Singh, V., Ho, Y-LD., Sanchis Martinez, L., Cryan, MJ., & Rarity, JG. (2006). High Purcell factor photonic crystal cavities for single photon sources. In *International Conference on Transparent Optical Networks, Nottingham, UK* (Vol. 4, pp. 272 - 272). Institute of Electrical and Electronics Engineers (IEEE).
<https://doi.org/10.1109/ICTON.2006.248477>

Peer reviewed version

Link to published version (if available):
[10.1109/ICTON.2006.248477](https://doi.org/10.1109/ICTON.2006.248477)

[Link to publication record in Explore Bristol Research](#)
PDF-document

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
<http://www.bristol.ac.uk/red/research-policy/pure/user-guides/ebr-terms/>

High Purcell Factor Photonic Crystal Cavities for Single Photon Sources

Vinita Singh, Daniel Ho, Lorenzo Sanchis, Martin Cryan and John Rarity

Centre for Communications Research, Department of Electronic and Electrical Engineering, University of Bristol, Bristol, BS8 1UB, UK, email: m.cryan@bristol.ac.uk

ABSTRACT

Enhancement of spontaneous emission is of crucial importance in the design of high efficiency single photon sources [1]. This can be achieved by creating defect cavities with both high Q and small effective mode volume, which results in a high Purcell factor[1-4]. Photonic Crystal (PhC) microcavities are very promising candidates in this area and this work is using 3D Finite Difference Time Domain modelling to investigate these devices. We have extensive experience in modelling and measuring more conventional pillar microcavities [5,6] and thus are ideally placed to assess PhC based structures.

Figure 1 shows the structure under consideration, this is the case for a one missing hole cavity. The figure also shows the strongly confined x directed Electric field. Figure 2 shows the simulated Q factor calculated from observing the ring down of the cavity mode and the use of Fourier transforms.

Figure 1. One missing hole PhC microcavity showing $Abs(E_x)$ field (x-horizontal, z-vertical), Lattice constant, $a = 0.254$ nm, $r/a = 0.3$, slab thickness $= 0.65a$, $n_{slab} = 3.6$.

Figure 2. Q factor calculated from time domain response of cavity for case of two different dipole directions.

As expected for this simple case very small Q factors are obtained. This work will go on to investigate different cavity configurations and calculate effective mode volumes in order to evaluate the Purcell factor in more advanced designs.

REFERENCES

- [1] H.Y. Ryu and M. Notomi: "Enhancement of spontaneous emission from the resonant modes of a photonic crystal slab single-defect cavity", *Optics Letters*, vol. 28, no. 23, December 1, 2003.
- [2] E. Waks and J. Vuckovic: "Coupled mode theory for photonic crystal cavity-waveguide interaction", *Optics Express*, vol.13, no. 13, pp. 5064-5073 (2005).
- [3] Jelena Vuckovic, Dirk Englund, David Fattal, Edo Waks, and Yoshihisa Yamamoto: "Generation and manipulation of nonclassical light using photonic crystals", *Physica E*, vol. 31, no. 2 (2006).
- [4] Dirk Englund, Ilya Fushman, and Jelena Vuckovic: "General recipe for designing photonic crystal cavities", *Optics Express*, vol. 13, no. 16, pp. 5961-5975 (2005).
- [5] D. Ho, T.Cao, P.S. Ivanov, M.J. Cryan, I.J. Craddock, C.J. Railton and J. Rarity, "Optimal Design Of Single-photon Source Emission From A Quantum-dot In Micro-pillar Microcavity", *International Journal of Quantum Information* 3: 229-238, Nov 2005.
- [6] C.Y. Hu, R. Gibson, Y.-L. D. Ho, M.J. Cryan, I.J. Craddock, C.J. Railton, D. Sanvitto, A. Daraei, M. Hopkinson, M.S. Skolnick and J.G. Rarity, "Quantum-Dots In Micro-Pillar Micro-Cavities: Experiment And Theory", *CLEO Europe*, Munich June 2005.