High-performance slow light photonic crystal waveguides with topology optimized or circular-hole based material layouts

Photonic crystal waveguides are optimized for modal confinement and loss related to slow light with high group index. A detailed comparison between optimized circular-hole based waveguides and optimized waveguides with free topology is performed. Design robustness with respect to manufacturing imperfections is enforced by considering different design realizations generated from under-, standard- and over-etching processes in the optimization procedure. A constraint ensures a certain modal confinement, and loss related to slow light with high group index is indirectly treated by penalizing field energy located in air regions. It is demonstrated that slow light with a group index up to $n_g=278$ can be achieved by topology optimized waveguides with promising modal confinement and restricted group-velocity-dispersion. All the topology optimized waveguides achieve a normalized group-index bandwidth of 0.48 or above. The comparisons between circular-hole based designs and topology optimized designs illustrate that the former can be efficient for dispersion engineering but that larger improvements are possible if irregular geometries are allowed.