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Experimental Confirmation of Strong Fluorescence Enhancement Using One-dimensional GaP/SiO₂ Photonic Band Gap Structure

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Motivation

Fluorescent microscopy is undoubtedly useful in bio-sensing and imaging due to

- Optical Sensitivity
- Bio-chemical Flexibility

For single molecule imaging on conventional microscope, there are two challenges:

1. Low signal to noise ratio
2. Low collection efficiency

Due to

- Weak signal strength
- Signal loss in the environment

Proposed Device

- Excitation light comes from the back coupled by a prism
- 1DPBG thin film structure is designed and fabricated on the surface of the substrate

Structure of 1DPBG

- Alternating thin films with high and low refractive indices
- GaP was chosen as the high index material with n₁=3.45, h₁=55 nm
- SiO₂ was chosen as the low index material with n₂=1.45, h₂=122 nm

Performance

- Photonic crystal resonance
  - Field enhancement of 9.2 folds for TE excitation beam at 532 nm, 44.07 degree incidence, 6-layer design
  - Field enhancement of 8.9 folds for TM excitation beam at 532 nm, 45.07 degree incidence, 7-layer design

Omni-directional reflection

Fluorescence signal λ=0.625 μm can be reflected back to the objective lens regardless of angle and polarization. The collection efficiency is increased to 80%

Enhancement Test

- Two 1DPBG samples with 6 and 7-layer designs were fabricated
- Quantum dots were used as the fluorescent materials

- Enhancement for both TE and TM excitation was verified

Omni-directional reflection was also verified

Jian Gao, Andrew M. Sarangan and Qiwen Zhan, Experimental confirmation of strong fluorescence enhancement using one-dimensional GaP/SiO₂ photonic band gap structure, Optical Materials Express, 1(7), 1216-1223, 2011.