Photonic crystals are being pursued for their great potential to control spontaneous emission of excited classical and quantum emitters.

Here, we study the radiative decay rate of excited PbS quantum dots inside a photonic crystal (Ph. C.). The photonic crystal consists of long pores etched from two directions in a silicon bar.

Photonic crystal on Si bar

Band gap between wavenumber 6600 and 8000 1/cm

Photonic crystal made by us in the MESA+ NanoLab [1]:

Steps (more details in [2]):
1. Choose a position on the silicon bar to measure, i.e., on the photonic crystal (Ph. C.) or on the reference position (Ref.)
2. Send a short laser pulse to excite the quantum dots in the focus, and start a timer
3. Detect a photon and stop the timer
4. Repeat a million times and make a histogram (top)
5. From the slope, extract the decay rate
6. Repeat at several wavenumbers (bottom)

Photonic crystal inside cuvette

Bar holder
Si bar with ph. crystal
Toluene + q-dots
Spring

Radiative decay rate

In band gap
Above band gap

0 0.5 1 1.5 2 2.5 3
Arrival time (μs)

10^3 10^4 10^5
Measured counts

0 0.5 1 1.5 2
Decay rate (1/μs)

6500 7000 7500 8000 8500 9000
Wavenumber (1/cm)

Conclusio

Emission just above the photonic band gap shows faster decay than inside the band gap.

That fits the theory: just above the band gap, there are many modes available for decay, meaning the decay goes faster [3].

Conclusion

Outlook

Improve decay rate fitting

Increase the percentage of light out of the photonic crystal compared to surroundings, such that we can see slower decay too.

Setup to measure spontaneous emission

Exciting quantum dots and collecting emission using the same objective

References