Tunable Fano resonance in symmetric multilayered gold nanoshells*

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Introduction

Fano resonances (FRs) are produced when a discrete state is coupled with a continuum. In addition to fundamental scientific interests, FRs in plasmonic systems give rise to the so-called plasmon-induced transparency. In this work we have studied the evolution of dipole-dipole all-plasmonic FRs in symmetric multilayered nanoshells as the function of their geometrical parameters. We demonstrate that symmetry breaking is not mandatory for controlling the Fano resonance in such multilayered nanoshells. Generation of FRs in these symmetric nanostructures presents clear advantages over their asymmetric counterparts, as they are easier to fabricate and can be used in a wider range of technological applications.

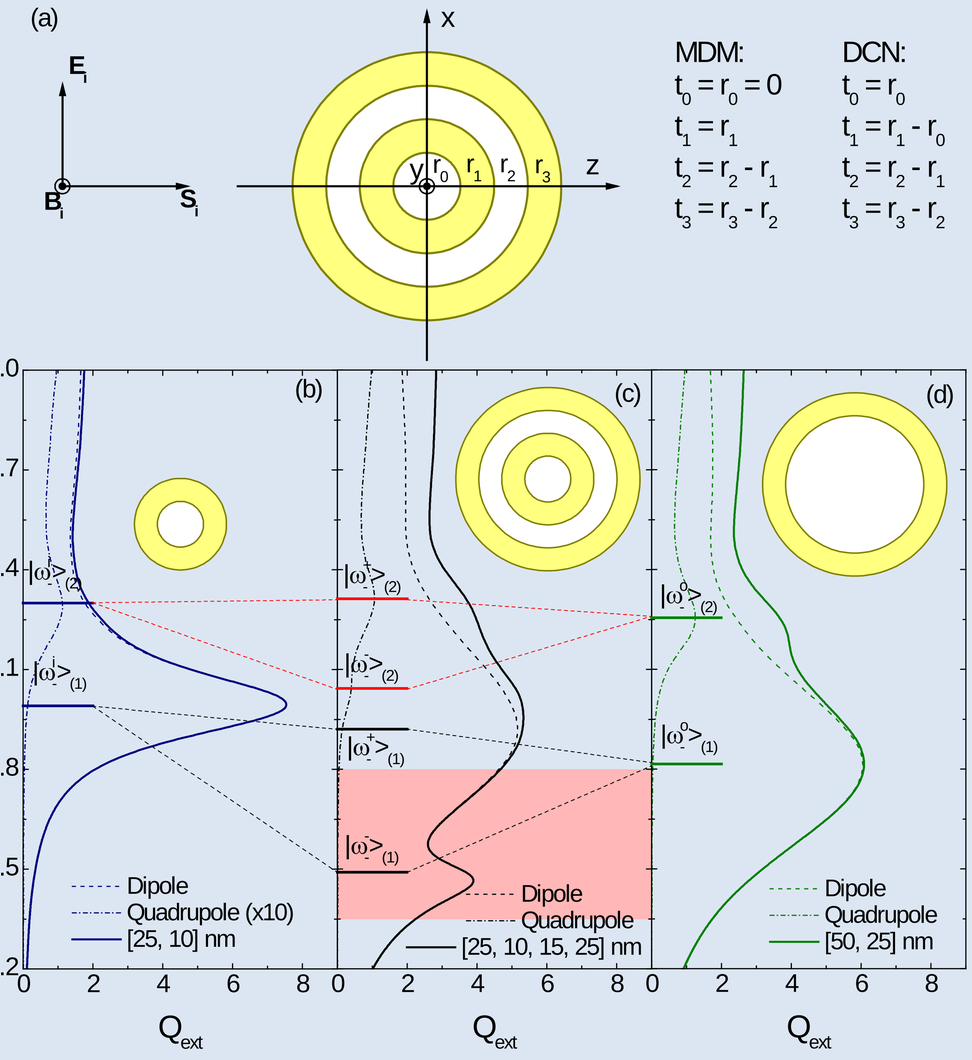

Figure 1. Double concentric nanoshell and its energy diagram, representing plasmon hybridization.

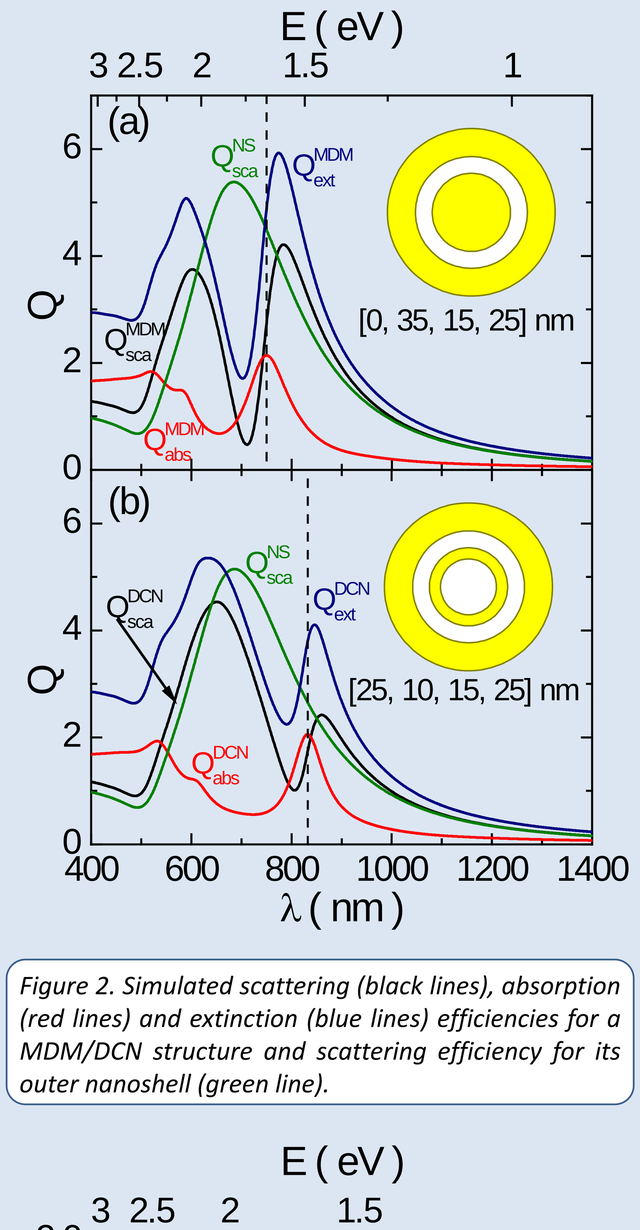

Figure 2. Simulated scattering (black lines), absorption (red lines) and extinction (blue lines) efficiencies for a MDM/DCN structure and scattering efficiency for its outer nanoshell (green line).

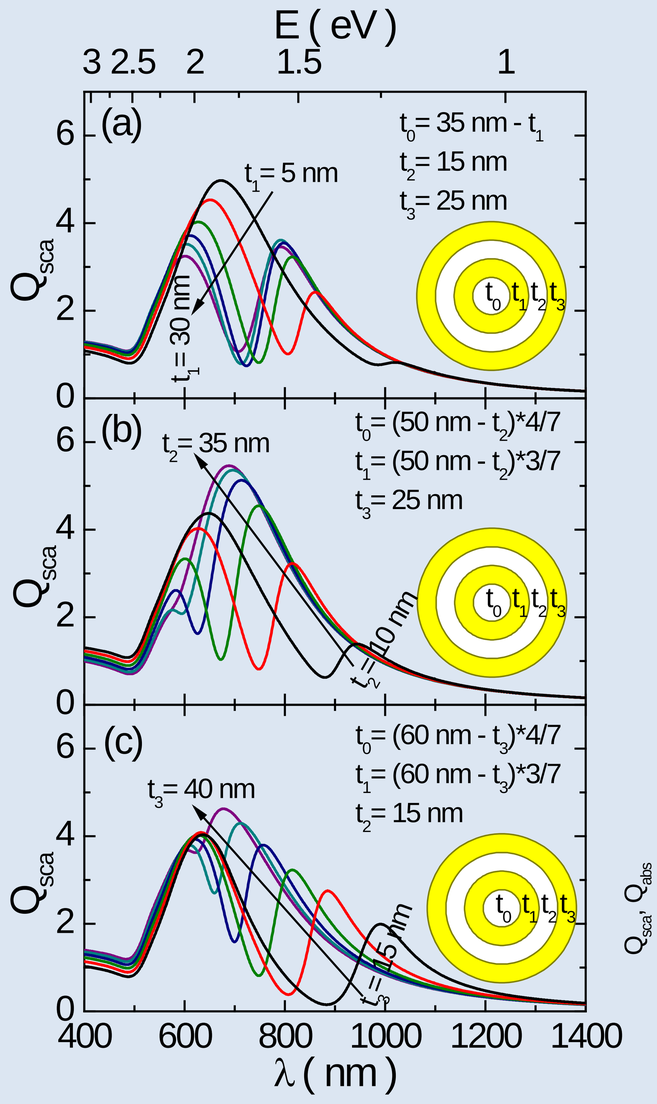

Figure 4: Simulated extinction efficiency for three different configurations of a DCN structure with 75 nm total size.

Gallinet and Martin, ACS Nano, 5 (2011) 8999.

$$Q_{sca}(E) = a^2 \cdot \frac{\left(\frac{E^2 - E_a^2}{2\,E_a\,\Gamma_a} + q\right)^2 + b}{\left(\frac{E^2 - E_s^2}{2\,E_s\,\Gamma_s}\right)^2 + 1 \qquad \left(\frac{E^2 - E_a^2}{2\,E_a\,\Gamma_a}\right)^2 + 1}$$

Figure 5: Typical fit of the scattering spectra, obtained using the above equation.

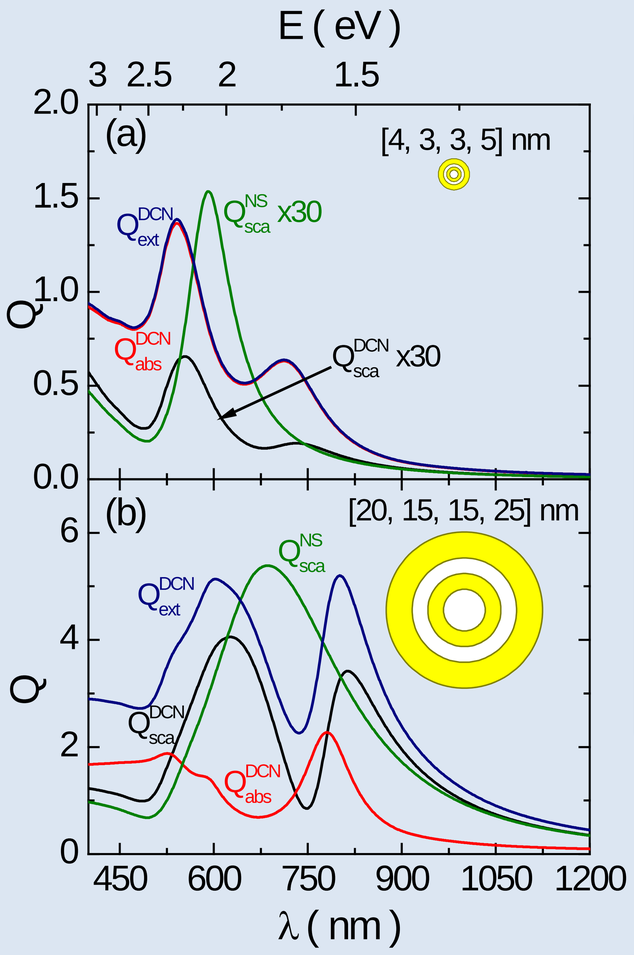

Figure 3. Simulated scattering (black lines), absorption (red lines) and extinction (blue lines) efficiencies for a DCN structure and scattering efficiency for its outer nanoshell (green line).

Conclusions

- FRs in symmetric multilayered nanoshells arise from the interaction between the wide dipolar antibonding energy mode dominated by scattering, and the narrow, mostly absorptive, dipolar bonding mode.
- For gold nanoshells, the position of the FR can be tuned between 600 and 950 nm and its intensity can be increased up to four fold with respect to the non-optimized structures.
- Generation of FRs in such symmetric nanostructures is clearly advantageous, as they are easier to fabricate and can be used in a wider range of technological applications.

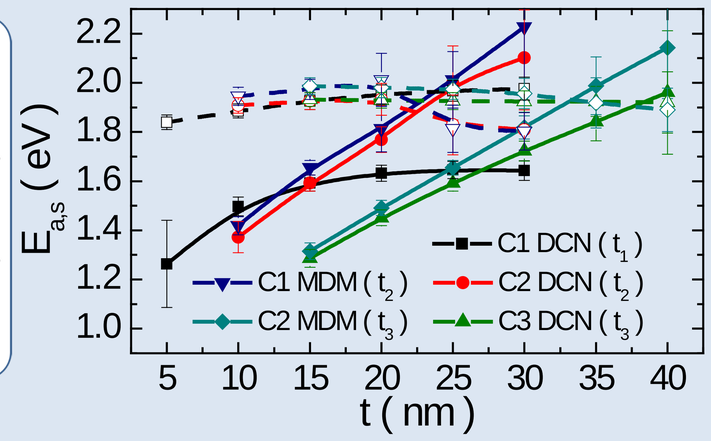

Figure 6: Position of the asymmetric (filled symbols, a index) and symmetric (open symbols, s index) resonances, obtained from the fits.

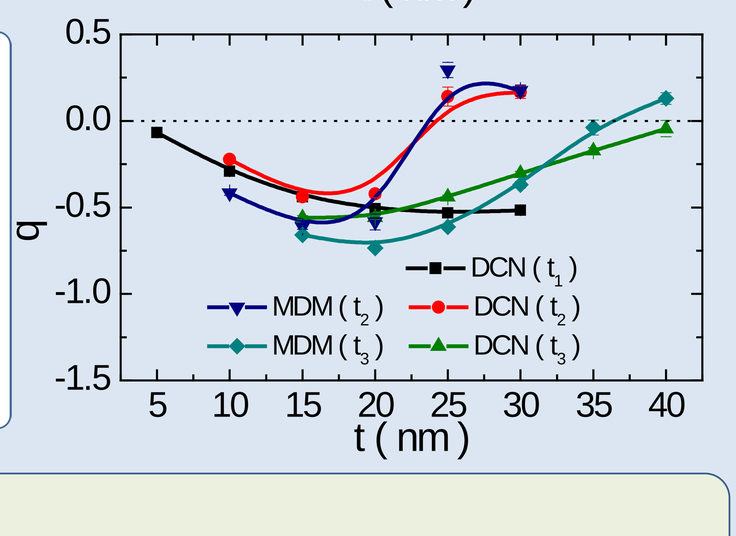

Figure 7: asymmetry parameters obtained from the fits.

* For details check: Peña-Rodríguez *et al.*, Nanoscale, DOI:10.1039/C2NR32281A (2012).

Acknowledgements

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