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Slow-light Propagation in Photonic Nano-Strucutres

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Abstract:

Artificial introduction of defects or disorders in periodic structures causes multiple scattering and coherences of light, which slow light propagation and localization in special direction could be observed in some situations as shown in Fig.11. However, large group velocity dispersion and higher-order dispersion in the slow light regime would cause a signal distortion thus limiting applications of slow light enhancement. In our previous works, wide-band low dispersion slow light propagations were theoretically investigated in both one dimensional (1D) and two dimensional (2D) periodic structures 26.
In 2D periodic structures, modifications of the conventional photonic crystal waveguides (PCW), including varying the waveguide width and changing air holes positions are proposed previously7, 8. But these methods will destroy the symmetry of PC and it is impossible to create efficient sharp bends. We therefore proposed a novel modified line defect PCW 2, in which additional dielectric pillars with radii r are added in the air holes nearest to the waveguide core. By carefully choosing r, a linear band structure appears, and the group index ng and normalized bandwidth $\Delta\omega/\omega$ of the ultralow dispersion characteristics can be tailored.
Recently, slot-based PCW has attracting great interest due to its potential benefits of both slow-light and high intensity localization in slot arising from dielectric discontinuity. However, little attention has been paid to the key issue of dispersion-free slow light in this waveguide. Therefore, we proposed a chirped slot PC waveguide to implement wide band dispersion free slow light 3. The mechanism in the proposed waveguide is dispersion compensation. The pulse propagation in the device is firstly dispersed and then recovered. The design provides opportunities for the use of active materials with slow light, and it would be favor for high-speed all-optical tunable-delay.
In 1D periodic waveguides, light confinement mainly depends on the total internal reflection and it is unable to tailor slow light with fundamental guided mode. By introducing holes into the corrugated grating waveguides, an ideal chair shaped higher order band
with slow light zone away from band edge can be achieved 4, 5. The 1D waveguide is suitable to obtain wide band low dispersion slow light through chirping the structure parameters. Moreover, as an improvement, we also proposed flat band slow light in an simpler 1D grating waveguide, which avoided the introduction of additional holes6. The 1D periodic slow light waveguides have the advantages of compactness and easiness for fabrication.
In conclusion, slow light with wide band and low dispersion can be tailored in periodic structures, and would be promising for delay lines, optics buffers and enhancement of various interactions between light and materials. The works has been supported by the National Natural Science Foundation of China (No. 11147014). In future, I will pay attentions to both the loss and dispersion issues about slow light propagation in periodic structures with fabrication disorders, and also try to make use of slow light to enhance various linearity and nonlinearity optical effects.

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