new device, the researchers first measured passive optical transmission between the different ports with no electrical signal applied. They then measured the frequency translating response, finding that the device exhibited filter passbands that shifted from their respective frequencies. The cross talk between channels stayed below 40 dB thanks to careful tuning of phase delays in the waveguides using thermo-optic phase shifters.

Gevorgyan adds, "While these first results are encouraging, the insertion loss is somewhat high; the lowest loss demonstrated to date is 13 dB. As with the regular filters, the frequency translating filters should have an insertion loss below 5 dB to find any practical application in data communication. This can be achieved by optimizing the efficiency, speed and propagation loss of p-n junction phase shifters used in the device. For quantum applications, the requirements would be even more stringent, targeting insertion loss below 0.5 dB. Because of inherent loss of the carrier plasma dispersion effect, we believe such efficiencies cannot be achieved using p-n diode phase shifters. However, implementation in material platforms such as lithium niobate, barium titanate or silicon-organic hybrid may make such applications possible as well."

More information: Gevorgyan's presentation is scheduled for Tuesday, 02 November at 16:30 EDT (UTC – 04:00).

Provided by The Optical Society