Derivation of Equation for Modified Quantum Yield

The quantum yield of an isolated fluorophore molecule is given by [1]

$$q^0 = \frac{\tau_r^0}{\tau_r^0 + \tau_{nr}^0} \tag{1}$$

where τ_r^0 and τ_{nr}^0 are the radiative and non-radiative decay rates respectively.

In the presence of a metallic particle there is an additional radiative channel τ_r^m , and an absorption channel τ_{abs}^m. The modified quantum yield is then given by [1]:

$$q^m = \frac{\tau_r^m / \tau_r^0}{\tau_r^m / \tau_r^0 + \tau_{abs}^m / \tau_r^0 + (1 - q^0)/q^0} \tag{2}$$

combining (1) and (2) gives :

$$q^m = \frac{\tau_r^m}{\tau_r^m + \tau_{abs}^m + \tau_{nr}^0} \tag{3}$$

Electromagnetic Modelling

Initially the absorption and scattering efficiencies of triangular prisms of equal sides and height of 50 nm were compared using FDTD and DDA techniques. This was to validate the FDTD technique, which has not been used previously for calculating the properties of particles manufactured by colloidal lithography.

Using FDTD the absorption, Q_{abs}, and scattering, Q_{sca}, efficiencies are calculated from [2]:

$$Q_{abs} = \frac{-\int_s \mathrm{Re}\left(\frac{1}{2}\vec{E} \times \vec{H}^*\right) d\vec{a}}{|S_i|} \tag{4}$$

$$Q_{sca} = \frac{\int_s \mathrm{Re}\left(\frac{1}{2}\vec{E}_s \times \vec{H}_s^*\right) d\vec{a}}{|S_i|} \tag{5}$$

Where a surface is defined fully enclosing the scattering object and S_i is the incident power density on the nanoparticle. For absorption the total power flowing through the surface is considered, whilst for scattering efficiency only the scattered fields are required.

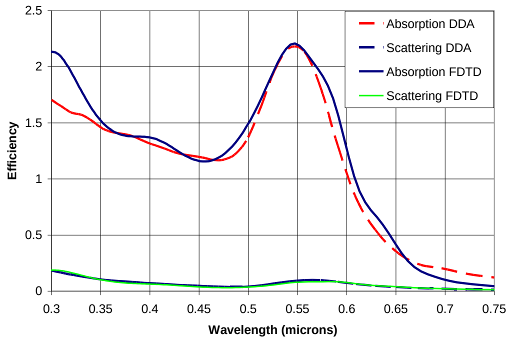

Figure 1. Calculation of Scattering and Absorption efficiencies for an equilateral triangular prism of lengths and height of 50 nm.

The results are shown in Figure 1 for an FDTD cell resolution of 2 nm. It can be seen that there is some divergence of absorption at shorter wavelengths, but overall there is good agreement. This gives us confidence that our FDTD calculations for nanoparticles produces by colloidal lithography are accurate.

References

1 P.Bharadwaj and L.Novotny, Optics Express, 2006, 15, 14266-14.

2 A.Centeno, F.Xie, J.Breeze, and N.Alford. IEEE Applied Electromagnetics Conference (AEMC), 2011, pp1-4.