5. Conclusion

We have presented a detailed analysis and a deterministic design of the ultra-high Q photonic crystal nanobeam cavities. With this method, $Q > 10^9$ radiation-limited cavity, and $Q > 10^7, T > 95\%$ waveguide-coupled cavity are deterministically designed. These Q-factors are comparable with those found in whispering gallery mode (WGM) cavities [45–47]. Meanwhile, the mode volumes are typically two or three orders of magnitude smaller than WGM ones. Furthermore, energy maximum can be localized in either the dielectric region or air region with this method. Although we demonstrate designs for TE-like, transversely symmetric cavity modes, the design method is universal, and can be applied to realize nanobeam cavities that support TM-polarized modes, as well as line-defect 2D photonic crystal cavities. We believe that the proposed method will greatly ease the processes of high Q nanobeam cavity design, and thus enable both fundamental studies in strong light and matter interactions, and practical applications in novel light sources, functional optical components (filters, delay lines, sensors) and densely integrated photonic circuits.

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