Nanoparticles and nanocomposites for display applications

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Abstract

The optical response of metallic structures has attracted significant interest for various applications in recent years. Of particular relevance to display applications is the ability to optimize the intensity and wavelength of the radiation which is scattered by the structure. In this thesis, original studies are presented across three main sections which investigate the optical response of a variety of composite structures formed from metal and dielectric elements.

In the first section, the optical response of planar structures comprised of continuous metal and dielectric layers is discussed. An extensive study is conducted into the transmission pass-band characteristics exhibited by these structures, in particular the dependence on parameters such as metal layer thickness, layer spacing and the number of periods.

The second and third sections include examples of structures in which the metallic elements are non-continuous. The simulations required here are considerably more involved, and so an introduction is given to the computational techniques used in subsequent chapters, accompanied with results for a test structure. The structures in the second section include single metallic nanoparticles and particle pairs which exhibit localised surface plasmon resonances (LSPRs). It is also shown that when particles are arranged into periodic arrays, the properties of the LSPR may be significantly modified by long-range and short-range interactions. This has implications both in terms of the line shape of the optical response, and the sensitivity of the optical response to changes in the surrounding refractive index.

The third section includes an investigation into metallic layers which have been perforated with periodic arrangements of holes. These structures have attracted considerable attention in recent years due to the enhanced transmission which is observed when the periodicity of the hole array facilitates grating coupling to surface plasmon-polariton (SPP) modes associated with the metal film. It is shown that these structures also support localised resonances similar to those of metallic nanoparticles. A comparison is made between the LSPRs observed in metallic nanoparticle and nanohole arrays for which the periodicity is non-diffracting for frequencies in the vicinity of LSPRs. In the final part of the thesis the role of LSPRs in facilitating a negative index of refraction in electromagnetic metamaterials having a fishnet-type structure is investigated.

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