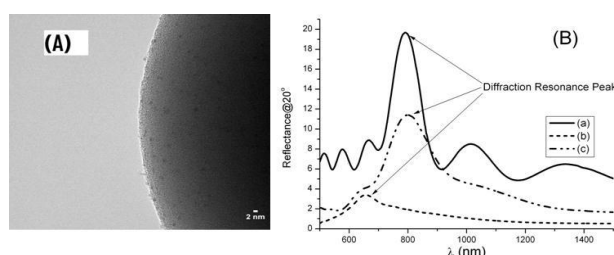


Fabrication and Characterisation of Colloidal Photonic Crystals Prepared from Au-Decorated Colloidal Silica Spheres

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There is currently enormous interest in the fabrication of photonic band gap materials or photonic crystals, and other examples of so-called metamaterials that involve metals, as a result of the possible influence of the metal plasmonic resonances on the resulting optical properties of the materials. This paper demonstrates how the incorporation of functional Au nanoclusters onto the surface of silica spheres (as $\text{SiO}_2\text{@Au}$ particles) can be effectively utilised to improve the 3-D photonic crystal properties when they are immobilised on a glass substrate in the form of an ordered photonic crystal. Monodispersed silica spheres have been prepared by a modified Stöber process and functionalised with Au nanoclusters by using the silane coupling chemistry. 3-Aminopropyl triethoxysilane has been used as the coupling as well as reducing agent in this study. The colloidal particles were then deposited onto a glass substrate by evaporation induced self assembly and the optical properties of the resulting metalodielectric photonic crystal structures have been measured in reflection and transmission as a function of angle of incidence. In both transmission and reflectance measurements, a relatively big blue shift (around $1/3$ particle diameter) of diffraction resonances was observed, which appears to contradict classical theory, i.e. a red shift of diffraction resonance should take place as the particle size increases by coating a metal shell outside, according to Bragg's law. However, we suggest that this result arises from the reduction of effective refractive index of the material that occurs because the dielectric constant of the gold nanoparticles at visible frequencies is negative. Therefore the Au nanoparticle shell covering the silica particles will decrease the effective index of the photonic crystal film as a whole. This idea is supported to some extent by the spectrum of a film which is assembled using the Au shell particles coated with a second silica layer, see figure below.



(A) TEM image of a $\text{SiO}_2\text{@Au}$ particle and, (B) reflectance spectra of photonic crystals prepared using (a), bare silica particles, (b), Au nanoparticle coated silica particles and (c), double shell silica-Au-silica particles.