Monolithically Integrated Optical Circulator on Semiconductor Substrate

Invention Provides Communication Networks with a Low-Cost Optical Circulator on a Single Chip

UCF researchers have developed an innovative optical circulator and methods for monolithically integrating the device onto a single semiconductor substrate. The device consists of an on-chip design that is broadband, color preserving, compact and integrable with physical processes that are indigenous to semiconductor wafers.

Optical circulators play a crucial role in optical communication networks. The unidirectional, non-reciprocal photonic devices help to prevent instabilities, adverse backward reflection and interference. Unfortunately, standard light emitting opto-electronic materials, such as III-V semiconductors, lack the magneto-optical properties needed to perform optical circulator functions. Thus, most photonic on-chip setups rely on added garnets and magnets (which are not compatible with integrated photonics platforms). Such arrangements provide only a limited degree of isolation, due to excessive losses. They also result in trade-offs between footprint size and device bandwidth.

In comparison, the UCF invention enables manufacturers of photonic integrated circuits to incorporate compact, on-chip optical circulator functionality into more complex optical designs monolithically. The new low-cost device exploits the interplay between non-hermiticity and non-linearity with a significantly smaller form factor. It can route optical pulses unidirectionally from port to port with better than 20 dB of isolation for the flow of optical pulses in the reverse direction.

Technical Details

The invention consists of an optical circulator design and methods for monolithically integrating the device on a semiconductor substrate, for example, a III-V semiconductor such as indium phosphide (InP). The device comprises two or more monolithically integrated input/output ports connected to one or more optical waveguides (for example, monomode ridge waveguides) and optical gain regions that are semiconductor optical amplifiers. Also integrated into the device are non-hermitian coupled waveguide regions. Each consecutive input/output port is oriented parallel to its preceding port.

An example embodiment is a unidirectional, four-port (4x4) optical circulator operating at 1.55 μm. The embodiment monolithically integrates four all-optical switches and four semiconductor optical amplifiers on an InP single semiconductor substrate. The design incorporates a single multilayered structure of hetero-semiconductor materials.
Benefits

• Significantly smaller form factor, yet provides equivalent or better performance to existing products
• Low cost
• Monolithically manufactured using industry standards and eliminates the need for hand assembly
• Can significantly decrease the size of commercial products that use optical circulators

Applications

• Telecommunications

• Computer networking

Additional Technologies

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Technology #33693


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