Modified spontaneous emission using higher-order pseudogaps in 3D polymer photonic crystal at telecommunication wavelengths

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Abstract: The fabrication of a three-dimensional woodpile photonic-crystal is realised in a homogeneously doped PbSe polymer-nanocomposite-material. Infrared emission from the PbSe nanocrystals is overlapped with higher-order photonic-crystal pseudogaps and modification of spontaneous emission is observed.
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1. Introduction

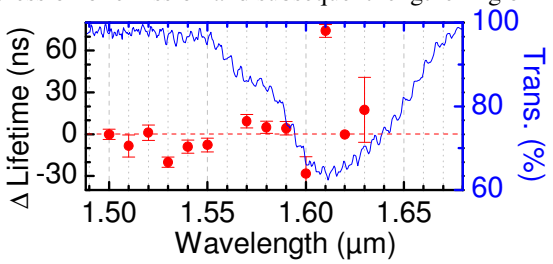
A photonic crystal (PC) lattice allows for the inhibition or strong enhancement of spontaneous emission even in the absence of a complete photonic bandgap (PBG). In this paper we present a unique approach to control of spontaneous emission be using a QD doped polymer material to fabricate void-channel woodpile lattices. Moreover we show the first experimental realisation of the control of spontaneous emission using higher-order pseudogaps.

2. PbS polymer nanocomposites & three-dimensional crystal lattices

PbSe QDs, unlike organic molecules which are poor infrared emitters, have been shown to be efficient infrared emitters with near unity quantum yield. QDs of mean size 4.1 nm showed narrow emission at wavelength 1.59 µm were introduced into Norland Products NOA63 optical adhesive. A homogenously dispersed PbSe/NOA63 film was then exposed to UV light, which results in a solid polymer material. After doping the QDs still maintained unchanged fluorescence characteristics. 3D woodpile PCs were fabricated within the nanocomposite using tightly focused femtosecond pulsed laser light [1]. Tuning the layer spacing with fixed layer to in-plane spacing ratio of 1.1 allowed for higher-order pseudogaps to transverse the emission band of the doped QDs [2].

4. Investigation of modified spontaneous emission

Time correlated single photon counting (TCSPC) was used to investigate changes in spontaneous emission rates of QD emitter embedded within fabricated PCs. Figure 1 shows a plot of the change in lifetime with respect to a non-photonic sample as a function of wavelength. Overlayed is the higher order photonic pseudogap of the crystal being interrogated. At shorter wavelengths far away from the PBG the lifetime of embedded emitters shows no change. As the lower band edge is approached an increase in lifetime is observed and towards the centre of the PBG a remarkable increase in lifetime is seen which is accounted for as a depletion of available radiative modes seen by the nanocrystals, resulting in a suppression of emission and subsequent lengthening of lifetime.



References

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