

Filter Shaping in Integrated Photonics using Non-Adiabatic Control

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Abstract

Exploiting the well-established analogy between light propagation in coupled waveguide arrays and quantum-state temporal evolution, we propose a versatile approach for the simultaneous spectral filtering and spatial routing of light. By introducing controlled, weak, and slowly varying modulations of the waveguides array parameters, selective coupling between distinct photonic modes can be achieved. This enables wavelength-dependent transfer of optical power across the structure, providing both spectral selectivity and spatial control within a single integrated platform.

Our framework describes the impact the (spatial) longitudinal variations of the waveguide array parameters using the same techniques as the one used to comprehend the dynamics of systems subject to (time) varying Hamiltonian. It is therefore possible to design the waveguide array in an inverse-design approach, so as to obtained directly the longitudinal variations resulting in the desired effect. Although the resulting designs share conceptual similarities with conventional Bragg gratings (BGs), it offers complementary functionalities that broaden its range of applications. In particular, beyond spectral filtering, the approach inherently enables routing capabilities, allowing light to be directed toward specific output waveguides depending on the operating wavelength. Moreover, the required modulations are smooth and of low amplitude, ensuring minimal perturbation to the waveguide geometry. As a result, this technique does not interfere with the operation of existing BG-based devices and can be seamlessly combined with them to achieve enhanced functionalities.

This work opens new perspectives for compact and multifunctional integrated photonic devices, particularly for wavelength-selective switching, filtering, and routing applications.

Keywords

Integrated photonics, waveguides, mode coupling, optical routing, spectral filtering.