Modulating transmission of waveguides with tunable cladding

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Photonic Integrated Circuits (PICs) are the photonic equivalent to Electronic Integrated Circuits (EICs): integrated devices able to perform several optical or optoelectronic functions employing visible or near IR light rather than electrons to carry the signals. PICs were born just 15 years after EICs; yet their evolution and level of integration are remarkably different: while EICs can integrate billions (10^9) of components in a single chip, the most complex PICs nowadays scarcely integrate one thousand components at most. Several reasons can be alleged for this vast difference; some of them are related to interconnections between active components, i.e., waveguides (WGs). This presentation discusses some modifications that can be included in WGs to boost the PIC functionality with a relatively low increase in complexity. All of them have been implemented using liquid crystals as tunable claddings of the WG core.

A first group of devices take advantage of the evanescent wave of the circulating mode to modify the transmission properties. Light intensity, phase and state of polarization can be modulated by the external LC upon switching. These effects lead to several devices, depending on whether the LC is mounted onto a straight or curved WG section, or in more complex structures such as Mach-Zehnder interferometers, resonant rings or couplers. Especial attention has been paid to Multimode Interference devices (MMIs), i.e., multimode sections inserted in monomode WGs. These devices generate electric field distributions varying with propagation (Fig. 1). Distances can be modified with a tunable LC cladding. The effect is enhanced if the evanescent component increases. Polymer WGs are being explored in this context.

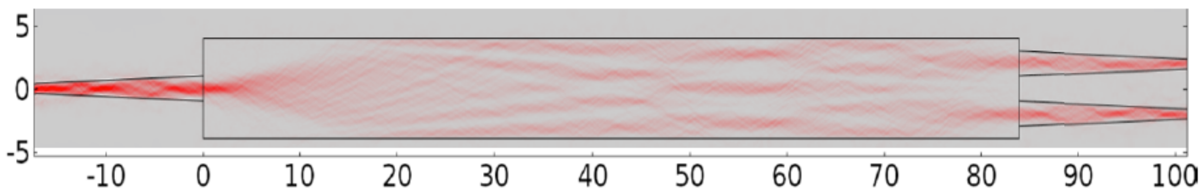

Fig. 1. COMSOL simulation of light intensity distribution in an MMI WG

A second enhancement aims to reduce the WG curvature radii by using photonic gap rather than index gradient guiding. This could be done with Blue Phase LC materials, that can behave as 3D photonic crystals under certain conditions.

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